A Seven-Day Journal

Coal Output

STATISTICS for Britain's coal industry, issued by the Ministry of Fuel and Power at the end of last week, show that during the second quarter of this year there was another drop in coal output compared with the first quarter of 1945 and with the second quarter of 1944. The output of 43,687,400 tons of coal for an average of 715,400 wage earners on colliery books represented a decrease of 1·8 million tons in the output of mined coal compared with the preceding quarter. Tonnage lost from causes other than absenteeism increased by the same amount, and included most of the VE holidays as well as part of the Easter and the whole of the Whitsun holidays. If compared with the second quarter of 1944, the output figures show a drop in mined coal of 2·4 million tons and an increase of one million tons in tonnage lost. The output of open-cast coal in the second quarter of 1945, was also slightly lower than in the same period of 1944. The average number of wage earners on colliery books, 715,400, was 5400 higher than a year ago, but was 1300 less than in the first quarter of 1945. The output per wage earner in the quarter averaged 61·1, compared with 63·5 for the first quarter of this year, and 64·9 in the second quarter of 1944. Manpower has been declining during the past quarter, there being 717,400 wage earners on March 24th and 712,200 on June 23rd. In the second quarter of this year absenteeism was 15·1 per cent., compared with 12·7 per cent. in the corresponding quarter of last year, but it was lower than in the first quarter of 1945, when the figure of absenteeism was 16·1 per cent.

Unemployment Returns

QUARTERLY unemployment returns issued by the Ministry of Labour and National Service on Tuesday, August 21st, show that the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed at July 16th, 1945 (exclusive of 19,507 men who had been classified as unsuitable for ordinary industrial employment), was 71,806. Those registered as on short time or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment numbered 389, and those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 728. As compared with April 16th, the numbers wholly unemployed showed an increase of 10,598; those temporarily suspended from work showed a decrease of 49, and unemployed casual workers showed a decrease of 24. The corresponding figures for women and girls at July 16th, 1945, were 40,019 wholly unemployed (exclusive of those, numbering 448, who had been classified as unsuitable for normal full-time employment), 509 temporarily stopped, and 17 unemployed casual workers. As compared with April 16th, the numbers wholly unemployed showed an increase of 12,258; those temporarily stopped showed an increase of 251, and unemployed casual workers showed a decrease of 45.

The Future of Whaling

THE Whaler Section of the Chamber of Shipping of the United Kingdom has drawn up and submitted to the Ministry of Food, the Ministry of Agriculture, and the Ministry of War Transport a report on post-war policy. The importance of whaling as a major source of food lies, it is pointed out, in the fact that the stock of whales has increased considerably in the years since 1939–40, during which practically no whaling operations have been carried out. The world production of whale oil in the six years to 1939–40 averaged 480,000 tons per annum, more than 90 per cent. of which was obtained in the Antarctic from an average of thirty-three whaling expeditions. The report suggests that the world requires a smaller number of floating factories than the pre-war number, and that about twenty would be sufficient, and that of these, nine should take their place in a British Mercantile Marine of adequate strength. All British floating factories have been lost. For nine floating factories it is suggested that about seventy-two modern whale catchers and nine old catchers would be sufficient. Seven British land stations may be expected to continue or to recommence operations at least for the first three post-war seasons, South Georgia, South Africa, Labrador, British Columbia (two), Newfoundland, and Australia. For these about three modern whale catchers and twenty-six older catchers should be sufficient. In addition, two modern British catchers may be required for operation from a Norwegian-owned station in South Georgia. The number of whale catchers suggested for the British Mercantile Marine is thus 112, seventy-seven built not earlier than 1935, and thirty-five older vessels. At the outbreak of war nine enemy-owned floating factories over 10,000 gross tons, were in service. It is suggested that all surviving enemy factories be transferred to British and Norwegian ownership. Several new floating factories are already under construction in the United Kingdom shipyards for British and Norwegian owners. The Whaler Section of the Chamber accepts the view of the Government that it would do more harm than good to withdraw from the International Regulations, and that every effort should be made to obtain the necessary amendments to the present Regulations.

Oil Engine Production

IT was announced by the Ministry of Supply, on Tuesday, August 21st, that a certain degree of relaxation of the control of the internal combustion engine producing industry has now become possible. In general, makers are now free to accept and execute all orders—including civilian orders for home and export—without prior reference to the Ministry of Supply, as has been necessary in the past. It is still necessary to agree the makers' aggregate programmes to ensure the proper allocation of supplies of raw material and to make certain that the arrangements are in accordance with the availability of manufacturing facilities and labour. The only exceptions are where capacity to produce some few types of internal combustion engines and spares for the Fighting Services is hardly sufficient to meet the prevailing demand. These exceptions are necessary in order to ensure that the Armed Forces and Government Services are still able to get the engines that they need.

An Atomic Energy Committee

SPEAKING in the House of Commons, on Tuesday, August 21st, Mr. Attlee, the Prime Minister, announced that His Majesty's Government had decided to appoint an Advisory Committee under the chairmanship of Sir John Anderson, to assist it in dealing with the many far-reaching questions raised by the atomic energy discovery. The members of the Committee were as follows:—Sir Alexander Cadogan, Permanent Under-Secretary of State, Foreign Office; Field Marshal Sir Alan Brooke, Chief of the Imperial Staff; Sir Alan Barlow, Second Secretary, Treasury; Sir Edward Appleton, Secretary, Department of Scientific and Industrial Research; Sir Henry Dale, President of the Royal Society; Professor P. M. S. Blackett; Sir James Chadwick; and Sir George Thomson. The Committee will deal with all questions as regards the international treatment of the new discovery, and its further development in this country, whether for industrial or military purposes. Mr. Attlee went on to say that the many questions involved in the future of atomic energy, including that of its international handling and its possible development for industrial purposes, were, of course, already engaging the attention of the Government; hence the formation of the Committee. He recalled his earlier statement of August 13th, in which he declared that it was the intention of the Government to devote all its efforts to making the new discovery serve the purpose of world peace, and to co-operate with others to that end. In reply to Mr. Churchill's question, Mr. Attlee added that policy had, of course, to be decided by the Government, and that the Committee would advise it both with regard to the scientific progress and the general background of the whole subject.

Durham and Lincoln Power Stations

RECENT developments have taken place with regard to the proposed new power stations at Durham and Lincoln which will modify the original plans. On Monday, August 20th, Mr. Lewis Silkin, the Minister of Town and Country Planning, announced that he had been informed by the North-Eastern Electric Supply Company that, in an endeavour to mitigate the effects of the delay which has taken place with regard to the proposed construction of a new power station at Kepier, near Durham, the company has already taken steps to meet the present demand for additional electric supply by the installation of plant elsewhere than at Kepier. Colonel S. E. Monkhouse, the managing director of the North-Eastern Electric Supply Company, said on Tuesday that the company was erecting new plant at its Dunston power station at a cost of nearly £2,000,000, but that extension was not an alternative to the £3,500,000 Kepier Durham scheme. In view of the difficulties raised, an alternative to the Kepier site would be considered by the directors. At Lincoln, the City Council decided at its meeting of August 9th, by thirteen votes to eleven, to reject the alternative scheme submitted by Mr. E. C. Farran—see our Journal note of August 3rd—and to accept the scheme recommended by the Electricity Commissioners, which provides four cooling towers and ultimately eight, each 90ft. high, at its new power station at St. Swithin's.

Private Enterprise and World Trade

PRIVATE enterprise and its relationship to world prosperity were referred to in a speech by Mr. Winthrop W. Aldrich, President of the International Chamber of Commerce, at a luncheon of the American Chamber of Commerce in London on Monday, August 20th. Mr. Aldrich said that the International Chamber of Commerce was convinced that not only was the private enterprise system the best means, but the only means of establishing world trade on a multilateral basis and thereby of achieving the greatest volume. That was another way of saying that the private enterprise system was the best means of bringing about world prosperity and employment, of assuring a higher standard of life for all peoples, and of securing and maintaining world peace. He felt that in order to speed the restoration of multilateral trade, a world trade conference should be called as soon as possible, and he hoped that conversations now taking place between representatives of the United Kingdom and the United States would lay an effective basis for such a conference. The removal of trade barriers, Mr. Aldrich continued, was a necessary prerequisite to the removal of exchange controls and the stabilisation of exchange rates, for the longer exchange controls were retained, the more they became part of the economic fabric of a nation's life and the more difficult was their elimination. It was only if trade barriers were removed that nations would be assured that debts incurred for stabilisation and other purposes could be repaid in goods, and the fear that certain currencies might become scarce disappear, and it was only by the removal of domestic economic controls that competitive forces would be given full play and national income rise to the level necessary to support a large volume of foreign trade. The restoration of competitive forces involved elimination of those practices which in peace-time interfered with the free functioning of the price system.

The St. Etienne-Cantales Dam

DESPITE the enemy occupation of France throughout most of the years 1940–44, the construction of a dam and hydro-electric plant on the River Cère, a tributary of the River Dordogne, which was begun before the war, has been carried on since the collapse of France in 1940, although with inevitable interruptions and in the face of many difficulties. The works, which are now nearing completion, are in some respects very similar, though on a smaller scale, to those of the Genissiat dam in the Rhône Valley, which we have already described.* The Genissiat power plant when installed to its maximum capacity, will be of the order of 416,000 kW; that at St. Etienne-Cantales will be no more than 75,000 kW.

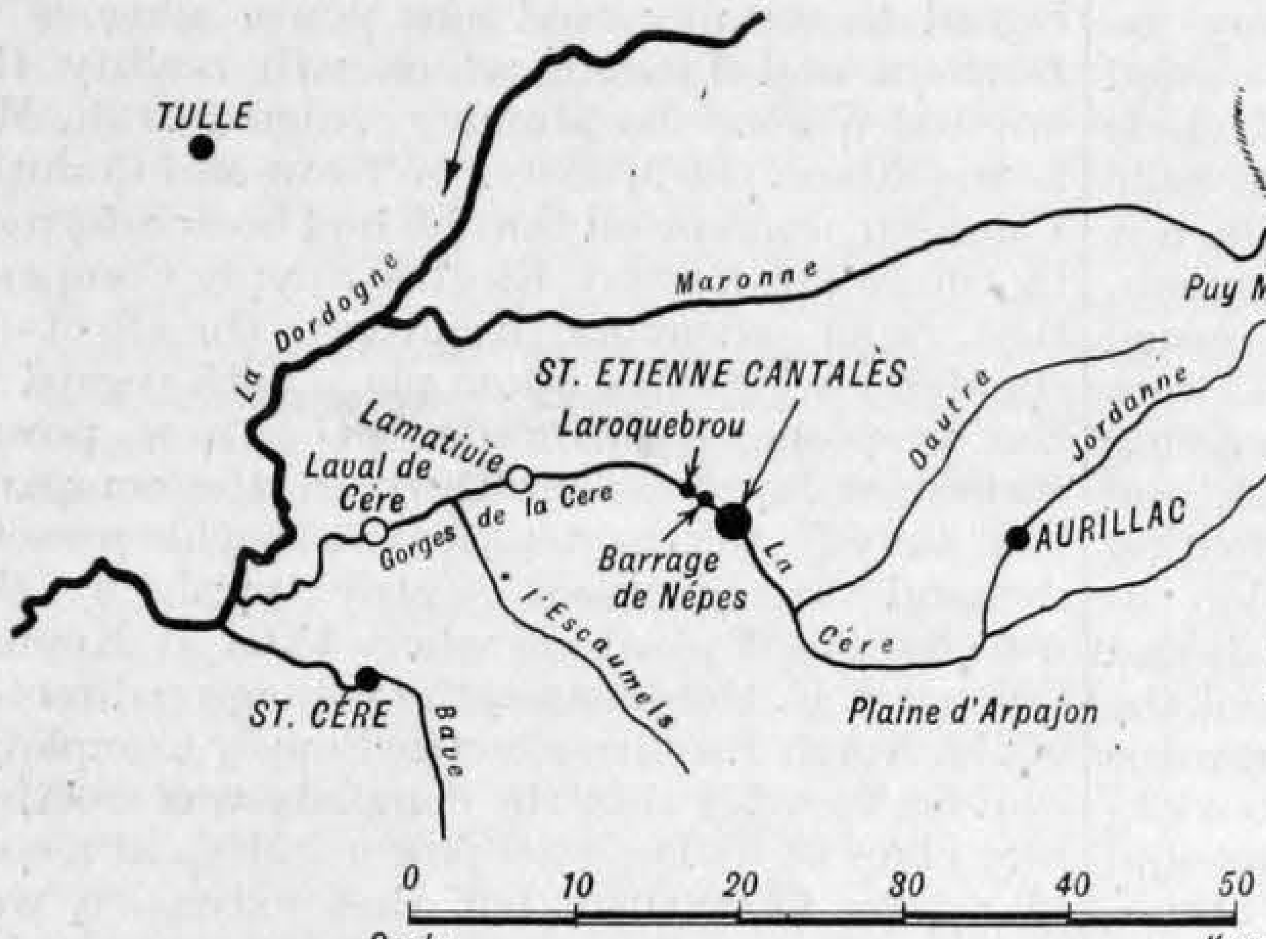


FIG. 1—MAP OF CERE VALLEY

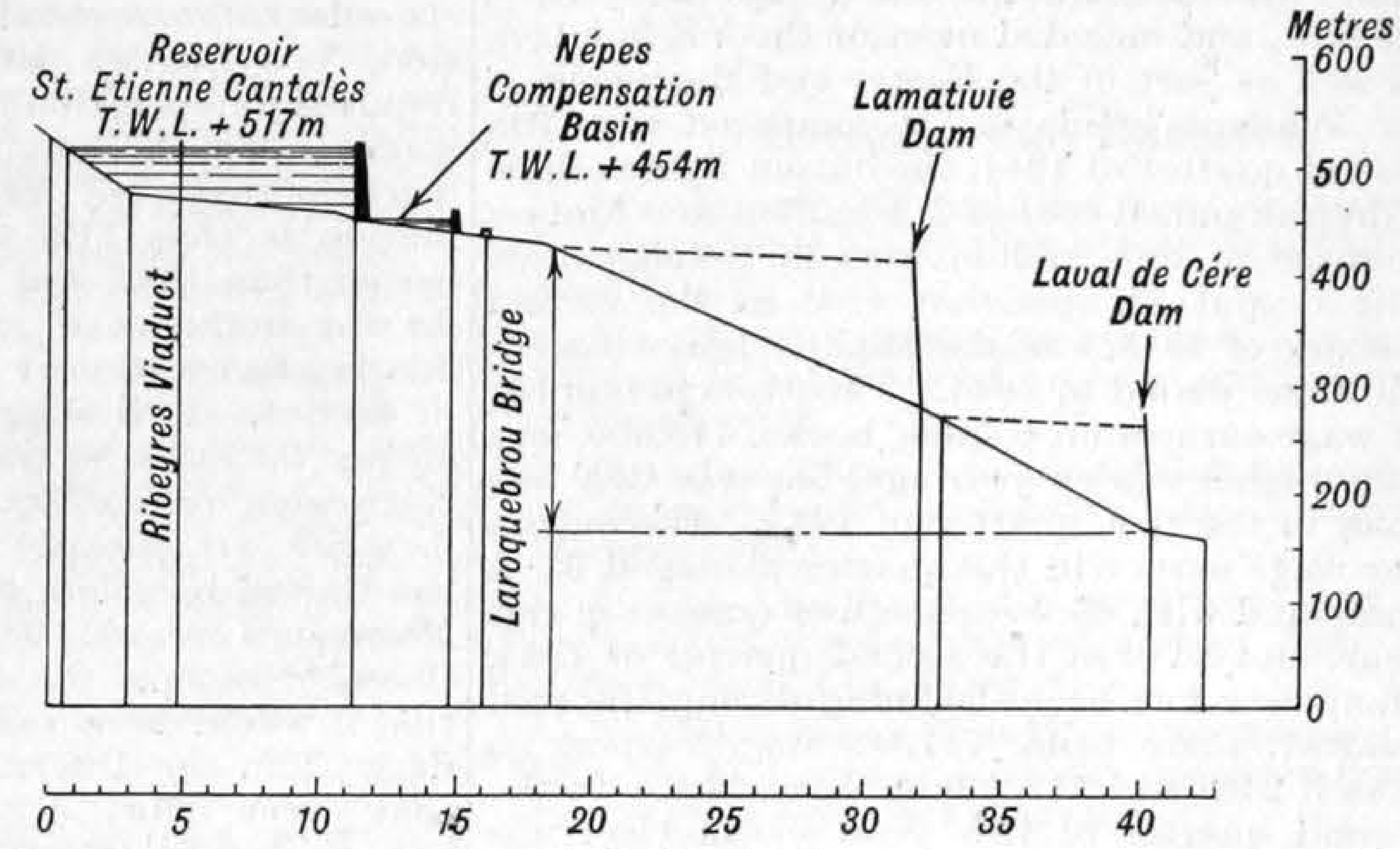
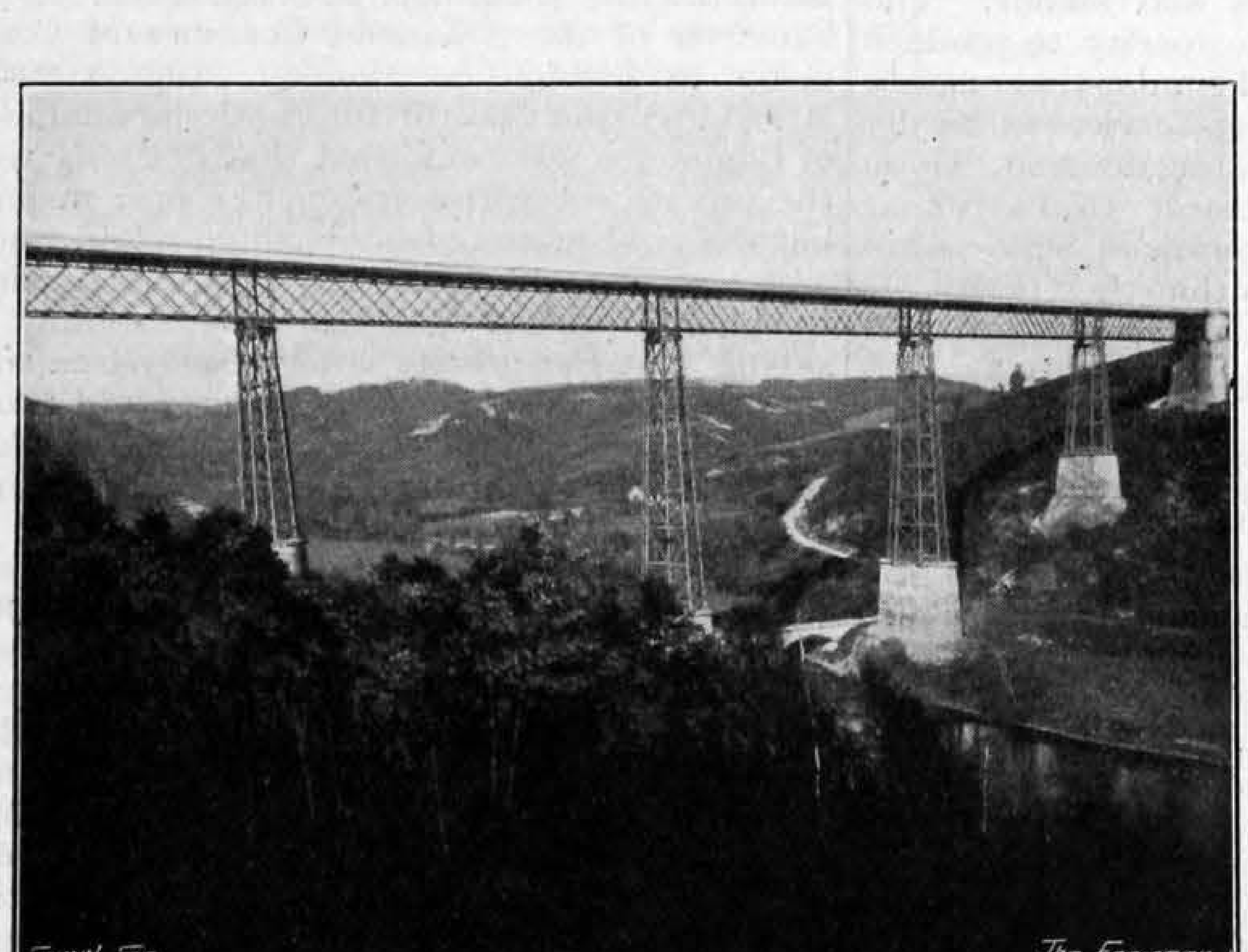
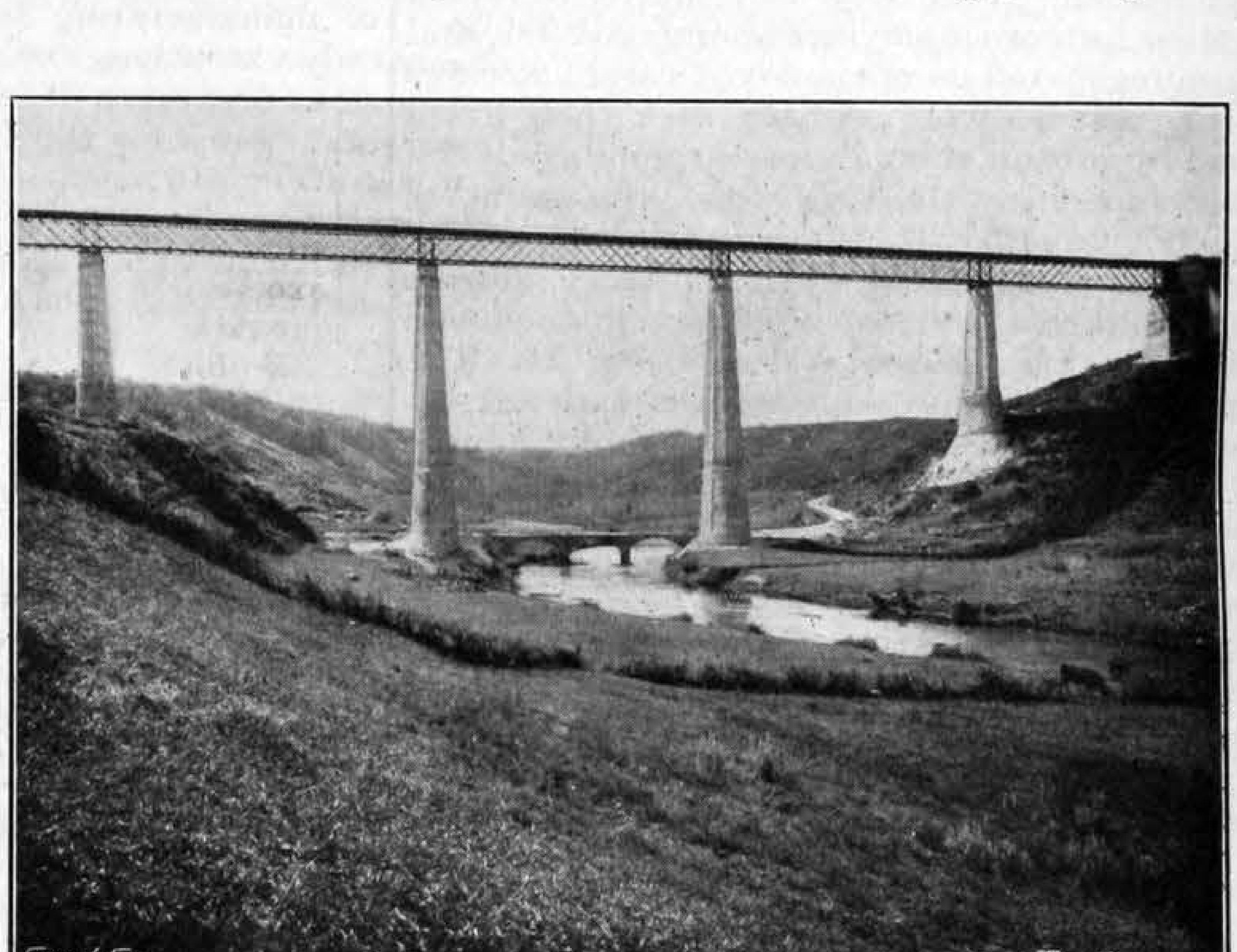


FIG. 2—PROFILE OF HYDRO-ELECTRIC DEVELOPMENT

The programme of electric power development in France which in 1938 was prepared by the industry in collaboration with the Ministry of Public Works, placed in a high priority the construction of the St. Etienne-Cantales dam, intended to complete the hydro-electric development of the Cère valley, in which two power plants had already been installed (Fig. 1). The use of the waters of the Cère for the generation of electric power had been undertaken by the Société Hydro-Electrique de la Cère, which had already constructed the dams and power stations at Lamativie and at Laval de Cère below the site of the new project. These plants, utilising a total gross head of 260 m., had a maximum installed capacity of 58,000 kW, and an average output of 200 million kilowatt-hours.





FIGS. 3 AND 4—RIBEYRES VIADUCT BEFORE AND AFTER ENCASEMENT OF PIERS

The *régime* of the River Cère is, like that of most of the rivers of the French *Massif-Central*, characterised by a period of full flow from November to May, occasionally reduced for a short period during the winter, and a low-stage period extending from June to October. The run-off falls on occasional days in summer to 0·6 cubic metres per second at the gauging station of Laroquebrou, about 5 kiloms. below the site of the St. Etienne-Cantales dam. On the other hand, the winter discharge normally exceeds 25 cubic metres per second, and floods of the order of 200 cubic metres per second are fairly frequent. The average flow at Laroquebrou is 24 cubic metres per second, from a catchment area of 746 square kilometres, equivalent to a run off of about 32 litres per square kilometre per second. This high discharge value extends to the highest part of the catchment basin, whose altitude ranges from +450 m. to +1850 m., and which lies east and west. On it falls the precipitation of the moisture-charged west and south-west winds arrested and condensed by the mountains of the Cantal lying to the eastward. As a result of this *régime* of the river flow, the power stations of Lamativie and Laval-de-Cère have a variable output, maximum in winter and minimum in summer. To correct and balance this inequality of output is the primary object of the construction of the St. Etienne-Cantales dam.

Site of the Dam.—3 kiloms. downstream from Laroquebrou the Cère enters a series of wild gorges, in which the river level falls 260 m. in a course of 21 kiloms. (Figs. 1 and 2). It is this part of the river course which has been utilised in making the power stations of Lamativie and Laval-de-Cère. Above these gorges the Cère flows for 15 kiloms. through a relatively wide and flat granite valley. In the lower part of this valley the plain, south of the village of St. Etienne-Cantales, narrows at the Pradel ridge, where a rocky spur considerably reduces the valley width and provides an excellent site and good foundation for a dam closing the wide valley above it. The torrential Cère has here scoured the alluvial deposit exposing the granite bed flanked by high rocky cliffs.

The geological examination of this site, by means of numerous borings, trial pits and trenches, proved the presence everywhere of a compact, homogeneous, hard granite of medium grain. The granite at some points shows evidences of intense pressure, crushing, and foliation, and there are veins of quartz and calcite here and there. These petrological characteristics are common to all the deep-seated granites of the *Massif Central*, and the traces of lamination and crushing do not impair in any way the strength and compactness of the rock foundation.

* THE ENGINEER, December 30th, 1938, and November 24th, 1939.

Impounding Level.—The top-water level of the reservoir above the dam is limited by the presence of the Aurillac-Figeac Railway, which, about 6 kiloms. above the dam, crosses the Cère Valley at Ribeyres, at a level of 55 m. above the normal water level of the river by a single-track steel viaduct, 310 m. long. Although it was practicable to submerge the steel piers which support the viaduct after they had been suitably protected by encasement, it was not possible to raise the water level in the reservoir beyond the underside of the viaduct girders, about +520·27 m. To provide a safe margin of 3·27 m., the impounded level of the reservoir was fixed at +517 m. The piers of the viaduct have been encased in concrete (Figs. 3 and 4). The completed work, a graceful and æsthetically satisfactory structure, is shown in one of the photographic views on the opposite page before the filling of the reservoir.

At level +517 m. the capacity of the reservoir is about 130 million cubic metres. Its length is 15 kiloms. and the water area about 650 hectares (1606 acres).

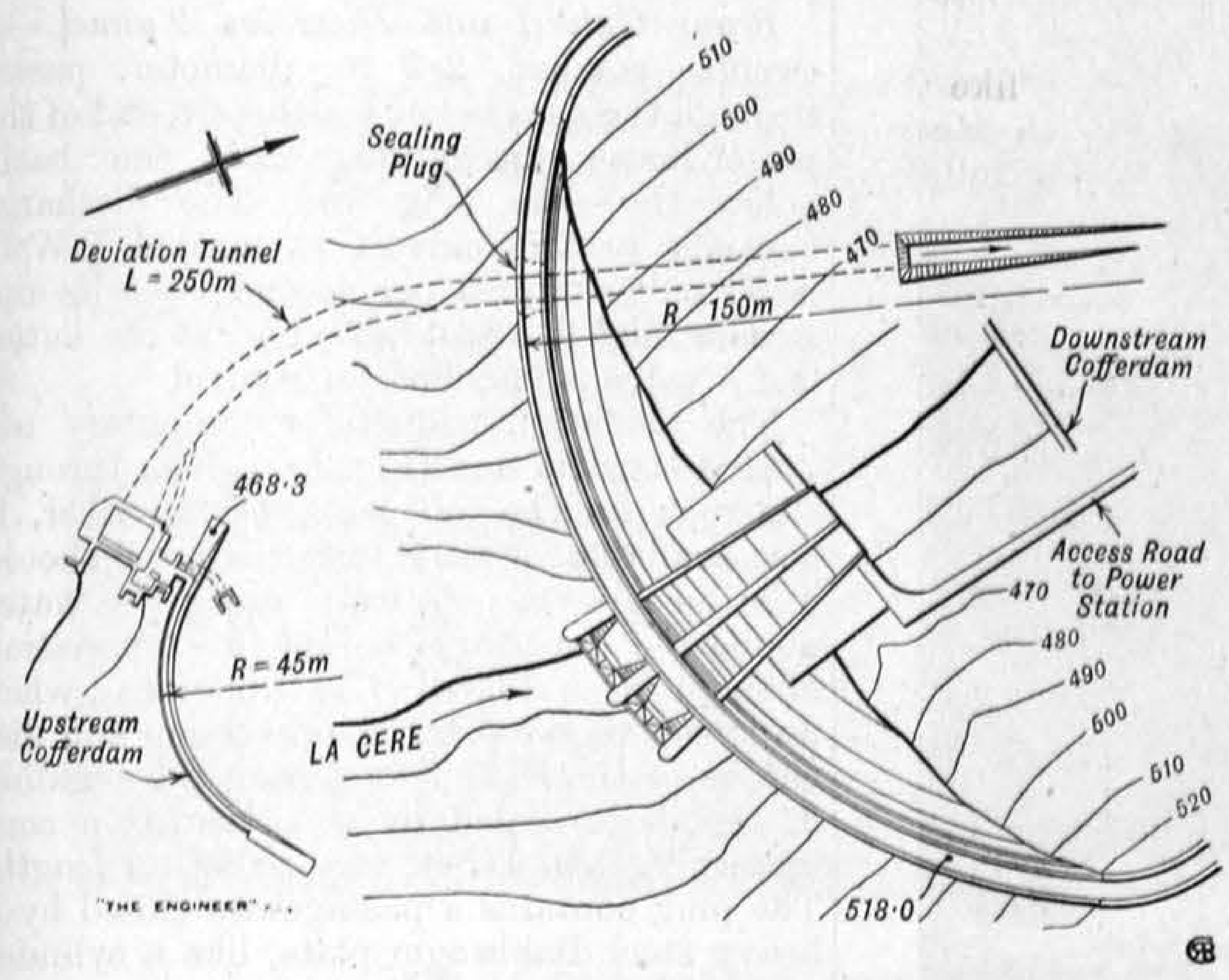
The Reservoir Dam.—When the reservoir project was first studied in 1931 the intention was to construct a gravity dam of normal type. Later, reasons of economy suggested the alternative of a multiple arch structure, a form which was well suited to the cross section of the valley at the selected site. Still later, the great increase of labour costs in France cancelled out the economic advantages of this type of construction, and this consideration, coupled with the vulnerability of relatively thin arch work to aerial attack, resulted in 1939 in the abandonment of the plan.

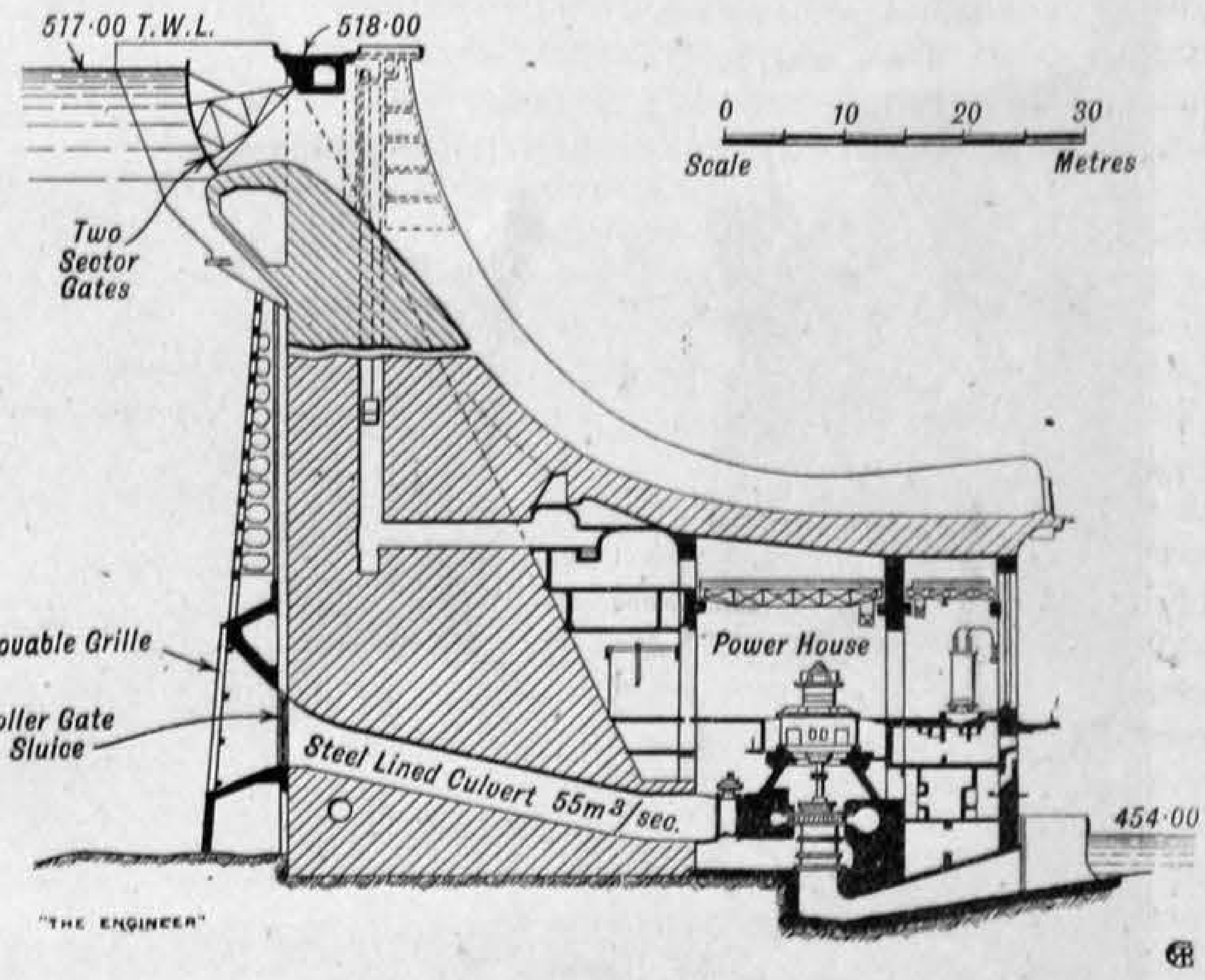
The design finally adopted is a compromise between the pure gravity type of construction and the arch dam, combining in a single block or structure the dam, power-house, and waste weir. It is of the type introduced by Monsieur Coyne, Inspecteur-Général des Ponts et Chaussées. Thicker in section than a pure arch, it is less massive than the true gravity dam, the narrowness of the rock gorge permitting full advantage to be taken of the natural abutments and of the arch effect.

The principal dimensions of the dam structure (Figs. 5 and 6) are :—

Normal T.W.L....	+517 m.
Level of lowest part of foundation	+446 m.
Maximum height	71 m.
Developed length of arch at crest...	270 m.
Radius of upstream face of arch ...	150 m.
Batter of upstream face of dam ...	0 (vertical)
Batter of downstream face of dam	1 in 2 in the symmetrical part, with thickening in the wings
Concrete content	140,000 cub. m.

The vertical joints in the concrete, both plain and recessed, are radial and are spaced about 14 m. apart on the upstream face, dividing the mass of the dam into a series of keyed vertical blocks. The joints were injected, after the concrete had cooled, with cement grout forced in under pressure. Vertical drains are formed in the concrete near the upstream face, and these extend down to the rock foundation of the dam. Inspection galleries are also provided. All the concrete work was vibrated.

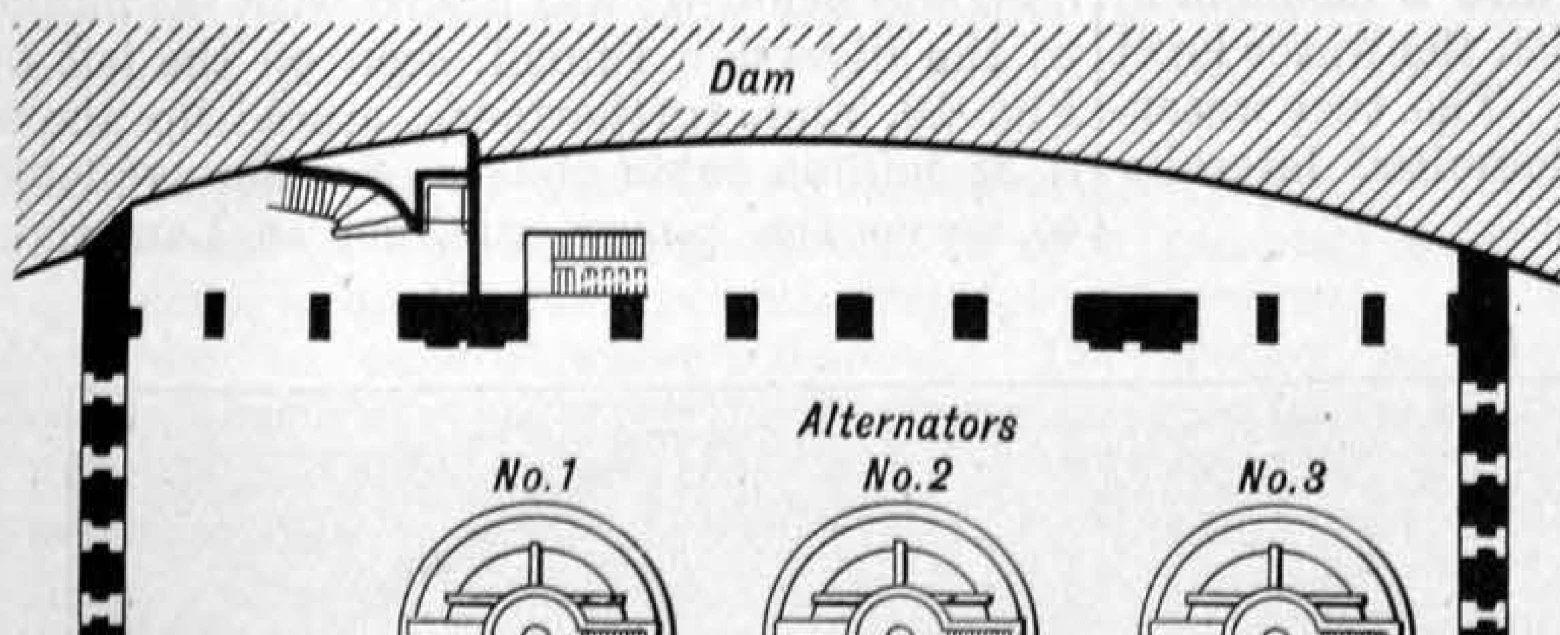


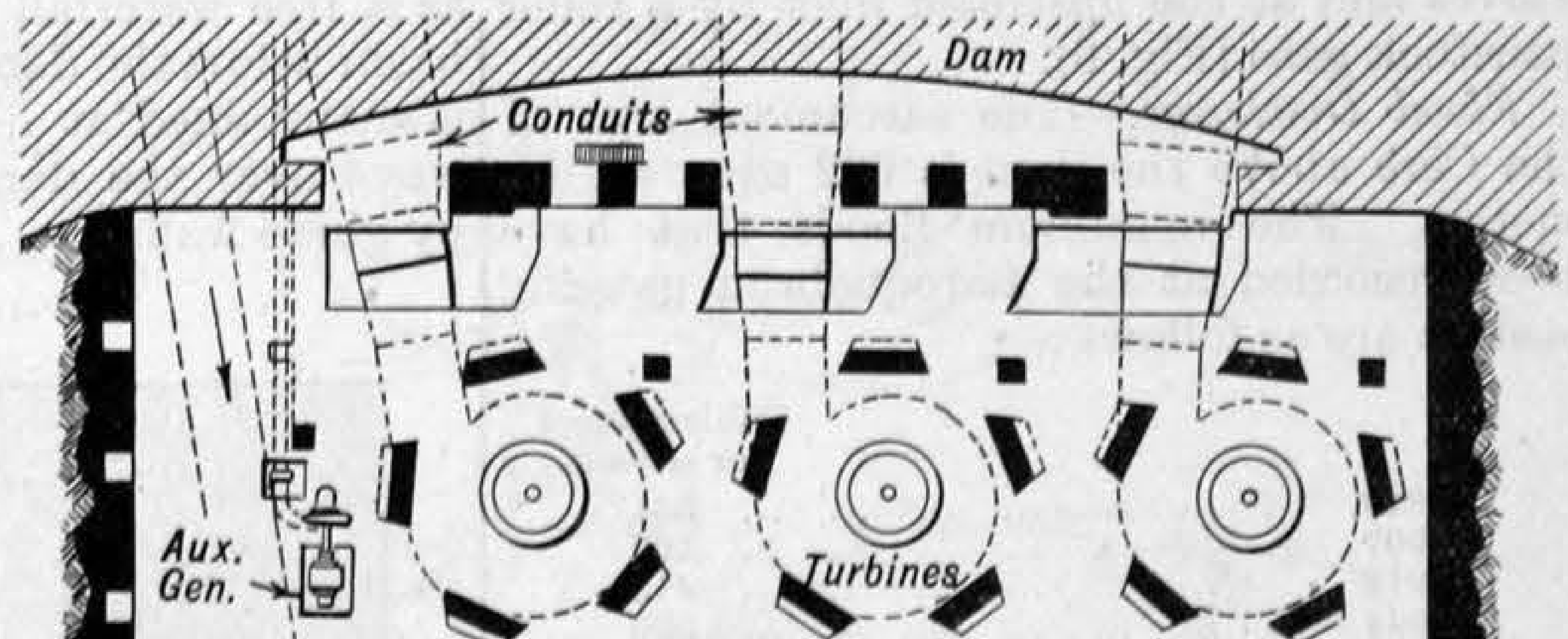


FIGS. 5 AND 6—PLAN AND SECTION OF ST. ETIENNE—CANTALES DAM

Power-House.—The power-house is situated along the toe of the dam below the flood water gates and spillway. The roof (Fig. 6) is of heavily reinforced concrete, 3 m. in thickness, and is formed to serve both as a discharge channel for flood water and to protect the power station against aerial attack. In the latter respect it is similar to the roof in the Genissiat design. In neither case, however, would the protection afforded be adequate to withstand attack by heavy bombs such as were used by the R.A.F. in some of the attacks on German dams during the European War.

The alternator chamber (Figs. 6 and 7) is 50 m. long by 14 m. wide and 23 m. in height. The space between the generator units and the dam face is occupied by various electrical apparatus and the switchgear. Provision has been made for the installation of three units of turbo-electric generators, each of 25,000 kW. Two groups have been installed ;





FIGS. 7 AND 8—SECTIONAL PLANS OF POWER HOUSE

the third will be added later. Each power unit is fed through a circular steel-lined pressure conduit, 4·15 m. in diameter, constructed in the body of the dam and closed at the downstream or turbine end by butterfly valves and at the upstream inlet by a roller penstock gate (Fig. 6).

Flood Discharge.—The catchment area of the Cère above the dam is 692 square kilometers. The maximum floods that have been recorded at the Laroquebrou gauging station are as follows :—

	Cubic metres per second.
1849	561
1907	463
1912	413
1944	500

The flood discharge provisions in the dam are estimated to be capable of evacuating, on any raising of the water level in the reservoir above +517 m., 1200 cubic metres per second, or a discharge equivalent to 1·75 cubic metres per second per square kilometre (1750 litres per second per square kilometre=0·25 cubic feet per second per acre). In case of necessity this discharge can be augmented by passing through the turbines 110 cubic metres per second and through the discharge culvert another 80 cubic metres per second. In total the flood discharge capacity would amount to about 1400 cubic metres per second, equivalent to 2030 litres per second per square kilometre.

The flood water flows over the sill of the dam weir and the roof of the power-house, the latter being formed somewhat like a huge ski jump take-off platform. The water passes through two openings, each about 11·5 m. wide and 7·7 m. in depth below the normal top-water level. These openings are closed by two steel hinged sector gates, seen in the cross section of the dam (Fig. 6). The profile of the waterways across the dam opposite the sector gates has been designed to avoid all cavitation and breaking up the stream wave. The curved waterways flatten out where they cross the power-house and at the ends the discharge is thrown off as a free waterfall falling into a cushioning basin below the dam in which the water level is maintained at +454 m. The two waterways over the dam are delimited laterally by guide walls.

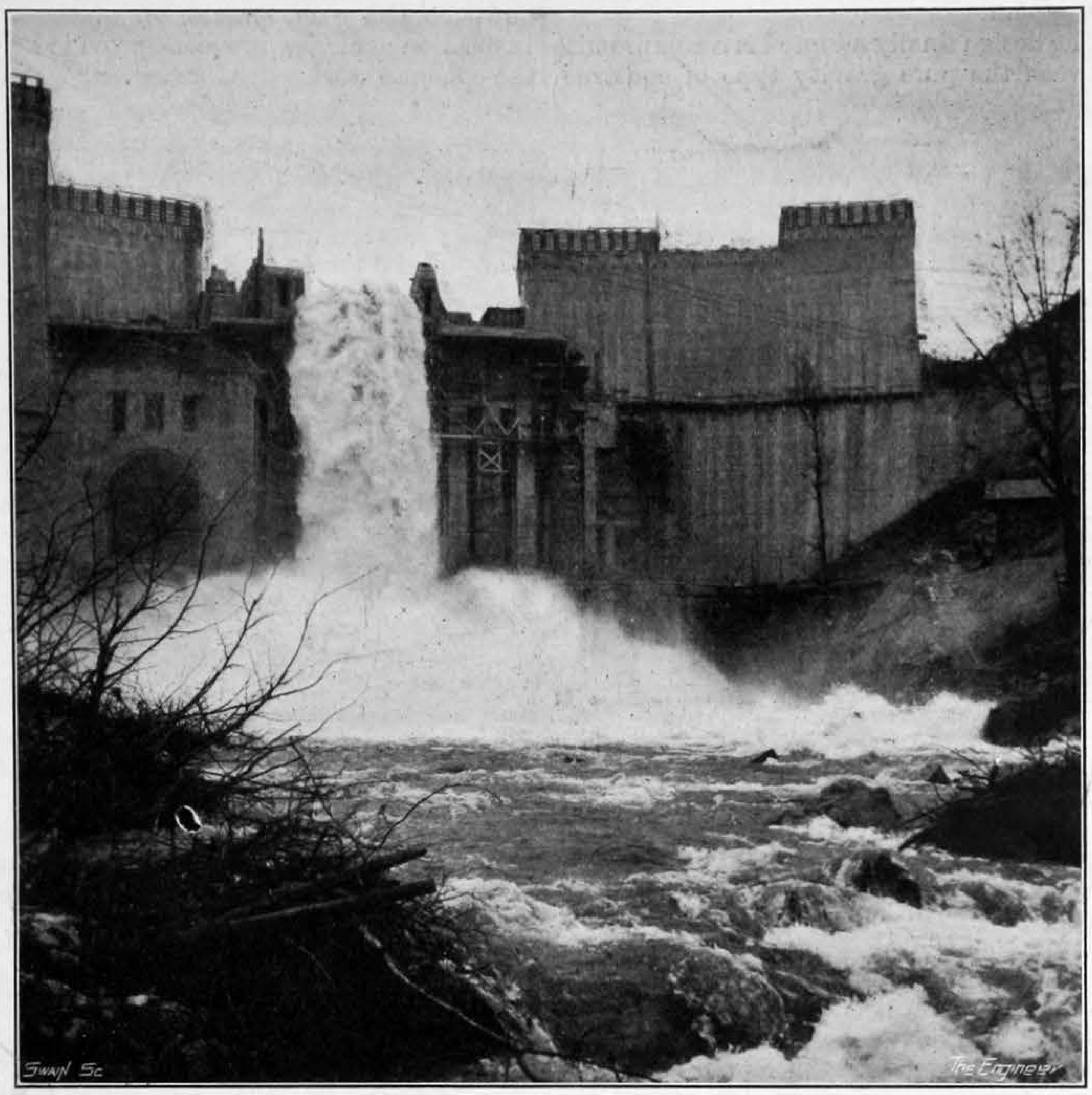


FIG. 9—DAM AND POWER HOUSE FROM DOWNSTREAM DURING FLOOD—1943

The arrangement of the various parts of the dam structures in the manner we have described effected some saving in the time needed for construction. When the power-house had been completed, no difficulty was experienced in passing over its roof flood water, over and above the capacity of the deviation tunnel to which reference is made below, as in the flood of January 15th, 1943. The view reproduced in Fig. 9 shows the incomplete structure from downstream, with flood water flowing over the power-house roof. The erection of the turbo-generator units was in progress at this period, when the dam structure itself was still far from completion.

Scour Culvert and Diversion Tunnel.—A circular conduit, 2·5 m. diameter, passes through the dam below the eastern end of the power-house discharging into the basin below the dam (Fig. 8). The discharge capacity of this culvert at normal T.W.L. is 80 cubic metres per second. At its upstream inlet is a stop gate and at the outlet end a valve is installed for control.

The deviation tunnel for temporary use during construction (Fig. 5), driven through the rock on the left bank of the river, is also available for use if in the future it should ever be necessary to draw down the water above the dam for a complete examination of the upstream face. The tunnel was, when no longer required for the diversion and discharge of the river flow during the building of the dam, sealed by constructing a concrete plug about half-way along its length. The plug contains a passageway closed by a heavy steel diaphragm plate, like a cylinder cover, secured by bolts, which, in case of need, can be cut by firing explosive charges. This operation would restore in part the discharge capacity of the tunnel. The tunnel is 6·25 m. diameter and had a capacity of 250 cubic metres per second. The whole of it is in compact granite.

Temporary Cofferdams. — The upstream cofferdam, seen in the view, Fig. 10, is an arch dam in reinforced concrete. Its height is 17 m., and it is 3·5 m. thick at the base and 1·4 m. thick at the crest, which has a length of 117 m. The cofferdam, whose primary function was the drying out of the dam site below it, was linked with the intake to the diversion tunnel, seen on the left of Fig. 10, and, furthermore, stored up above it 3½ million cubic metres of water available to serve the power stations at Lamativie and Laval-de-Cère in times of drought, until the time when the storage capacity of the main reservoir becomes available.

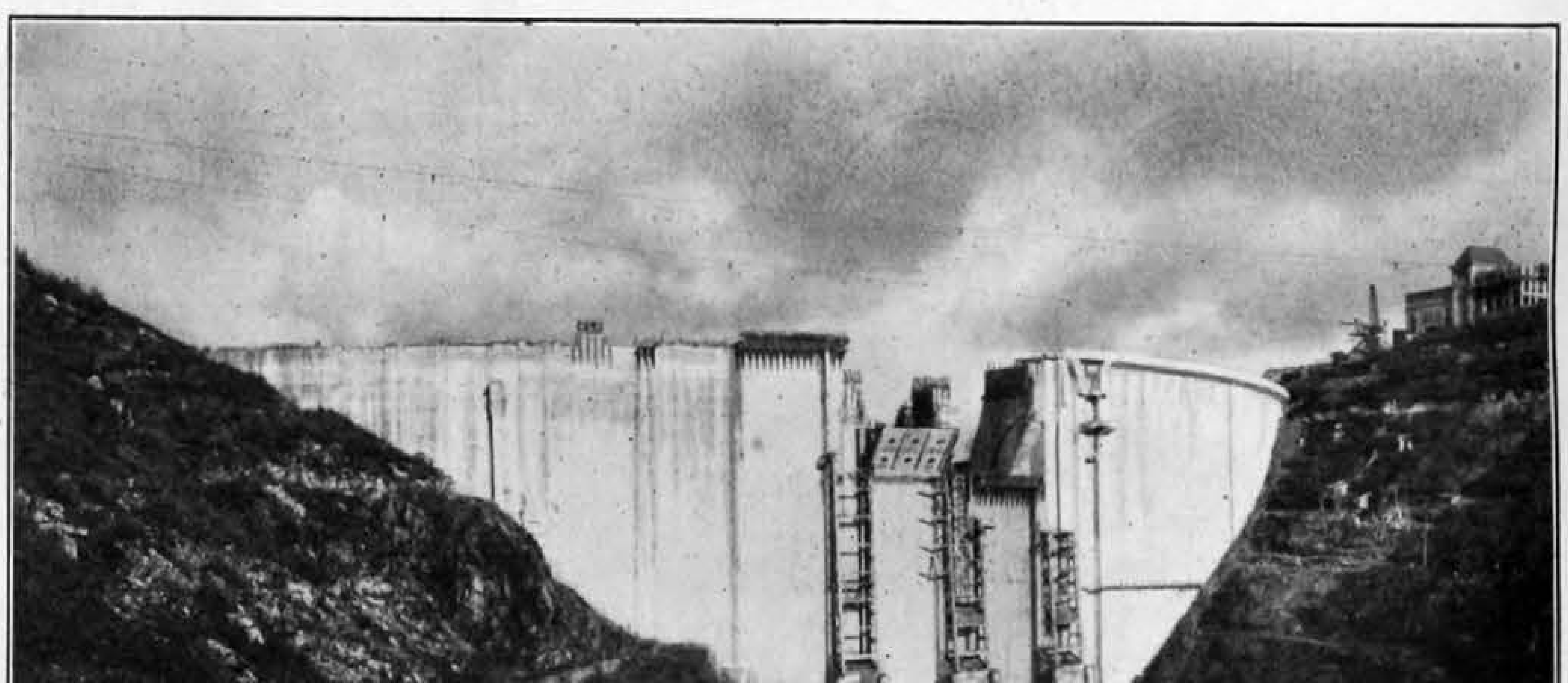


FIG. 10—DAM UNDER CONSTRUCTION AND UPSTREAM COFFERDAM—DECEMBER 1943

The downstream cofferdam (Fig. 11), made in 1938, is a simple straight-line concrete wall, lightly reinforced, having a maximum height of 15 m. and a length of 53 m.

The Compensation Basin.—2 kiloms. below St. Etienne-Cantales, at Nepes, there has been constructed in a contraction of the valley a small barrage about 15 m. in height. This creates below the main dam a compensation basin of about 2,300,000 cubic metres capacity (Fig. 2). This storage permits, without loss of water, of a concentration of six hours of the maximum turbine discharge at the power dam and facilitates the control of the water flowing to the two lower power stations in the valley, in accord with their load requirements. The Nepes barrage comprises (*a*) a central portion, 70 m. long, formed by a multiple arch dam of seven bays in reinforced concrete, 0·40 m. thick, inclined at 45 deg. to the horizontal, the arches being capped by a longitudinal beam or sill which forms the spillway; and (*b*) two earth dams, 54 m. and 50 m. long respectively, in each of which is a thin diaphragm wall of reinforced concrete to ensure water-tightness. The earth dams close against two tower structures forming terminals at either end of the multiple arch dam. Two culverts, each of 2·3 m. diameter, passing through the barrage and closed by butterfly valves, provide for the control of the discharge of the stored water.

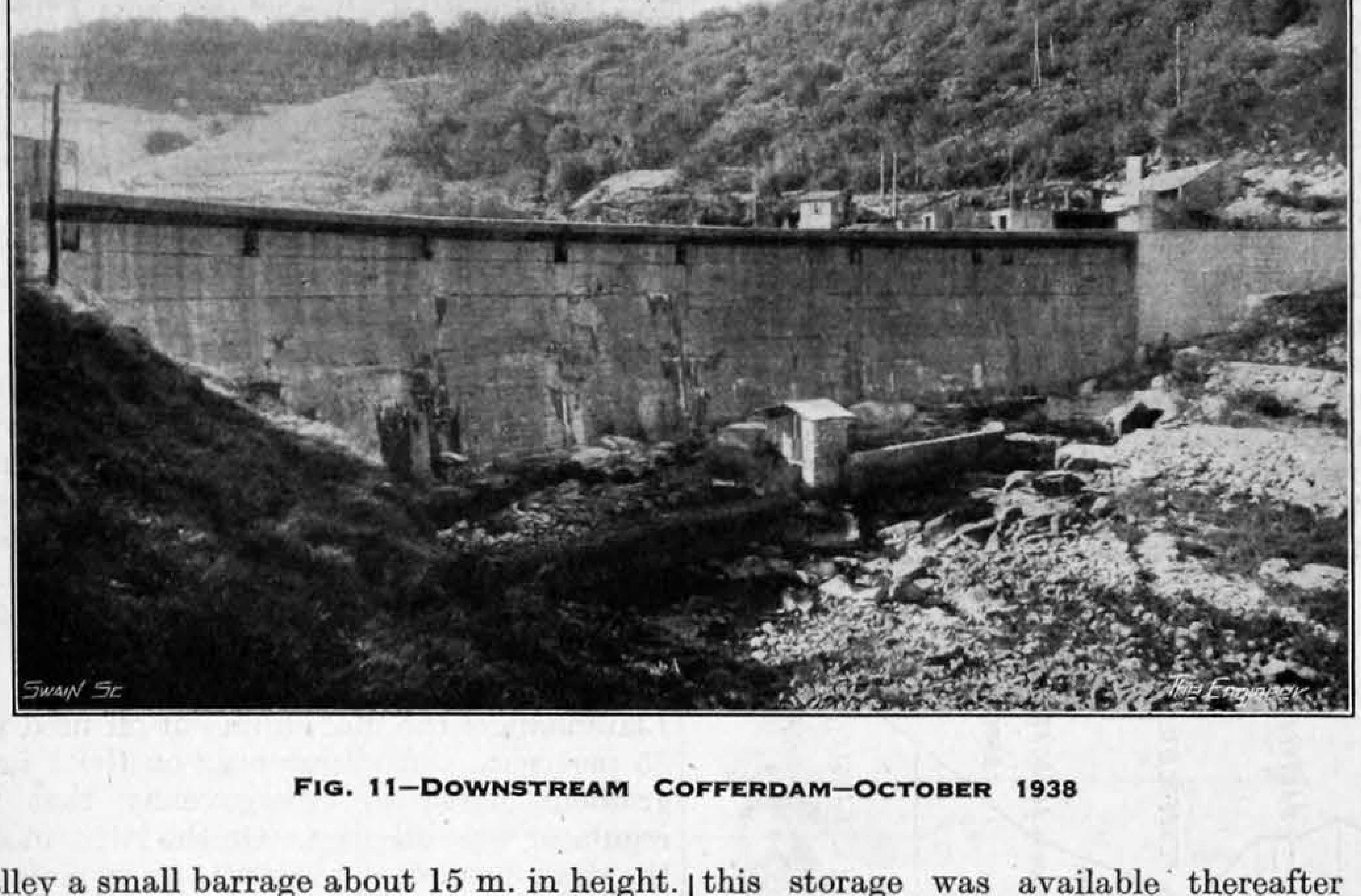


FIG. 11—DOWNSTREAM COFFERDAM—OCTOBER 1938

Roads and Railway.—As we have already mentioned, the encasement in concrete of the steel piers of the Ribeyres railway viaduct was necessary before the filling of the reservoir could be effected. The abutments of the viaduct and also the railway embankments at five separate points, where the impounded water will be in contact, have been protected by concrete revetments. Road deviations necessitated by the flooding of the valley were made, amounting in all to about 15 kiloms. of highway.

Progress of the Works.—The preparatory and temporary works had been completed in 1938. These included the diversion tunnel and the upstream and downstream cofferdams. The excavation on the dam site was begun in November, 1939, and was practically completed during the winter of 1940–41. The concreting of the dam structure and the power-house was started in February, 1941, but the works had not been completed when D-day came in June, 1944. The installation of the first unit of turbo-alternators, begun in July, 1942, was completed in October, 1944, and this unit is now in use. The second unit is expected to be in operation in this summer The dam was so far advanced by January, 1943, as to permit of the storage of water above it, and this storage was available thereafter for regulating the supply to the two power stations lower down the valley. The Nepes barrage, begun in April, 1944, is expected to be completed in November next.

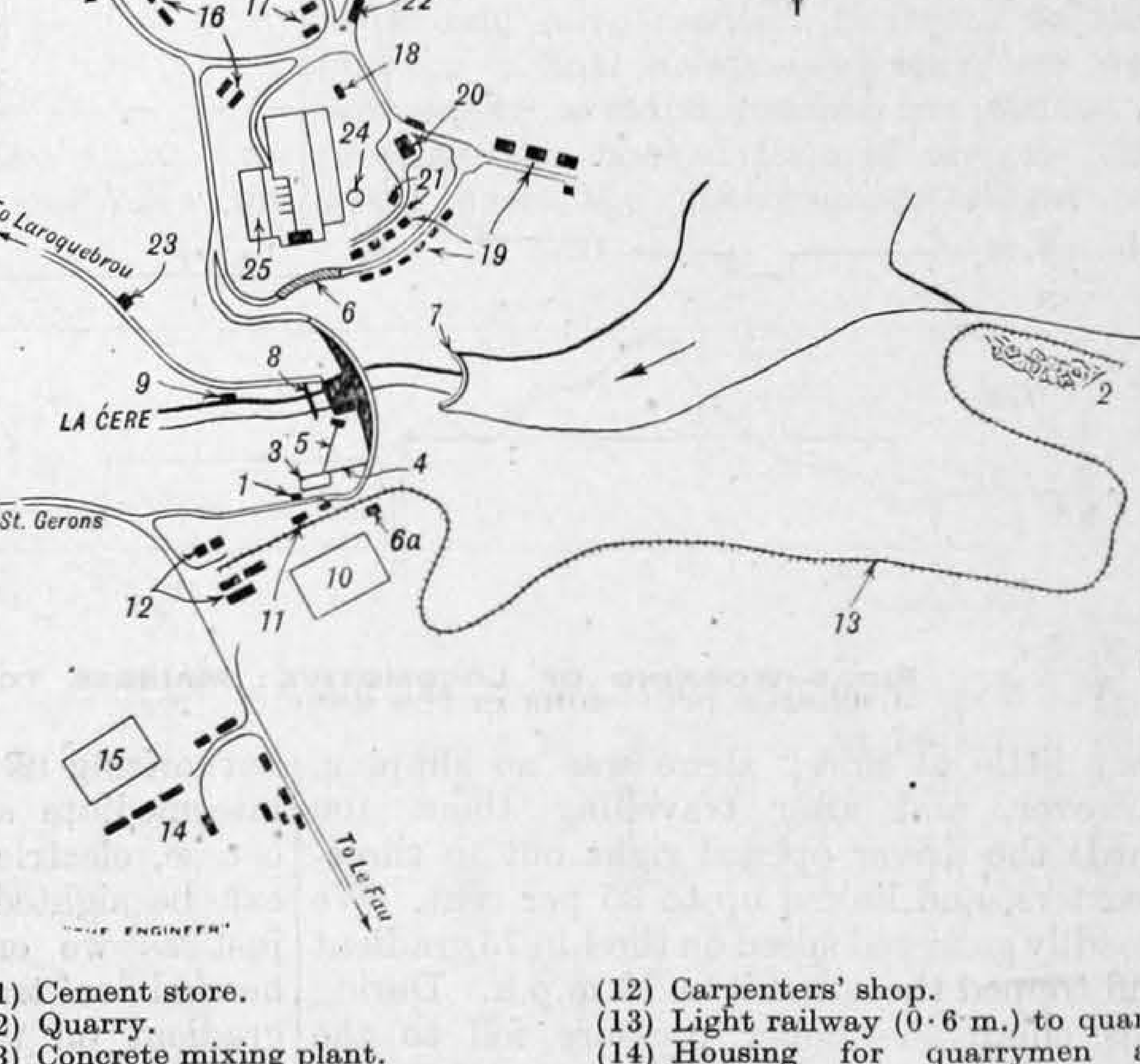
The war mobilisation in 1939 recalled to the colours many of the technical staff and workmen then engaged on the works. The disorder following June, 1940, the enemy occupation of the country, and transport difficulties, all seriously interfered with progress. In 1943 concreting had to be suspended for lack of cement, and in 1944 the supply of steel for reinforcement was interrupted. From May, 1944, to January, 1945, all rail transport ceased, and in June, 1944, the French Forces of Resistance took what remained of road transport vehicles. The supply of labour for the works was throughout the war years a constant difficulty, but towards the end of 1942 many workers, seeking escape from the German forced-labour drives, found refuge in this somewhat isolated valley. On June 7th, 1944, the management of the works was able to mobilise from the labour force then employed, two complete companies of the Resistance. In the subsequent fighting in the *Maquis* and in the region of the *Massif Central*, sixteen men of these companies, including the works director, lost their lives.

Construction Plant.—The plan diagram reproduced in Fig. 12 shows the general disposition of the plant employed on the works. Cement supplies were brought by lorry from Laroquebrou railway station; the quarry, opened out on the left bank of the river above the dam, was connected with the works by a light railway and had a daily output of 150 tons of crushed aggregates; the concrete-mixing plant, also on the left bank, turned out daily 50 cubic metres of concrete for the dam and 10 cubic metres for the power-house. Housing accommodation for the labour force, which normally should have been upwards of 1000 men, was constructed on the hillside between the village of St. Etienne-Cantales and the dam site.

The dam site was spanned by two aerial ropeway transporters used for carrying the mixed concrete and depositing it in the work. The two transport towers on the right bank were movable on a track way; one fixed tower only was constructed on the left bank, and that served both transporters. The fine concrete used in the reinforced concrete work of the power station was delivered from the mixers to the work by a concrete pump, through a pipe line of 170 mm. internal diameter. The concrete skips of the transporters were of 3 cubic metres capacity each.

Conclusion.—The construction of the dam and the creation of the resulting reservoir has a three-fold object:—First, a valuable additional power unit and a reservoir of water power are provided; secondly, this reserve can be used for regulating and maintaining the power output of the two generating stations at Lamativie and Laval-de-Cère, which are capable of a combined output of 250 million kilowatt-hours; and, thirdly, the abundant winter water supply is conserved for use in periods of low flow.

The new dam and power plant will enable the three stations on the River Cère together to produce 475 million kilowatt-hours of electric energy annually.



(1) Cement store.
(2) Quarry.
(3) Concrete mixing plant.
(4) Electric hoppers and track for conveying concrete to aerial ropeway.
(5) Concrete pump.
(6) Track for two movable transporter towers.
(6*a*) Fixed transporter tower.
(7) Upstream cofferdam.
(8) Downstream cofferdam.
(9) Pumping station.
(10) Slab reinforcement shop.
(11) Quarry office.
(12) Carpenters' shop.
(13) Light railway (0·6 m.) to quarry.
(14) Housing for quarrymen and drillers.
(15) Sports ground.
(16) Housing.
(17) Canteens.
(18) Works office.
(19) Housing.
(20) Works hotel.
(21) General office.
(22) Stores.
(23) Gate-keeper's house.
(24) Drinking-water reservoir.
(25) Transformers.

FIG. 12—PLANT EMPLOYED ON WORKS

British Locomotive Working in Wartime

By O. S. NOCK

No. II—*(Continued from page 125, August 17th)*

THE G.W.R. "CASTLE" CLASS 4-6-0s: Part II

Bristol–Shrewsbury

THE way in which a heavy bank, such as the Filton Incline, is attacked from a standing start must necessarily depend upon the prevailing weather conditions, and with greasy rails it might well be imperative to take assistance with a load of 460 tons behind the tender. On the day of my journey with the West to North express, the rails were dry, and in the comparative shelter of the cuttings north of Stapleton Road the wind was not troublesome. It was interesting therefore to see how much reserve of power the "Castles" have in the ascent of a 1 in 75 gradient from a standing start. As usual, the driver used full gear for the first few revolutions, and then linked up to 45 per cent. cut-off. The regulator was opened a very little at first; there was no slipping, however, and after travelling about 100 yards the driver opened right out to three-quarters, and linked up to 35 per cent. We steadily gathered speed on the 1 in 75 gradient and topped the summit at 19 m.p.h. During this climb the boiler pressure fell to the lowest figure noted anywhere on the trip, 210 lb. per square inch.

Approaching Filton Junction we were severely checked by signal, and a similar delay was experienced at Patchway, so that the first 4·4 miles out of Stapleton Road took as much as 12½ min. But we managed to get through without a dead stand, and our descent to the Severn Tunnel promised to be really fast. The road is splendidly aligned for high speed, and, in fact, an engine of the "Castle" class has been timed at 98 m.p.h. on this section. On clearing Patchway advanced starting signal, "Usk Castle" was given 17 per cent. cut-off and the jockey valve, and on a gradient descending at 1 in 90–68, speed rose from 35 to 75 m.p.h. in 2 miles; but then, unfortunately, adverse signals were again encountered, and we were brought down to walking pace at the entrance to the Severn Tunnel. To assist in the operation of the heavy war traffic through the tunnel, intermediate signals have been installed at approximately 1 mile from the entrance. Previously the entire length of the tunnel was included in a block section, 4·7 miles long, but under the new arrangement a train is allowed to enter the tunnel and proceed as far as the intermediate signals, even though the previous train is not clear at the far end. The preceding train must, of course, have passed the intermediate signals before a second train is allowed to enter the tunnel.

As we approached the east entrance, the distant signal located there was "On," authorising us to proceed only as far as the intermediate signals. These latter are, of course, electric colour lights, and ordinarily can be sighted from a long distance; but just as we entered the tunnel a double-headed coal train was ascending the 1 in 100 gradient on the up road, and its passage completely filled the tunnel with smoke. Visibility was just nil. There was nothing for it but to feel our way, at about 10 m.p.h., till we received the audible signal from the automatic train control apparatus relating to the repeater of the intermediate home signal. Thus we spent exactly 6 min. in covering the first mile of the tunnel, eventually to receive the "clear" indication, just before we actually sighted the green light itself through the murk. Both the repeater and the home signal are equipped with A.T.C. ramps.

As a result of this enforced caution, we had only a mile of 1 in 100 descent in which to get a run at the heavy gradient leading up to the Monmouthshire end of the tunnel, and although we attained 50 m.p.h., there is a great difference between this and the 75 m.p.h. which we could have been doing with a clear road. On the 1 in 90 ascent the engine slipped once or twice on the wet rails, so we took as much as 37¼ min. to cover the 14·9 miles from Stapleton Road to Severn Tunnel Junction, 9 min. having been lost from Filton alone. This was particularly unfortunate, because drivers can usually get some time in hand here to offset the severe uphill timing from Maindee. On the level stretch from Severn Tunnel Junction speed rose to 56 m.p.h., after which came a further signal check. But once over the Maindee junctions, where we turned from the South Wales main line and headed north, we got a really clear road, and Driver Edwards was able to regain a substantial amount of the lost time. At Maindee North Junction, passed at 15 m.p.h., we were 39½ min. late.

The working of the locomotive during the ascent into the Black Mountains is illustrated in the diagram Fig. 6. The road itself is heavy, but running conditions between Pontypool Road and the summit of Llanvihangel are made worse by the 50 m.p.h. restriction at the Penpergwm curve. Similarly, the 40 m.p.h. speed restriction at Caerleon precludes any possibility of taking a "run" at the bank from Ponthir. On the ascents both to Pontypool Road and to Llanvihangel the maximum cut-off used was 35 per cent., but it was only on the 1 in 82 gradient north of Abergavenny that the regulator was full open. On the latter incline the draw-bar horsepower was approximately 1000, at 20½ m.p.h., rising to 1040 as the engine accelerated to 24 m.p.h. on the 1 in 95 gradient leading to the summit. The indicated horsepower was probably in the region of 1250. Boiler pressure was steadily maintained at 220 lb. to 225 lb. per square inch during both these ascents, and the water consumption between Maindee North Junction and Llanvihangel was 1400 gallons—62 gallons per mile.

The 20-mile stretch of line between Llanvihangel summit and Hereford begins with 6½ miles of steep descent. No high speed can, however, be maintained, owing to the curves; as at Penpergwm, a reduction is required at the foot of the incline. The succeeding length of 9 miles is gradually rising, while the final descent into Hereford includes a 20 m.p.h. slack over Red Hill Junction. In view of these hindrances no better time than 24 min. could be made over this 20-mile stretch, but we nevertheless covered the 33·5 miles from Pontypool Road to Hereford in 46¾ min., 3¼ min. less than schedule time. By now we had got down to some very indifferent coal; its swelling qualities seemed well below standard, and the fire was tending to form cavities in places. But by judicious firing, and a brief use of the blower, Taylor kept a full head of steam—very necessary, for while we were standing at Hereford Edwards said he was going to try to make Shrewsbury in 65 min. This was the pre-war timing over this 51-mile stretch and 7 min. less than the present allowance.

In crossing the Herefordshire plain, and entering the hill country beyond Ludlow, the line rises steadily for 29 miles out of Hereford; there are several undulations, some on gradients as steep as 1 in 100, but none long enough to have any appreciable effect. The average inclination is about 1 in 650. Edwards used three-quarter regulator and 17 per cent. cut-off throughout this length, and we covered the 29 miles in 38½ min. from the start, though our running average was affected by a slack to 45 m.p.h. through Leominster. The economical working of the engine on this stretch was reflected by the water consumption of only 25 gallons per

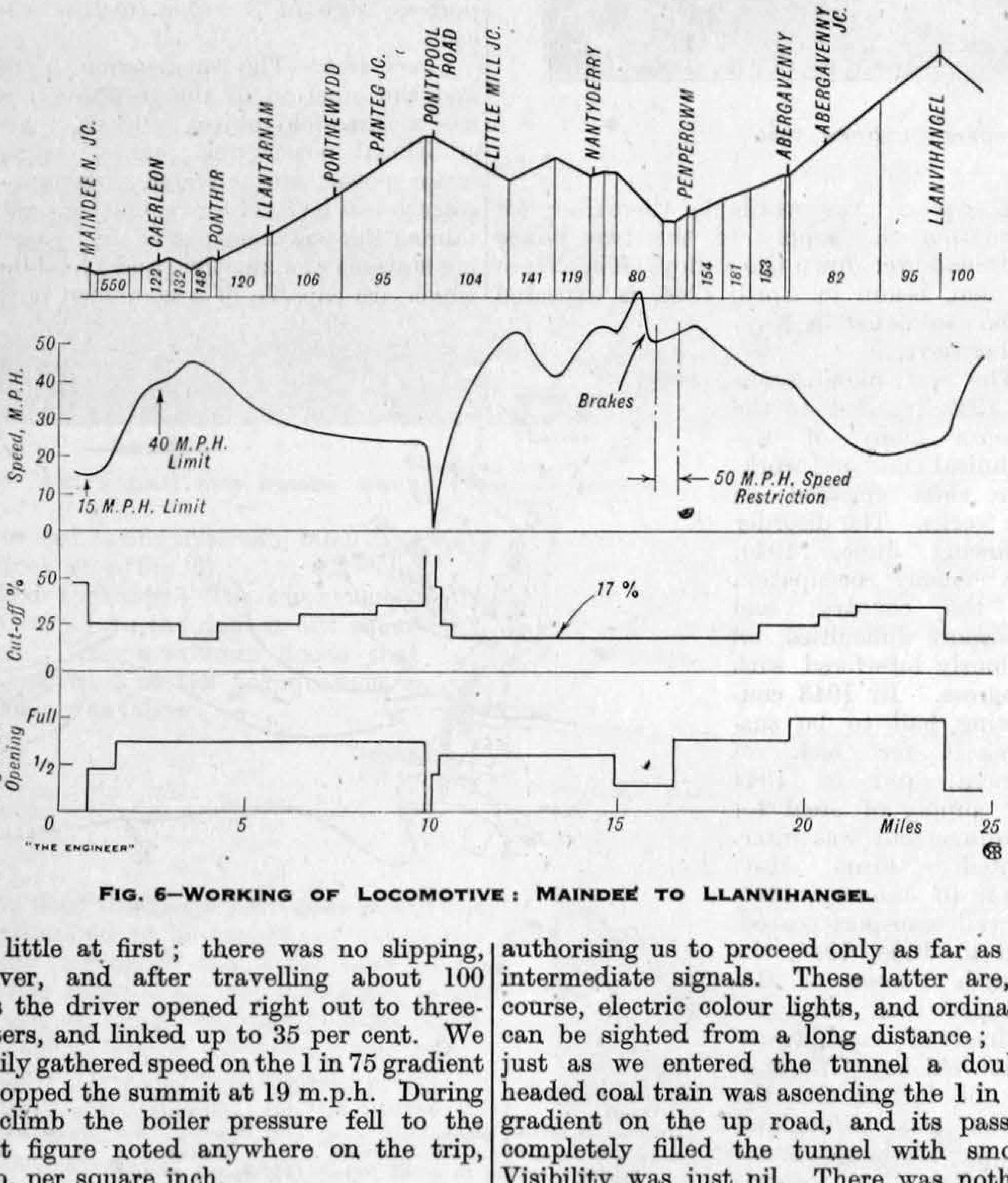


Fig. 6—Working of Locomotive: Maindee to Llanvihangel

mile, though the net running average speed of 52 m.p.h. demanded a continuous output of 900 D.H.P.

The final climb of the journey, from Ludlow to Church Stretton, is shown in the diagram Fig. 7. The use of 17 per cent. cut-off was continued till beyond Craven Arms, but no more than 25 per cent was needed on the heaviest section. The work of the engine here was very fine, particularly coming at the conclusion of a 216-mile run, and still the boiler pressure was fully maintained. At Church Stretton the fire-door was closed and cut-off shortened to 15 per cent. for a fast run down to Shrewsbury. The steady 33 m.p.h. which "Usk Castle" had sustained amid the beautiful hill country quickly changed as we swept down to the valley of the Severn. Leebotwood was passed at 68 m.p.h., Dorrington at 76, but then the regulator was practically closed and the speed drifted down. By Condover (46·7 miles), passed in just 61 min., it was evident we were coming very close to the driver's estimated time, but adverse signals at Bayston Hill compelled a slowing to 20 m.p.h. and ruined our chances. Actually we reached Shrewsbury in 68¾ min. from Hereford, though with a clear run in we should probably have made the trip in 66 min. or a shade less. Despite this check we had recovered more than 8 min. of lost time from passing Maindee.

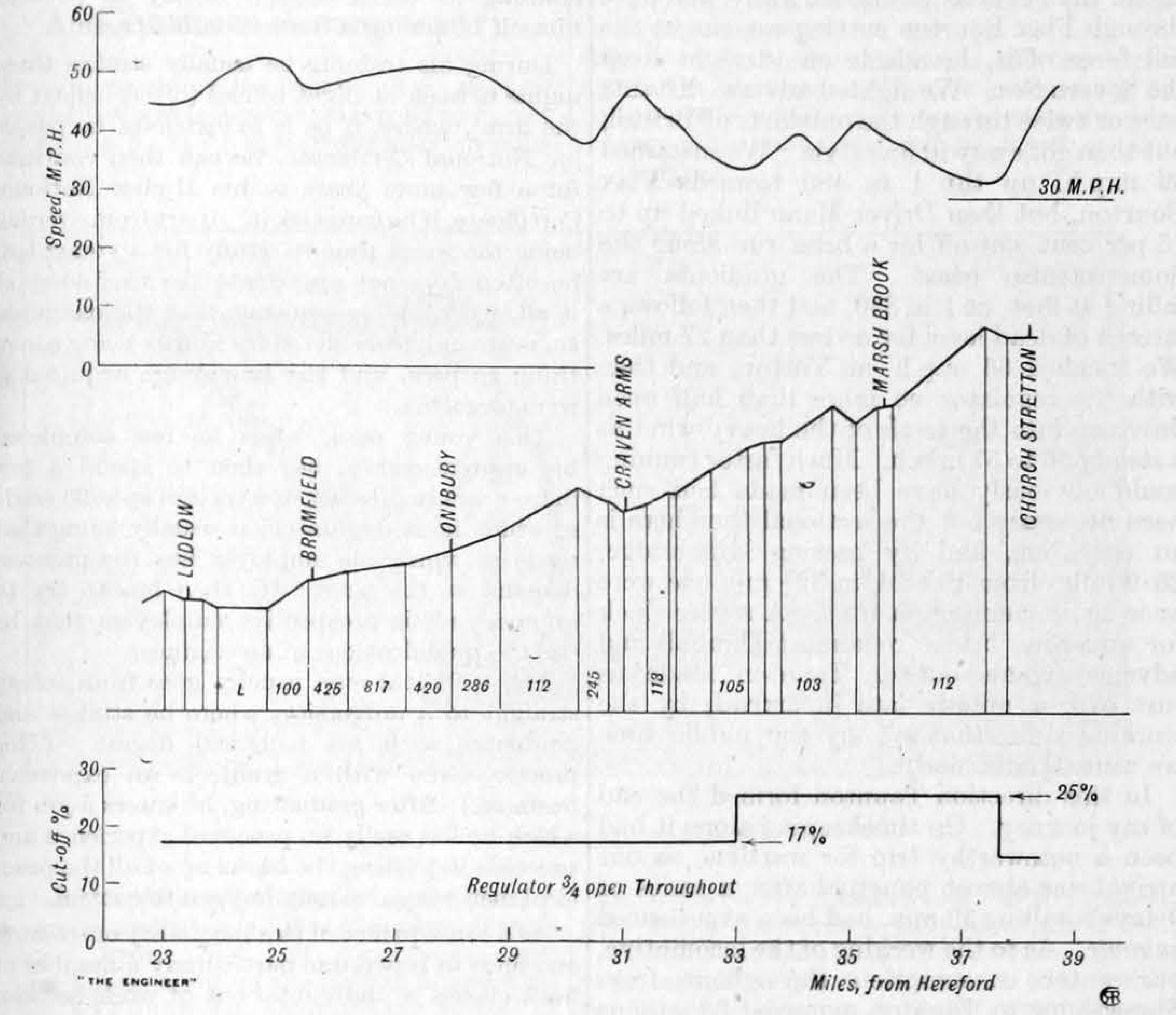


FIG. 7—WORKING OF LOCOMOTIVE: LUDLOW TO CHURCH STRETTON

On arrival at Shrewsbury Inspector Davies and I made a careful estimate of the amount of coal left on the tender, and this indicated a total consumption of some 3½ tons, which is equivalent to about 35 lb. per train-mile. Our total water consumption was 7800 gallons, that is 36 gallons per mile. The coal per train-mile was roughly equal to that burnt in the early days of the "Castle" class in working maximum tonnage loads on the "Cornish Riviera Express." The firing rate was, of course considerably less on this war-time journey, and equal to about 45 lb. per square foot of grate area per hour running time, against an average of about 66 lb. on the pre-war "Limited"; with "Usk Castle" the maximum rate was about 80 lb. on the heaviest gradients, whereas on peacetime schedules these engines were sometimes fired at the rate of 90 lb. per square foot of grate area per hour, for 60 or 70 miles at a stretch. Taken all in all, the performance of "Usk Castle" on coal considerably below pre-war quality, can be considered as most satisfactory.

SHREWSBURY–BRISTOL

On the return trip with the 12.10 p.m. express from Shrewsbury we had a Newton Abbot engine, No. 5072, "Hurricane," with Driver D. J. Mann and Fireman C. Satchell in charge. Locomotive Inspector Harris, of Wolverhampton, accompanied us as far as Bristol, and he again was somewhat concerned about the coal: "Makes too much smoke, and does not swell enough," was his comment, even before we started. On the southbound run the heaviest work of the whole journey comes right at the start, in the 12-mile climb to Church Stretton. Here, one or two bad slips, or some undue pounding might easily pull the fire to pieces, and lead to a prolonged spell of bad steaming. The load was again heavy, 450 tons behind the tender, and the timing of this train over the 51 miles from Shrewsbury to Hereford is only 3 min. more than that of pre-war days, 68 min., as against 65 min. The advertised departure time is, however, 12·5 p.m., and if station work is completed, advantage can be taken of this extra time on the run to Hereford. We were signalled away at 12.6 p.m., but unfortunately the road was not clear, and we were stopped by adverse signals at Sutton Bridge Junction, ¾ mile out of Shrewsbury.

The ascent to Church Stretton is shown in the diagram, Fig. 8. Driver Mann made frequent changes in the cut-off, and got some excellent work out of the engine, especially considering that this was from a cold start. In sustaining 28 m.p.h. on the 1 in 100 gradient, the draw-bar horsepower was approximately 1150. Satchell had begun with a relatively thin fire, but built up rapidly as we made the ascent; pressure was steadily maintained at 220 lb. per square inch, and when we passed the summit the fire was in much the same shape as that used by Fireman Taylor on "Usk Castle." The downhill run from Church Stretton towards Hereford requires a modest haulage effort from the locomotive, but the winding nature of the road calls for constant changes in the controls if the riding of the train is to be comfortable. For most of the distance "Hurricane" was linked up to 17 per cent. cut-off, except on the steep descent from Church Stretton, where Mann used 35 per cent. in conjunction with the jockey valve. On what is normally the fastest stretch, from Craven Arms to Ludlow, we were checked by signal, and so did not exceed 70 m.p.h. The usual slack to 50 m.p.h. through Ludlow and a temporary restriction to 50 m.p.h. through Leominster, also made this section less favourable than it might appear from the gradients alone. Over the 24 miles from Bromfield to Shelwick Junction, where we averaged 55 m.p.h., the water consumption was 27 gallons per mile.

In spite of the signal stop at Sutton Bridge Junction, and the further signal check at Onibury, which caused a slowing to 35 m.p.h., we should have reached Hereford on time but for a final delay. Actually, we were brought to a stand outside the station at precisely our booked time of arrival. The speed over the intermediate stages was

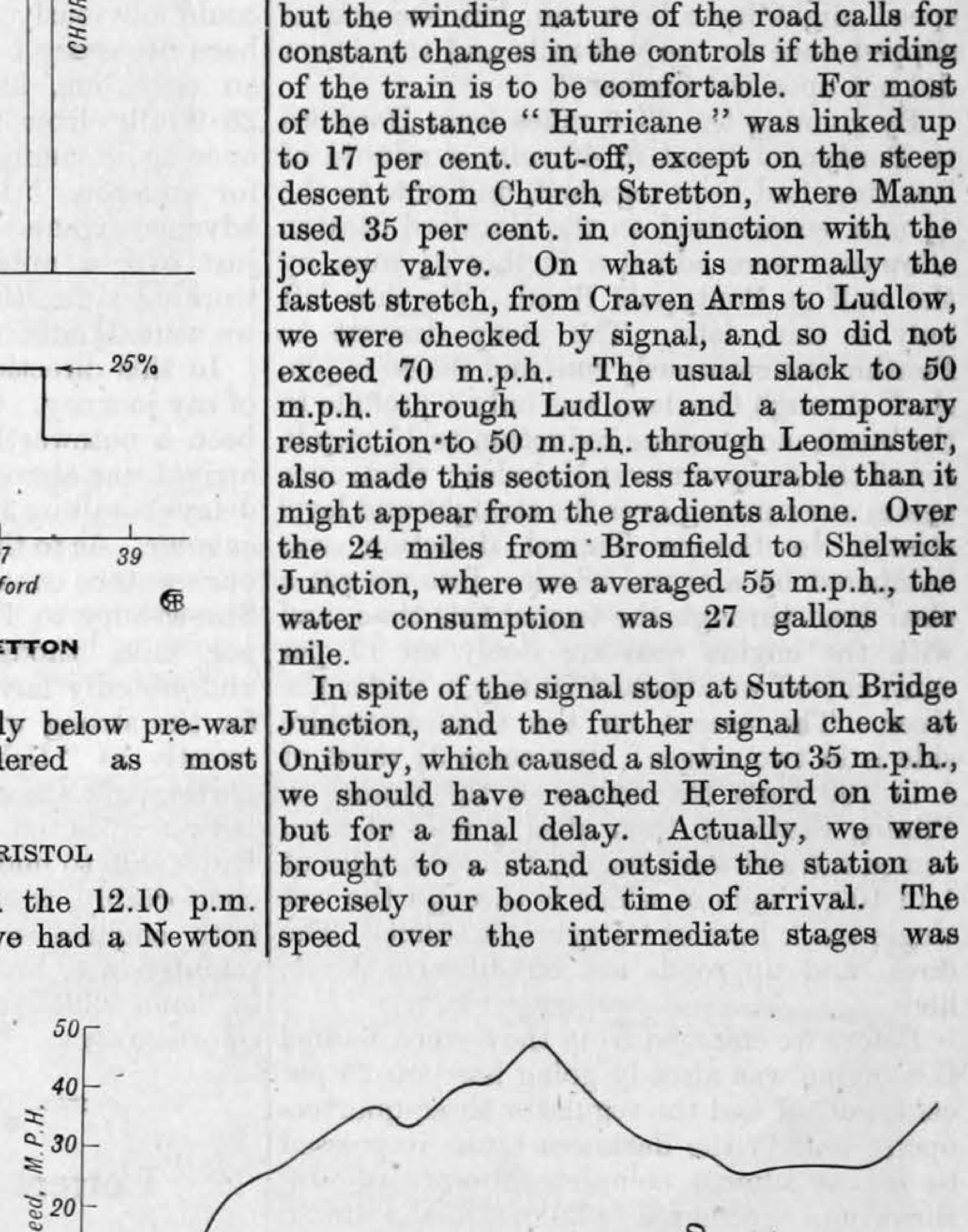


FIG. 8—WORKING OF LOCOMOTIVE: SHREWSBURY TO CHURCH STRETTON

equivalent to a 67-min. run from Shrewsbury to Hereford.

The delay outside Hereford was a lengthy one, and it was not until 1.31 p.m.—13 min. late—that we drew up in the station. To the credit of all concerned, however, the whole of this loss had been recovered before we approached Bristol. From the locomotive point of view, the task became easier, as a small portion from South Wales was detached from the rear of the train, reducing the load to 385 tons ; on the other hand, we ran into some rough weather. The wind was rising, clouds were enveloping the summits of the Black Mountains, and it was raining hard before we began the ascent to Llanvihangel. But even so, the 385-ton load did not call for such strenuous working as previously, and it was only on the last 1½ miles of the climb at 1 in 100 that cut-off was advanced as much as 30 per cent. From an initial speed of 60 m.p.h. this incline of 6½ miles, 3½ miles varying between 1 in 170 and 1 in 216, and the rest at 1 in 100, brought us down to exactly 30 m.p.h. at the summit. A higher speed might have been run, but the engine slipped once on the wet rails and the driver did not open out further.

By running the 33·5 miles from Hereford to Pontypool Road in 46 min. a minute of lost time had been regained, and now to the 4½ min. economised on the Hereford Station allowance were added a further 3½ min. by the staff at Pontypool Road. We thus left only 4 min. late. The steep descent to Ponthir was cautiously run, and the 40 m.p.h. slack through Caerleon was only a prelude to the much more severe reduction to 15 m.p.h. round the sharp curve at Maindee ; then, once again, our running over the straight and level stretch to Severn Tunnel Junction was hampered by a signal check. But we got a clear road through the tunnel this time, and with the engine coasting freely on 17 per cent. cut-off we attained 70 m.p.h. under the river. The ascent on the Gloucestershire side is in two stages : first come 3¼ miles of 1 in 100 from the centre of the tunnel to Pilning Station ; then after ¾ mile of level comes the awkward second bank—3 miles at 1 in 100, 1 mile of which is through the wet single-track bore of Cattybrook tunnel. The down and up roads are on different levels here.

Before we emerged from the Severn Tunnel the engine was already going hard on 28 per cent. cut-off and the regulator three-quarters open ; but in the darkness I was impressed to see an almost complete absence of fire-throwing. Speed fell to 28 m.p.h. at Pilning, though it recovered to 39 m.p.h. on the short level stretch even though the gear was linked up to 25 per cent. On the second bank cut-off was advanced to 32 per cent.; we climbed steadily through the tunnel and were approaching the summit at 28 m.p.h. when adverse signals were sighted once again. We had just won back to time, but this slack at Patchway proved only the beginning of a prolonged series of delays, through which our arrival at Bristol, Temple Meads Station, was 17 min. late.

Bristol-Taunton

A typical wartime crowd was waiting on the platform ; so many passengers joined the train, indeed, that the gross load behind the tender was nearer 390 than 385 tons on the continuation of our run. But in spite of this number of travellers the station staff cut their allowance of 23 min. by more than half, and saw us away only 4 min. late. The cleaners who had come over from the running sheds to get coal forward did their work with zest, but as on the northbound trip a goodly proportion of the fuel they unearthed was little better than slack. Inspector Harris, taking his leave, had no words bad enough for it ! So far, however, Satchell had never less than 220 lb. per square inch showing on the gauge, though on arrival at Bristol there were signs of clinker on the bars. On the rest of the journey we had the pleasure of Inspector Davies's company.

The rain had now ceased, but the wind was higher than ever as we started away, and once through Flax Bourton cutting we caught the full force of it, broadside on, straight from the Severn Sea. We sighted adverse distants once or twice through the outskirts of Bristol, but then got away in fine style. We sustained 39 m.p.h. up the 1 in 180 towards Flax Bourton, but then Driver Mann linked up to 15 per cent. cut-off for a brisk run along the Somersetshire coast. The gradients are falling at first, at 1 in 330, and then follows a stretch of dead level for no less than 27 miles. We touched 66 m.p.h. at Yatton, and then with the regulator no more than half open drove on into the teeth of the heavy wind at a steady 56 to 57 m.p.h. Much faster running could obviously have been made had such been necessary but the sectional time here is an easy one, and by passing Highbridge, 26·9 miles from Bristol, in 32¾ min. we were once again running on time. A severe slack for underline bridge repairs at Dunball and adverse signals outside Taunton made us just over a minute late in arrival, by the working time, that is ; by the public time we were 3½ min. early.

In this direction Taunton formed the end of my journey. On timekeeping alone it had been a noteworthy trip for wartime, as our arrival was almost punctual after a series of delays totalling 39 min. had been experienced *en route*. As to the working of the locomotive, our water consumption throughout from Shrewsbury to Taunton averaged 33 gallons per mile, though, of course, this would undoubtedly have been less had it not been for the strong wind. "Hurricane" rode as sweetly as "Usk Castle"; her action was particularly smooth on the winding stretches between Church Stretton and Maindee, and I was able to make my numerous notes quite comfortably while standing. The work of both engines revealed a high standard of maintenance, and altogether the round trip of some 385 miles left the happiest of impressions.

Letters to the Editor

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

THE TRAINING OF ENGINEERS

Sir,—You have recently published a number of letters under the heading "Who's Fault?" all of which throw some different aspect on the training of engineers ; however, I feel that none of them get to what I consider is the seat of the trouble.

Wherever one goes in the engineering industry, it is noticed that there is a vast difference in degree of engineering education that the various individuals possess. It is usually found that there are two classes of engineer : (*a*) the person with the most excellent practical experience and little theoretical knowledge ; (*b*) the person with the highest technical qualifications and little or no practical experience. There are, of course, intermediary grades between these two extremes.

It is my considered opinion that this rather inefficient and unsatisfactory state of affairs could be remedied to the betterment of the engineering industry and our whole community by the development of a scheme whereby engineers would be trained in such a way that they receive both the practical and theoretical knowledge, so building up a strong engineering community.

Let us first consider the causes ; the practical man is usually the victim of circumstance, his lack of technical knowledge being forced on him by his parents' lack of money. He usually starts work straight from school as an apprentice, and during the four or five years of his training he earns enough money to prevent himself becoming a burden on his parents.

During his training he usually studies three nights a week at night school (often helped by the firm), where, if he is industrious, he passes his National Certificate, he can then continue for a few more years to his Higher National Certificate, if he can stick it. Apart from evening being the worst time to study for a young lad, he often does not appreciate the usefulness of it all, with the consequence that the examinations are only considered by him as being something to pass, and the knowledge acquired is soon forgotten.

This young man, when he has completed his apprenticeship, has then to spend a few more years improving in a certain specific trade in which he finds himself, it usually being that trade in which his employer has the greatest demand at the time. He then has to try to impress on his prospective employers that he has the qualifications of an engineer.

The technical man usually goes from school straight to a university, where he studies and graduates with his technical degree. (This process, even with a grant, is an expensive business.) After graduating, he enters a job for which he has really no practical experience and succeeds in putting the backs up of all the practical men whom he may happen to control.

As a consequence of this inequality of training one finds in peacetime particularly a number of both classes of individual out of work because both have qualifications which are not enough without those possessed by the other.

I maintain that all engineers (those persons desirous of bettering themselves by seeking administrative posts) should receive a course of training whereby they would graduate as universally recognised fully qualified engineers at the age of twenty-five.

The course of training should consist of a thorough four years' practical apprenticeship (on similar lines to those at present undertaken), commenced at the age of seventeen years, two years should then be spent in the drawing-office and then two years at a university. The student should be given the preliminary education up to, say, Inter B.Sc. standard before entering the university, so that he could graduate in two years satisfactorily ; this will also enable him to prove his worth first.

Between seventeen and twenty-one the youngster gets used to working hard for his living and has the opportunity of studying working life ; during this period he should be given an insight into the meaning and scope of the employers' federation, trades unions, and other interesting features of the industrial field, which will help him in his after life.

Between twenty-one and twenty-five he is best able to assimilate knowledge and the drawing-office experience will go well in harmony with the university course.

I further suggest that proper scales of pay be laid down for this training right up to the age of twenty-five years. He should also be receiving at least £4 per week during his free university training. This could be met by a fund levied in some way on all the engineering firms in the country, since all firms will eventually benefit by the scheme, or by some other suitable means.

I think that an administrative degree might also be promulgated somewhat on the lines of the syllabus of the Institute of Administrative Engineers.

In this way the engineering industry would soon be in possession of really fully qualified engineers, who could easily be recognised and assessed by prospective employers.

T. HAYDN WHITEHOUSE.

Englefield Green, August 19th.

A Concrete Compactor

IN order to obtain the best resultant strength from the low water/cement ratio road concretes, such as the 5 : 2½ : 1 mix, frequently specified

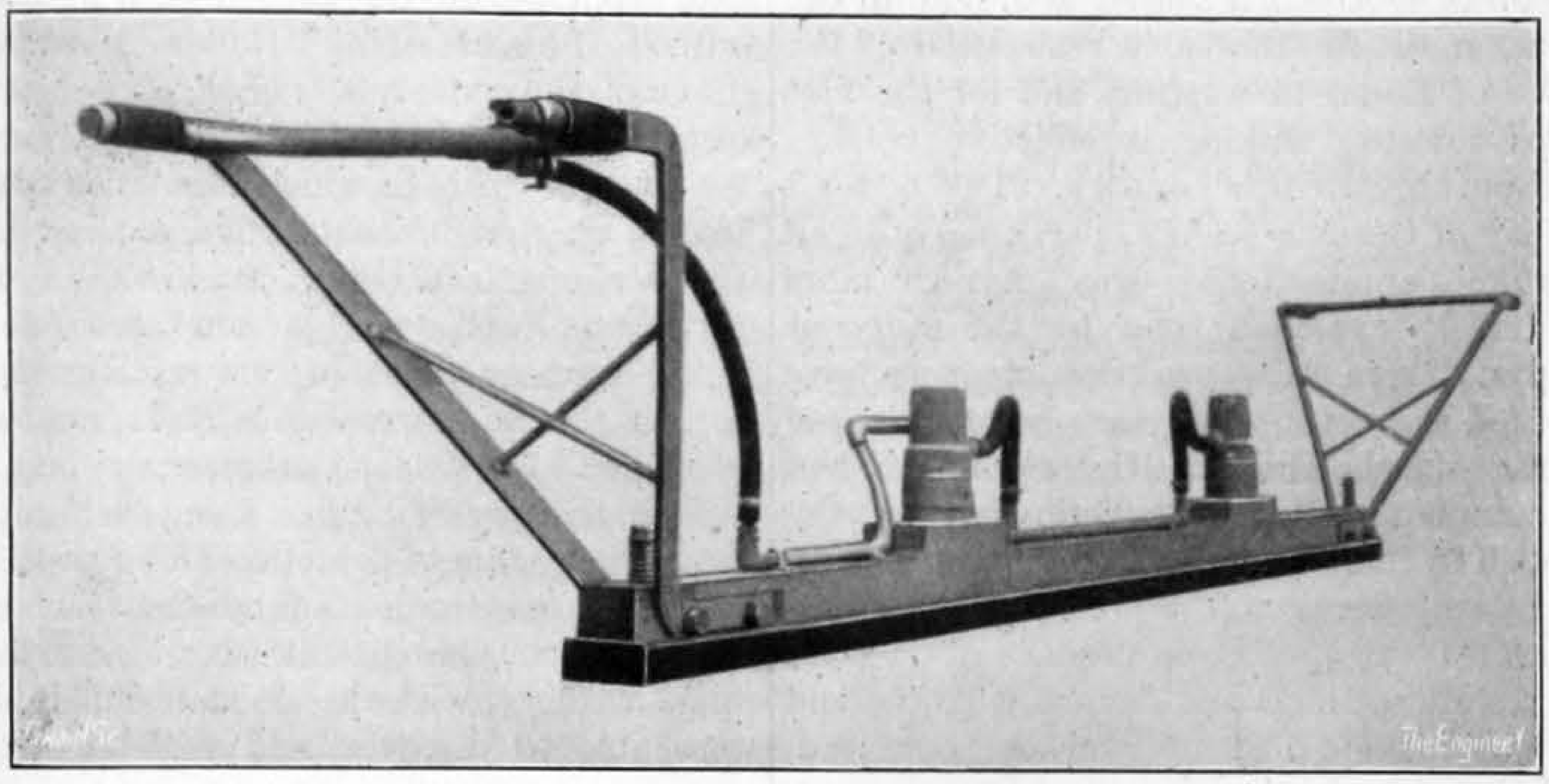


FIG. 1—CONCRETE COMPACTOR

for roads, rapid and complete compaction is of the utmost importance. For this class of work Holman Bros., Ltd., of Camborne, have designed and placed on the market a new compactor, which directly hammers the surface of newly laid concrete at high speed. The new machine is of strong, but particularly simple design, and its general arrangement may be seen in the accompanying illustrations. It consists of a pair of valveless pneumatic hammers mounted on a machined wooden screed batten which is a floating fit in a steel channel, the batten and channel being held together by a spring-loaded retaining pin at either end.

The drawing, Fig. 4, shows the means of transmitting the hammer blows through the batten on to the screed channel. Piston blows fall directly on to anvil pins, passing through guides in the batten, and on to anvil plates welded to the inside base of the channel. This channel lying on the concrete thus distributes the blows, falling at a speed of about 1500 per minute, over the surface it covers.

A pair of rigidly braced operator's handles are mounted at each end of the compactor, and the air inlet hose nipple is at the end of one branch of the handle. Air passes through the handle to a valve, within easy reach of the operator, thence through a pipe line to the hammers. This arrangement ensures that the air hose clears both operator and concrete.

Machines are made with screed channels up to 12ft. long, with a standard width of 4in., and as no part projects more than ⅛in. beyond the channel ends, the compactor is effective right up to the side forms. When it is necessary to do sub-grade work to a set depth below the side forms, adjustable stops can be fitted on the ends of the channel, and screeds can be supplied with flat or cambered profiles as required.

Trials have shown that the machine is capable of giving full compaction to a depth of 1ft. with 6–1 concrete having a 0·48 water/cement ratio. In tests to determine rate of working, the standard machine has been found capable of covering up to 1·6 square yards of concrete per minute when compacting to a depth of 8in. to 9in. We recently had an opportunity to see the new machine giving good compaction on a 14–1 concrete road having a water content of 0·8. When using this method of compaction the maximum efficiency can obviously only be obtained if the concrete mix is laid with a reasonably level surface. In order to obtain such a top level rapidly and economically the firm has designed the simple leveller shown in Fig. 2. This consists of a horizontally vibrated plate set between two light, two-wheeled, hand-propelled trucks, which are pushed along on the side forms. On the front of the plate is mounted a screed, which is adjustable for height. As the apparatus is propelled along, the vibrating screed plate pushes surplus material in front of it, leaving the required level for the compactor.

In use the compactor has to be lifted and replaced on the concrete after each 4in. width has been completed, and this means that passing it over the surface once tends to leave small ridges 4in. apart. Although making an excellent key for a macadam carpet, this finish

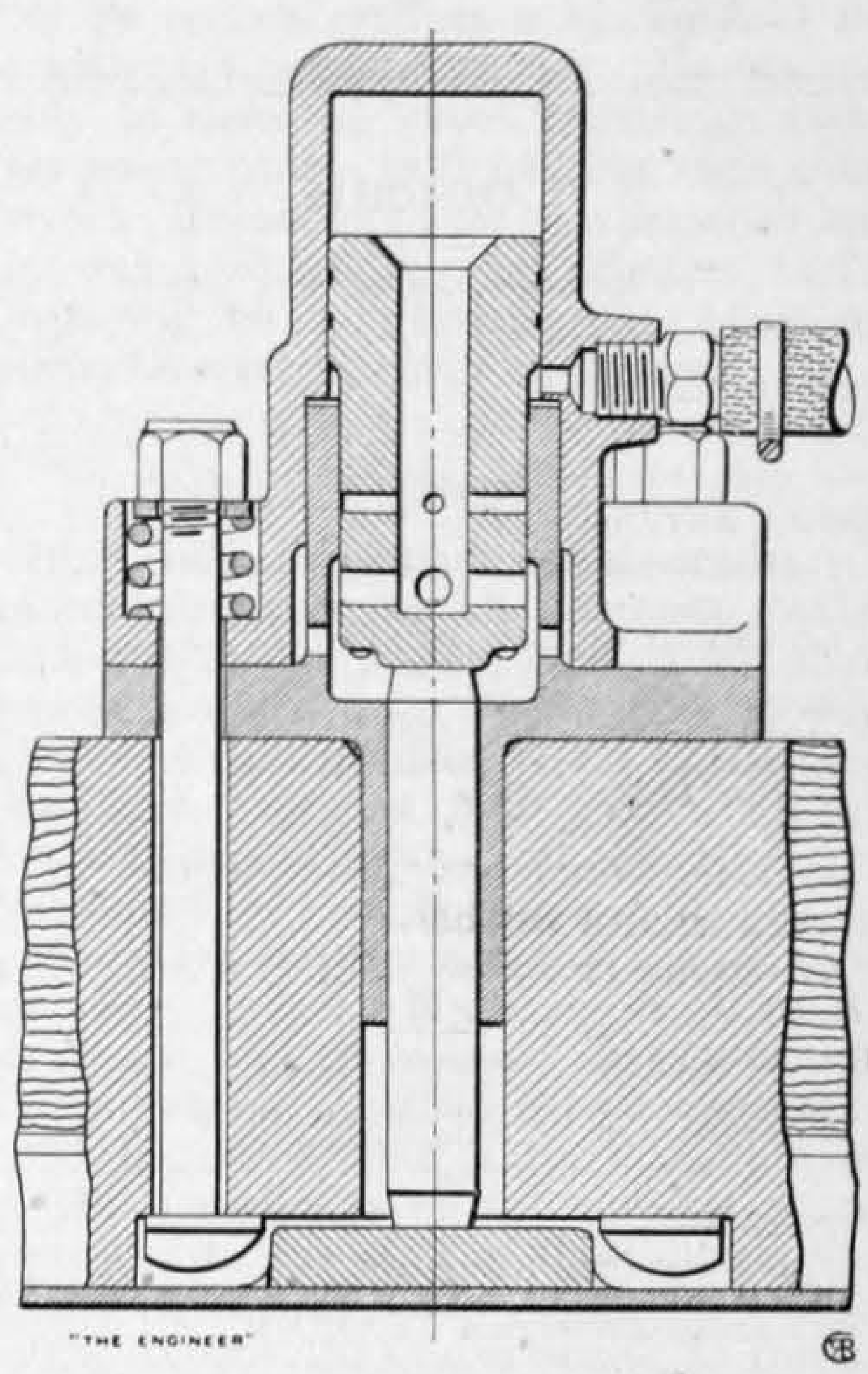


FIG. 4—ARRANGEMENT OF HAMMER

is not satisfactory for a normal concrete surface, and so, to get the required smooth finish, the firm has introduced another new machine. This simply comprises a tee iron on which are mounted two small vibrators and carried by a similar pair of handles to those on the compactor. The ends of the tee iron rest on the side forms and, as the finisher passes over the concrete after compaction, the flat of the tee vibrates the top ⅛in. of surface to impart a smooth finish.

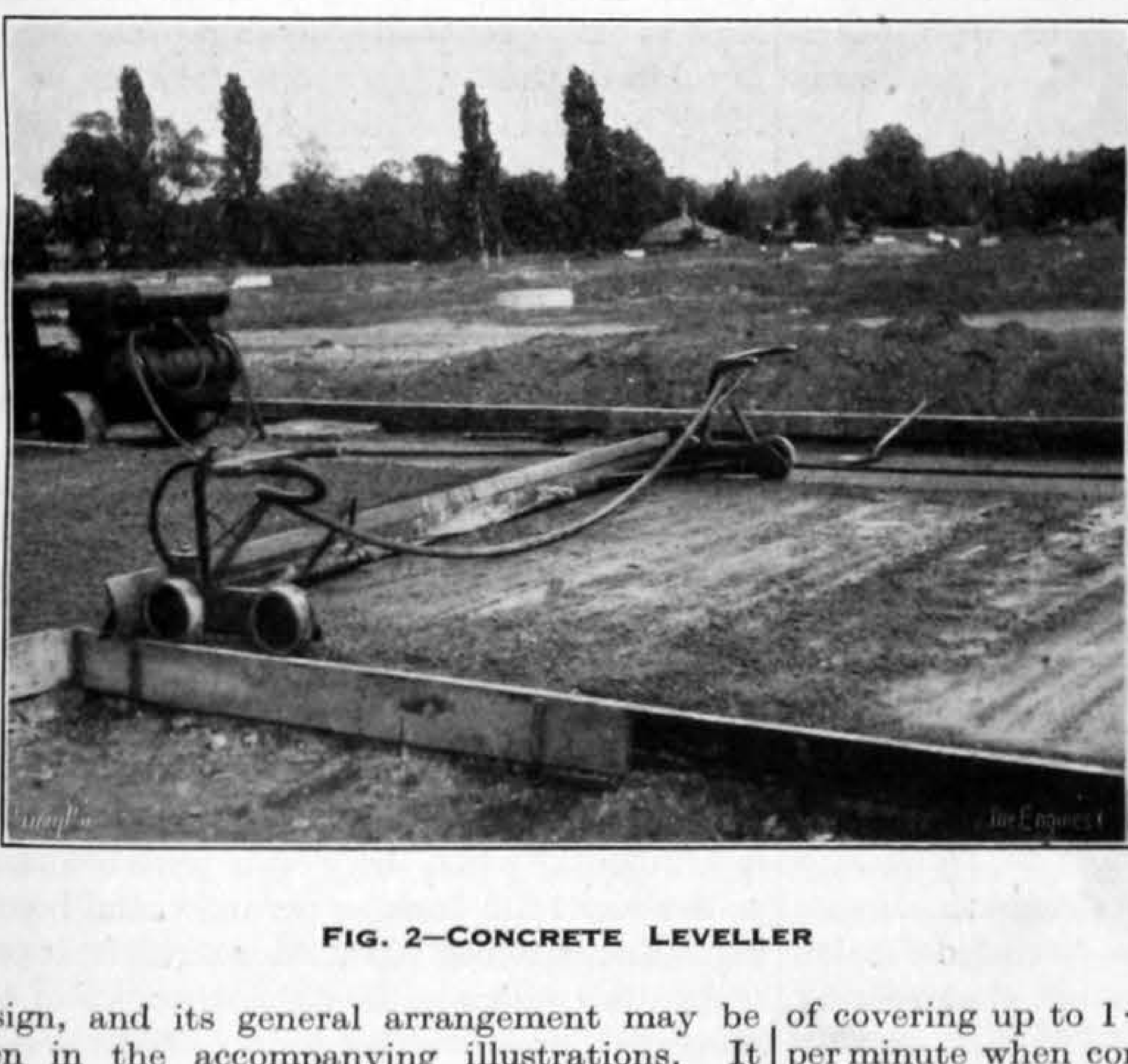


FIG. 2—CONCRETE LEVELLER

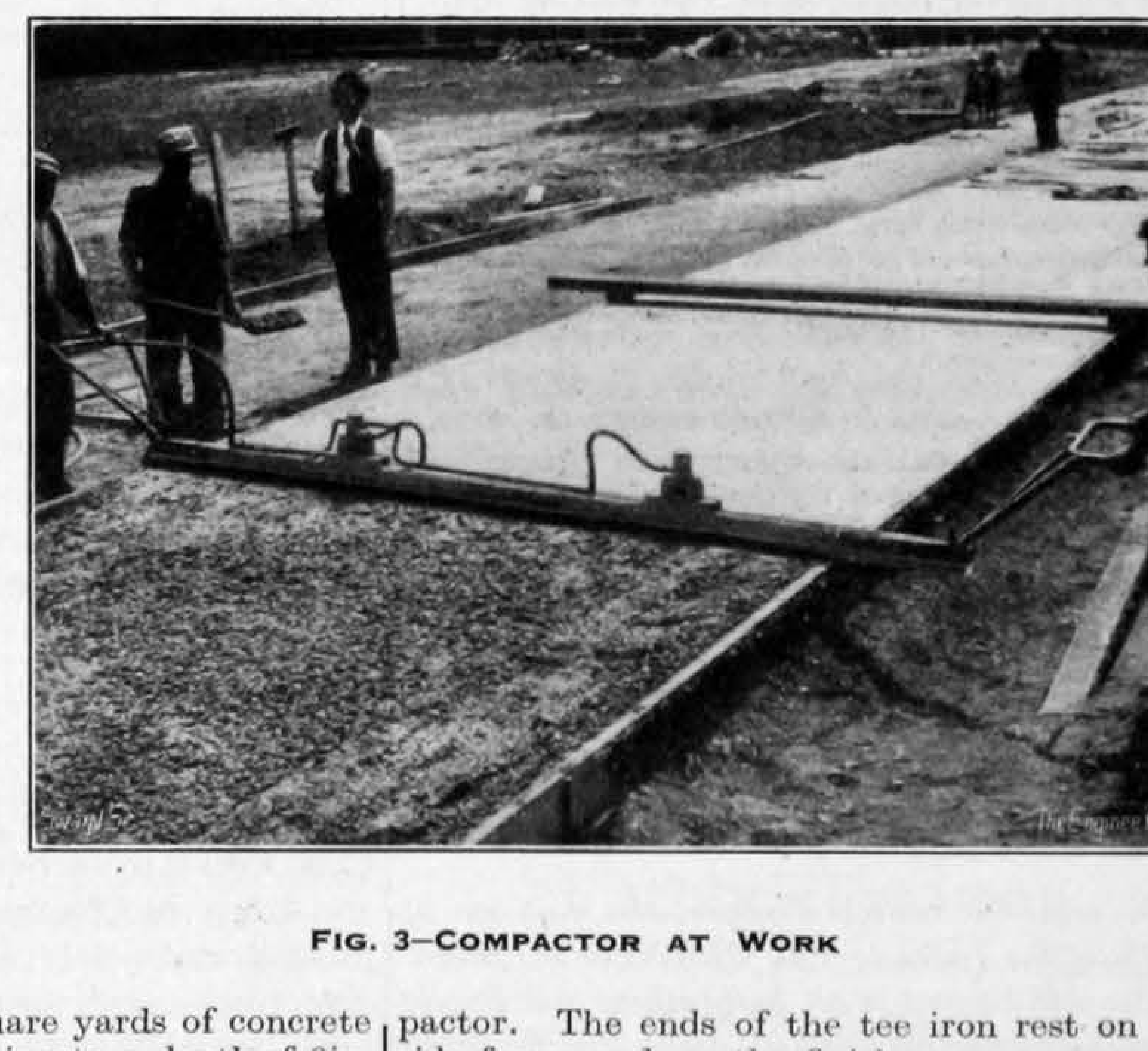


FIG. 3—COMPACTOR AT WORK

MYSORE STEELWORKS.—It is reported by *Iron and Coal Trades' Review* that plans are on foot to expand the Mysore iron and steelworks, India. The works now include a modern charcoal blast-furnace, with a capacity of 80 tons of pig per day; a foundry for making pipe specials and other iron castings; two basic open-hearth furnaces, each between 25 and 30 tons capacity; a rolling mill, to handle between 80 and 100 tons a day; electric furnaces and a steel foundry, besides a ferro-alloy plant, the first of its kind in India, producing 75 per cent. grade ferro-silicon.

The Engineer

AUGUST 24, 1945

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Contents

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RADAR

The story of Radar, its inception and development, and of its many uses by the Armed Forces during the past six years, has now been officially told in great detail. Many important chapters have still to be written on the technical side, chapters describing how Radar does its work. The whole world, however, has now been allowed to learn the nature of that work—or at least a great deal of it—and has been informed of the names of those chiefly associated with it. On the strength of what has already been revealed, it is safe to say that the variety of its applications and the success of its achievements far surpass anything that the uninitiated were permitted to learn or were able to surmise while the war lasted. Radar, it is now plain to everyone, occupies a foremost position among the inventions which aided the Allies to win the war against Germany. It is gratifying to learn of the leading part taken by British scientists in its development and application. While the scientists and manufacturers of America shared with ours in the work, credit for the early realisation of the value of Radar in wartime and for the first steps towards making it effective belongs indisputably to this country. The boasted ability of German science, particularly in all warlike applications, was never more effectively exploded than by the story of Radar. From a captured document we have learned that even two years before the end of the war the German High Command had to admit the "great superiority" of the British in this department of applied science, and sternly to admonish its Communications Section for its failure to produce other than makeshift methods and devices. To the end the Germans failed to overtake our lead, although they were under no illusion regarding the potency of Radar as a war-winning weapon. Here again perhaps we may view with thankfulness the mad insistence of their leaders on the development above all things else of the flying bomb, long-range rocket, and other "vengeance" weapons.

When we were in Suffolk during the early months of the war we heard many rumours of mysterious structures near the coast, which were variously credited with the power of emitting "death rays" or rays which would stop the engines of approaching motor-cars. Only now have we learned that these rumours were deliberately spread in order to hide the activities of those who, unknown to nearly everyone, were then engaged in that neighbourhood on the installation, operation, and perfection of radiolocation apparatus. Radiolocation was initially conceived and developed as a means of detecting the approach to our shores of hostile aircraft. During the year between the Munich crisis and the outbreak of war—that vital twelve months of grace which we are gradually coming to recognise as a heaven-sent interlude—the Radar detection belt spread from a small area covering the Thames estuary to embrace nearly the whole of the East Coast from Scapa Flow to Dungeness and down the Channel to Portsmouth. Begun in this way solely as a means of defensive detection—important although that *rôle* by itself would have been—Radar quickly proved to be adaptable to many other purposes on land, at sea, and in the air. Before the war with Germany ended it was being used, not only to warn us of the approach of raiders, flying high or low, but to train our guns and searchlights on them as soon as they came within range, to manœuvre our fighters towards the area about to be attacked and, by means of a miniature airborne version, to give each of these fighters individual power to locate and attack the enemy even when invisible to the eye. At sea, as on land, Radar was initially applied to detect the approach of enemy aircraft. It was soon found, however, that it could be developed to detect the presence of unseen surface vessels and give their range to our gunners with an accuracy surpassing that of the optical range finder, and under conditions of fog and darkness which rendered that instrument useless. The battle off Cape Matapan, fought on March 28th, 1941, provides a remarkable example of the value of naval Radar. The presence of the Italian fleet was revealed by its agency to our ships long before the enemy knew we were near them. Indeed a few seconds before H.M.S. "Warspite" opened fire the Italian guns were still trained fore-and-aft. Radar gave our gunners the enemy's range and bearing accurately to within a few yards and out of the six 15-inch shells which the "Warspite" fired in her first broadside five secured hits. The Italians lost three cruisers and two destroyers, and the action proved to be the turning point of our perilous situation in the Mediterranean. Radar was also developed to detect submarines on the surface, thereby filling in a keenly felt gap in the Asdic system of detection and compelling the enemy to introduce a fundamental change in his tactics. Our coastal batteries and long-range artillery, with the assistance of Radar, were able to discover and register on to any enemy vessel daring to approach or pass them. During the last months of the war the Dover guns sank eleven out of eighteen German ships trying to escape from Boulogne without actually seeing one of them.

In keeping with the course of the war, Radar in time passed from the primary defensive duties for which it had been brought into being to become an active agent assisting our bombing offensive. As an aid to the navigation of aircraft towards their targets it eventually became so highly developed that a controller sitting in an office in England could follow the course of our bombers, guide them towards the point of attack, and tell them the exact instant at which to release their bombs. The short heavy "saturation" raids employing a thousand or more aircraft which devastated Essen, Cologne, and other German cities were made possible only by the perfection of our navigational Radar system. The same method of home control navigation was used to bomb and completely destroy just before D-day a number of big guns on the Normandy coast which, had they been left alone, would certainly have gravely interfered with our landing operations. Radar in a further form provided us with the means of bombing "by instrument" when the clouds were too thick or the night too dark to permit visual bombing. Fitted to our pathfinder aircraft, it presented our pilots with a ghostly map of the ground below on which even in the worst of weather the enemy's ports, railways, and principal buildings could be distinguished. In addition, on the same map a revolving beam could locate the position and course of any enemy night fighter in the neighbourhood.

An early urgent problem which had to be solved by the Radar scientists was the provision of some means of distinguishing between friend and foe. A device was developed which, when fitted to our aircraft, subjected the returning wireless echo to a periodic modification which indicated to the observing station that it came from a friendly machine. Another form of periodic modification which the pilot could bring into action at the touch of a switch was used as a distress signal. Seeing this signal, the observer, quickly turning a dial or two, could determine the bearing and distance of the distressed aircraft and speed the rescue services to the spot almost before the aircraft landed or struck the water.

These are some of the high lights of the wartime use of Radar. It was undoubtedly a trump card in our hand, and those connected with its scientific development and its Service employment co-operated to play it brilliantly. It is natural to speculate as to its future. On the side of pure science Sir Edward Appleton has stated that work is now in progress aiming at the radiolocation study of meteor trails and of the moon. On the practical side Radar should find an immediate peacetime application as an aid to navigation, both marine and aerial, and will obviously provide a sure and precise means of locating icebergs at sea. Other applications suggest themselves, but it may be worth noting that every use to which Radar has so far been put or for which its future employment has been suggested is characterised by a common feature. The essential duty of Radar is the supply of information, information concerning the presence, direction, and distance of objects. We are tempted to speculate whether this characteristic will always remain its sole feature. The wonders it has achieved during the war and the pace of scientific development generally have been so great that it would be foolish to believe that Radar will always and inevitably remain shackled to the supply of information and never unite with its capacity for transmitting messages the power of initiating action at a distance.

Obituary

JOHN SOMERVILLE HIGHFIELD

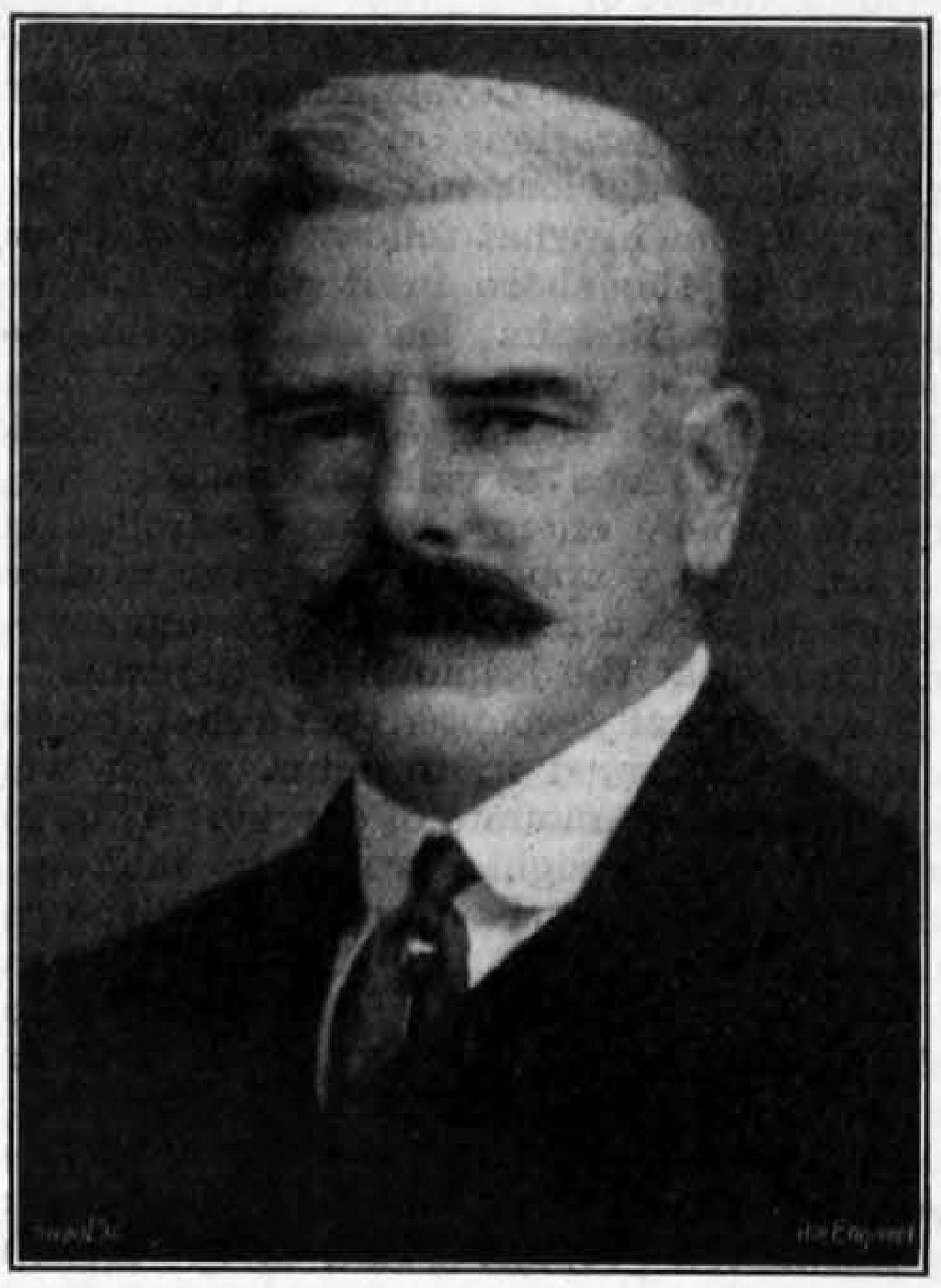
BY the death, on Wednesday, August 15th, of Mr. John Somerville Highfield, at his home, "Stirlings," Cookham Dean, the electrical engineering profession has lost one of its outstanding early workers. Mr. Highfield, who was the senior partner of Highfield and Roger Smith, consulting engineers, of 36, Victoria Street, London, S.W.1, and Birmingham, died in his seventy-fourth year.

He was born at Liscard, in Cheshire, and received his education at Rydal School, and afterwards at King's College, London, under Dr. John Hopkinson and Professor Ernest Wilson. On leaving college he gained a position with the Electrical Storage Company, Ltd., and at a later date became an assistant in the Electricity Department of the Manchester Corporation, at a time when Dr. Hopkinson was engaged in introducing the five-wire D.C. system of distribution. On leaving Manchester he became chief engineer to the Stafford Corporation Electricity Supply Department. While at Stafford Mr. Highfield devised the automatic reversible booster for controlling the input and output of storage batteries. His next appointment was that of chief engineer of the St. Helens (Lancashire) electricity undertaking.

Following that appointment he came to London as the chief engineer and manager of the Metropolitan Electricity Supply Company, and he introduced the Thury system of high-voltage D.C. distribution in a large area of West London.

During the war of 1914 to 1918, he took part in experiments connected with underwater signalling, and demonstrated at sea the use of shrouded hydrophones for submarine detection. He also developed a special process for the preparation of crucible clay. Before the end of the war, in 1917, Mr. Highfield started business as a consulting engineer in Victoria Street, and in 1921, he was joined by his brother, the late Mr. W. R. Highfield, and in 1924, by the late Mr. Roger T. Smith, the present partners in the firm being Mr. E. Ambrose and Mr. A. L. Coward.

Mr. Highfield acted as consulting engineer to many important electricity and other engineering undertakings in this country and abroad, and the firm was for many years one of the consulting engineers to the Central Electricity Board. His services were also frequently in request as an expert witness in actions and arbitration at law. He was the author of many inventions relating to engineering and yachting, and was a recognised authority on the principles underlying the sale of electricity, besides being the author of several technical papers and articles. At the time of his death, Mr. Highfield was chairman of the Fullers' Earth Union, Ltd., and a director of the London Power Company, Ltd., London Associated Electricity Undertakings, Ltd., and the Central London Electricity, Ltd.



JOHN SOMERVILLE HIGHFIELD

For many years he served on the Council of the Incorporated Association of Electric Power Companies, and represented this Association on the Federation of British Industries. He was a Fellow of King's College and a Past-President and Honorary Member of the Institution of Electrical Engineers, a member of the Institution of Civil Engineers, a Fellow of the American Institution of Electrical Engineers, and the Société des Ingénieurs Civil de France. He was a Past-President of the Junior Institution of Engineers and of the Association of Supervising Electrical Engineers, also a Past Vice-President of the Royal Institution of Great Britain, and the Royal Society of Arts.

Mr. Highfield took a very keen interest in the sailing of boats and yachting. He was Vice-Commodore of the Royal Thames Yacht Club, the Brixham Yacht Club, and an honorary member of the New York Yacht Club. He was also a Member of Council of the Yacht Racing Association. Other societies to which he belonged included the Dynamicables, of which he was an honorary member, and he was one of the Knights of the Round Table. He was a Past-President of the Batti-Wallahs' Society, in which he took a great interest.

At the time of his death Mr. Highfield was engaged in many activities besides his profession, and he devoted himself unsparingly to his country during the war. He will long be remembered as a kindly host with considerable personal charm. He was ever ready to share his great knowledge and to help young people in furthering their chosen careers. Those who were privileged to know him well, held him in great affection, and his death will be mourned by the whole profession he served so long and so well.

HENRY PEIRSON HARLAND

IT is with deep regret that we have to record the death, at his home at Radlett, Hertfordshire, on August 11th, of Mr. Henry Peirson Harland, who for many years was a director of Harland and Wolff, Ltd., and its associated firms, and who since 1939 until this year served as the Unionist Member of Parliament for East Belfast.

Henry Peirson Harland was the son of the late Rev. A. A. Harland, of Uxbridge, Middlesex, and he received his education at Rugby School. In 1893, he was apprenticed to Harland and Wolff, Ltd., at Belfast, and on the completion of his training he was appointed to the staff of the Chinese Engineering Company, at Tientsin, in North China. About 1910, he returned to Harland and Wolff, Ltd., at Belfast, and was later transferred to the firm's Govan establishment. During the last war Henry Harland served on the staff of the Controller of Merchant Shipbuilding under Lord Pirrie. At the end of the war, when German shipping was taken over, Mr. Harland was elected chairman of the committee of technical advisers appointed to superintend the completion of the German liner "Bismarck" at Blohm and Voss's Hamburg yard. That liner, we may recall, was later renamed the "Majestic" and sailed for many years in the White Star Company's Southampton to New York service. Henry P. Harland became a director of Harland and Wolff, Ltd., and was chairman of Heaton, Tabb and Co., Ltd. He was a director of Short and Harland, Ltd., and the Ocean Transport Company, Ltd. He was a member of the Institution of Civil Engineers, the Institution of Naval Architects, and the Institute of Marine Engineers, and a member of the Court of the Shipwrights' Company, as well as a member of the General Committee of Lloyd's Register of Shipping. He also served on the Consultative Committee of Shipbuilders and Engineers appointed to confer with the Marine Department of the Board of Trade.

SIR ALLAN MACDIARMID

IN our last issue we recorded with regret the death, in London, on August 14th, of Sir Allan Macdiarmid, who for close upon twenty years was the managing director and chairman of Stewarts and Lloyds, Ltd., and was President of the Iron and Steel Federation. Sir Allan, who was born in 1880 at Glasgow, was the son of the late Allan Macdiarmid. He attended the Kelvinside Academy, Glasgow, and later on went to Uppingham School, after which he studied for the profession of a chartered accountant, and entered the office of the Glasgow firm of McClelland Ker and Co. In 1903, he headed the list of successful candidates from the West of Scotland in his final examination. It was in 1909 that he was appointed secretary to Stewarts and Lloyds, Ltd., and at the end of the last war he was made a director of the company. He was appointed chairman and managing director of the company in 1926, and in the following years, which were so important for the British steel and tube industry, he took a leading part in the reorganisation and development of his company. During his chairmanship the decision to utilise the Northampton iron ores was reached, and plans were made for the great works at Corby, which, with their blast-furnaces, basic steel plant, and tube works, were to play such an important part in the war effort.

Even before the war Stewarts and Lloyds, Ltd., and its associated firms were manufacturing the greater part of the tubes made in this country and were taking a leading part in export trade. In the course of his chairman's speech at the last annual general meeting of the company, Sir Allan made some mention of its great war task, which, he said, had included the supply of fifty million shell forgings. The part played by the firm in the "Pluto" pipe line scheme has already been referred to in our pages, notably the production of the "Hamel" steel pipes for the supply underneath the English Channel of petrol to our Forces. In addition to his chairmanship of Stewarts and Lloyds, Ltd., he was chairman of the Stanton Ironworks Company, Ltd., and a director of Tube Investments, Ltd., the United Steel Companies, Ltd., Richard Thomas and Co., Ltd., and the Davy and United Engineering Company, Ltd. He succeeded Sir James Lithgow as President of the British Iron and Steel Federation in April, 1944, and during recent months gave much attention to the drawing up of a new constitution for the Federation, for which he was mainly responsible and which was adopted. His work was recognised by the bestowal of a knighthood in the New Year Honours this year.

His death, at the comparatively early age of sixty-five, will be widely mourned. He was a leader in industry, with wide vision and great courage, and he looked forward to a new spirit in the industry which he so well served. His artistic nature and his charm of manner endeared him to a wide circle of friends.

Literature

SHORT NOTICES

Rolling Bearings. By R. K. Allan, A.M.I. Mech. E. London: Sir Isaac Pitman and Sons, Ltd., Parker Street, W.C.2. Price 30s. net.—Although ball and roller bearings are now an essential feature in practically every type of mechanical appliance with moving elements, specialised technical literature on the subject is practically non-existent. Designers and students have had, in the main, to rely upon scattered information given in institution papers, articles in the technical Press, and the publications of bearing makers. Up to the time of this book's introduction we believe that only one similar book had been published in this country, and that in 1924. For this reason alone it will be welcome to all concerned with this important branch of industry. It is evident that the author has spared no effort to produce a very comprehensive treatise on the subject to cover all aspects of bearing theory, design, selection, and application. The more practical reader will also find some very useful chapters on lubrication, fitting, maintenance, and performance of these types of bearings. This can be recommended as a good reference work for all engineers and designers concerned with this side of industry.

BOOKS RECEIVED

Redgrave and Owner's Factories, Truck, and Shops Acts. Sixteenth edition. By Joseph Owner. London: Butterworth and Co. (Publishers), Ltd., Bell Yard, Temple Bar, W.C.2. Price 35s. net.

The Atomic Bomb

No. II—(*Continued from page 133 August, 17th*)

Chain Reaction and the Atomic Bomb

THE foregoing survey of the development of atomic and nuclear physics, though necessarily brief and incomplete, has traced the growth of the idea that there are enormous reserves of energy in all matter; that these are of a nature quite different from those involved in chemical processes, such as the burning of coal or oil or the detonation of T.N.T. or other explosives, and that the nuclear reactions by which they are released are more comparable to those occurring in the sun or stars or in the natural radioactive elements found on the earth.

While this idea has been formed and steadily strengthened since the discovery of the phenomenon of radio-activity at the end of last century it is only since the discovery, reported at the beginning of 1939, of the special phenomenon of fission that a way has been clearly seen by which this atomic or nuclear energy in matter could be released, controlled, and put to use by man.

In recent years the enormous effort expended on the solution of this problem, practically all of which has been borne by the U.S.A., has been concentrated on the development of an atomic bomb. Considerations of security make it impossible to disclose many of the details of this work, but in what follows some indication is given of the share in it which has been carried out in Britain. Before doing this, however, it may be worth summarising the nature of the problems relating to the use of fission, either to produce a violent explosion or to liberate atomic energy under controlled conditions, as they appeared when the work was organised, with a new sense of its urgency and importance, at the beginning of the war.

It was generally accepted that a chain reaction might be obtained in uranium which would yield enormous amounts of energy. This, on a basis of equal weights, would be millions of times greater than that produced by the combustion of coal or oil. But it was realised that, if this chain reaction was to be divergent and self-sustaining, certain critical conditions must be satisfied. In the first place, the system as a whole must be of such a size that there was not too great a probability that neutrons, produced in the fission process, would escape from the system and so be unable to take any further part in the chain process.

Secondly, the system must not contain more than a limited amount of material that would absorb neutrons and, in this way again, remove their chance of contributing to the divergent fission chain reaction.

Thirdly, the fact was appreciated that, if the reaction was not to "run away," it was essential to make use of neutrons of very low energy in the individual steps of the chain process. Only then would it be possible to introduce methods which would allow the rate of development of the process to be controlled. The neutrons produced when fission occurs have very high energies, but this is dissipated as a result of elastic collisions with the nuclei of other atoms that may be present. Professor Joliot and his co-workers in Paris and Professor Fermi and other physicists in the U.S.A., were giving thought to the possibility of using a mixture of uranium and some suitable "slowing-down" medium arranged in such a way that the fast neutrons produced by fission would lose their energy by elastic collisions before initiating further fission in the uranium. A suitable "slowing-down" medium must, above all, not have any large probability of capturing a neutron, and its atoms should be of as small mass as possible in order to get the maximum rate of loss of energy in the neutrons through elastic collisions. The most suitable materials to fulfil both these conditions were "heavy hydrogen" or its compound "heavy water," helium, beryllium, and carbon.

At the beginning of 1940, Dr. Frisch and Professor Peierls, of Birmingham University, and Professor Sir James Chadwick, of Liverpool University, independently called attention to the possibility of producing a military weapon of unprecedented power. They pointed out that the slow neutron chain reaction would not produce explosive effects much greater than those obtained with ordinary explosives, but that if a chain reaction with fast neutrons could be realised the explosive effects might be enormous. It was realised that ordinary uranium would not be suitable, for even if a fast chain reaction could be realised with it, a very large quantity of metal would be required. On the other hand, the isotope U.235, if it could be separated, offered great possibilities. It seemed that the amount required to make a bomb would not be very large, certainly between 1 kilo. and 100 kilos., and rough calculations of the energy released showed that the explosion of such a bomb might be equivalent to many thousands of tons of T.N.T.

The explosion of an atomic bomb is very different in its mechanism from the ordinary chemical explosion, for it can occur only if the quantity of U.235 is greater than a certain critical amount. This is because the reaction depends on the conservation of the neutrons produced in the fissions. In a block of pure, or nearly pure, U.235, the neutrons will either be absorbed in the mass of metal, producing new fissions, or they will escape into the outer air, thus being wasted and useless for propagating the reaction. The proportion of neutrons which escape can be reduced by increasing the size of the block of metal, since the production of neutrons is a volume effect and will therefore increase more rapidly with size than the loss by escape, which is surface effect. It follows that if the explosion is possible it will require a certain minimum amount of material, which is called the critical size. The chain reaction will develop so fully that an explosion occurs only if the quantity of U.235 is greater than this critical amount. Quantities less than this are quite stable and perfectly safe. On the other hand, if the amount of material exceeds the critical size it is unstable and a reaction will develop and multiply itself with enormous rapidity, resulting in an explosion of unprecedented violence. Thus all that is necessary to detonate a bomb of U.235 is to bring together two pieces each less than the critical size, but which, when in contact, form an amount exceeding it.

If an appreciable fraction of the atoms in a mass of U.235 undergo fission within a very short time, the amount of energy liberated will be so great that the mass will attain a temperature of many million degrees and a pressure of many millions of atmospheres. It will consequently expand with very great rapidity. As the density of the mass decreases the neutrons can escape more easily from it, and the chain reaction will come to an end. In order to release an appreciable fraction of the available energy it is therefore necessary that the reaction should develop so rapidly that a substantial part of the material can react before the system has time to fly apart. The neutrons produced in the fission process are fast enough to fulfil this condition (but not if they are slowed down by artificial means, as mentioned in the paragraphs above).

The interval of time between the beginning and the end of the nuclear reaction is exceedingly brief. In this interval the mass will have expanded so much that the nuclear reaction breaks off, owing to the escape of neutrons. During this interval a substantial part of the mass of U.235 should undergo fission, releasing a large amount of energy. If only 1 lb. of U.235 is affected, this release of energy will be as much as from 8000 tons of T.N.T.

Professor Sir George Thomson's Committee

A committee of scientists, with Professor Sir George Thomson as chairman, was set up in April, 1940, originally under the Air Ministry and later under the Ministry of Aircraft Production. This committee was instructed to examine the whole problem, to co-ordinate work in progress, and to report, as soon as possible, whether the possibilities of producing atomic bombs during this war, and their military effect, were sufficient to justify the necessary diversion of effort for this purpose.

The first step to be taken was to establish the nuclear data on which depended the possibility of an atomic bomb and which determined its size.

This work had already begun at Liverpool early in 1940, under Professor Sir James Chadwick, and it was now pushed on more rapidly with Drs. Frisch and Rotblat as his senior collaborators. As the work developed and further problems appeared, it was extended to the Cavendish Laboratory, Cambridge, under Drs. Feather and Bretscher. This also had the advantage of providing an insurance against possible interruption from the effects of bombing, to which the Liverpool laboratory was somewhat exposed.

The many theoretical aspects of the problem were investigated by Professor Peierls, assisted by Dr. Fuchs and others. They used the experimental data provided by Liverpool and Cambridge to calculate the critical size of the bomb, they examined the mechanics of the reaction, and calculated the amount of energy likely to be released in an atomic explosion, studying the conditions for increasing the amount.

This was clearly only one side of the problem, for it would not have been of immediate practical use to show that an atomic bomb was feasible provided that a certain quantity of U.235 were available unless it could also be shown that there was a reasonable possibility of separating such a quantity of U.235 from ordinary uranium and in a reasonable time.

This aspect of the problem was also considered by the committee. In the early stage of the work not much actual experiment could be done owing to the scarcity of men and of facilities, but one method of separation was examined at Liverpool and shown to be unpromising. There are, of course, several methods available for separating isotopes on a laboratory scale. These were examined very carefully by the committee, having in mind that it was essential to select and concentrate on what was likely to be the most economical method, owing to the fact that the manpower and industrial resources of Britain were already wholly engaged on production for immediate war needs. The committee came to the conclusion that the gaseous diffusion method was by far the most promising for large-scale production. It is based on physical principles which have long been fully understood and which are easily amenable to calculation, and it seemed likely to make fewer demands for highly skilled precision work.

Research on this method of separation was taken up by a team of workers under the direction of Dr. F. E. Simon, in the Clarendon Laboratory, Oxford. They were aided on the theoretical aspects by Professor Peierls and his group, and on the chemical side by Professor W. N. Haworth and a group of men under his direction in the Chemistry Department, Birmingham University. The Metropolitan-Vickers Electrical Company and Imperial Chemical Industries, Ltd., were consulted on the many technical questions which were involved. Some experimental work on the diffusion method was also started at Imperial College, London University.

By the early summer of 1941, the committee decided that the feasibility of a military weapon based on atomic energy was definitely established and that this weapon had unprecedented powers of destruction, that a method of producing the amounts of material required was in view, and that a fair estimate of the industrial effort needed to accomplish the project could be given. Accordingly, the committee drew up a report dated July 15th, 1941, which summarised its findings and which made recommendations for the prosecution of the project on a large scale. By agreement between the Minister of Aircraft Production and the Lord President of the Council, this report was referred to the Scientific Advisory Committee of the War Cabinet, of which Lord Hankey was the Chairman.

It is proper at this point to consider in general terms what had been done and what remained to be done.

The experiments on the nuclear properties of uranium had confirmed that ordinary uranium itself would be useless for the purpose of an atomic bomb and that it would be necessary to use the isotope U.235, which is present in ordinary uranium only to the extent of 0·7 per cent. They had further shown that if pure or nearly pure U.235 were available in sufficient bulk a chain reaction could develop which would result in an explosion of extreme violence. The data which had been obtained were sufficient to give an estimate of the amount of U.235 required, but this estimate was very rough and the critical size was known only to a factor of three.

The theoretical work had confirmed the early result that the amount of energy released in an atomic explosion would be very large compared with the effect of ordinary bombs. Calculations had been made on the effect of " tampers " and on the best size of bomb. The method of assembly of the material for use as a weapon and the method of fusing had been considered, but no experiments had been made.

On the problem of production of this material U.235 it had been decided to concentrate on the gaseous diffusion method, and research and development on some aspects had shown considerable promise. A scheme had been put forward by Dr. Simon and Professor Peierls which had proceeded to the first stage of design. Leading experts of industrial firms had been consulted who had agreed that it should be, possible to build a satisfactory plant, although difficulties were to be anticipated. Estimates were given for the cost of a plant to provide adequate quantities of U.235 and for the time required to build it.

In short, the Committee was completely convinced that an atomic bomb depending on the fission of U.235 was feasible and that its effect would be comparable with that of some thousands of tons of T.N.T. and that a method of separation of U.235 from ordinary uranium could be realised on a large scale, so that sufficient quantities of the material could be obtained.

Admittedly, a great deal of work remained to be done on all aspects of the project. More precise nuclear data were required so that, for example, the critical size could be estimated with better precision; some points needed confirmation; methods of assembly and of fusing of the material had to be thoroughly examined. The main problem, however, was the design and construction of a plant for the production of the material, and this most essential part of the project was only in its early stages.

A different, but important, aspect of the application of the fission of uranium was also reviewed by the Committee. This was the possibility, mentioned in a previous section of this statement, of finding conditions under which a mixture of uranium and some suitable " slowing-down " medium might give a neutron chain reaction in which the release of energy was obtained in a controlled way. This work was being carried out at Cambridge by Drs. Halban and Kowarski. These two French physicists had been sent by Professor Joliot to this country at the time of the fall of France in June, 1940.

They brought with them the 165 litres of " heavy water "—practically the whole world stock of this material—which the French Government had bought from the Norsk Hydro Company just before the invasion of Norway. Drs. Halban and Kowarski were instructed by Professor Joliot to make every effort to get in England the necessary facilities to enable them to carry out, with the co-operation of the British Government, and in the joint interest of the Allies, a crucial experiment which had been planned in Paris and for which the " heavy water " had been acquired.

Facilities were provided at the Cavendish Laboratory, Cambridge, and, by December, 1940, they produced strong evidence that, in a system composed of uranium oxide (as actually used) or uranium metal with " heavy water " as the slowing-down medium, a divergent slow neutron fission chain reaction would be realised if the system were of sufficient size.

It seemed likely that, if uranium metal were used, this critical size would involve not more than a few tons of " heavy water."

" The Committee concluded that this work had great potential interest for power production, but that this particular application was not likely to be developed in time for use in the war.

" It was, however, recognised that the slow neutron work had a bearing on the military project, for the plutonium which would be produced in such a system could be extracted chemically and might be capable of use in an atomic bomb instead of U.235. The difficulties in the way of building a slow neutron system seemed to be prohibitive at that time. In order to produce the quantities of plutonium which, it was guessed, from analogy with U.235, might be required for a bomb, many tons of uranium and many tons of heavy water would have been necessary. The latter particularly would have demanded a major industrial effort."

During this period, April 1940 to July, 1941, similar problems were occupying the minds of American scientists. Contact was maintained partly by the transmission of reports through the normal scientific liaison machine and partly by visits in both directions by scientists on general scientific missions.

Professor Bainbridge, of the National Defence Research Committee of America (N.D.R.C.), was in England in April, 1941, and Professor Lauritsen (N.D.R.C.) was in England in July of the same year on general scientific matters. Both were invited to attend meetings of Sir George Thomson's Committee.

Directorate of Tube Alloys, D.S.I.R.

The Scientific Advisory Committee of the War Cabinet, of which Lord Hankey was the Chairman, endorsed the view of Sir George Thomson's Committee on the importance of the atomic bomb, with the result that Mr. Churchill, who had been kept informed on the developments by Lord Cherwell, asked Sir John Anderson, in September, 1941, to undertake personal responsibility for the supervision of this project as one of great urgency and secrecy. To advise him he set up, under his chairmanship, a Consultative Council, of which the members were the Chairman of the Scientific Advisory Committee of the War Cabinet (Lord Hankey and, later, Mr. R. A. Butler), the President of the Royal Society (Sir Henry Dale), the Secretary of the Department of Scientific and Industrial Research (Sir Edward Appleton), and Lord Cherwell. To ensure continuity the Minister of Aircraft Production, Lord Brabazon of Tara, served on this Council at the beginning.

The direction of the work was entrusted to a new Division of the Department of Scientific and Industrial Research, and thus fell under the general administrative charge of Sir Edward Appleton as Secretary of the Department. It was known, for reasons of security, as the Directorate of Tube Alloys. Mr. W. A. Akers was, at Sir John Anderson's request, released by the board of Imperial Chemical Industries, Ltd., to act as Director, with direct access to the Minister on all questions of policy.

Mr. Akers had, as his deputy and principal assistant, Mr. M. W. Perrin, who was also lent by I.C.I. Mr. Akers was advised by a Technical Committee, under his chairmanship, composed of the scientists who were directing the different sections of the work and some others. The original members were Professor Sir James Chadwick, Professor Peierls and Drs. Halban, Simon and Slade, with Mr. Perrin as Secretary. Later it was joined by Sir Charles Darwin and Professors Cockcroft, Oliphant, and Feather.

Visit of U.S. Mission to Britain, November, 1941

In November, 1941, at the time when the new T.A. (Tube Alloys) organisation was set up, an American mission, composed of Professors Pegram and Urey, of Columbia University, came to this country to study the experimental and theoretical work which had been done on the T.A. project, to learn our ideas for future work and to agree on arrangements for complete and rapid interchange of information.

They visited all the establishments where T.A. work was in progress and took part in a meeting of the new T.A. Technical Committee, at which progress was reviewed and new programmes discussed.

Visit of British T.A. Mission to U.S.A., February-April, 1942

Under the new organisation a great extension of the scale of work, both in university and industrial laboratories, was started. In the U.S.A. also a greatly intensified T.A. effort had followed the return of Professors Pegram and Urey from England. A mission composed of Mr. Akers, Dr. Halban, Professor Peierls and Dr. Simon visited America at the beginning of 1942 to ensure that the programmes planned for the United Kingdom were co-ordinated as efficiently as possible with the American work.

Every section of the American programme was examined in detail and it was already clear that the new American T.A. organisation intended to make the fullest use of the enormous resources available in the universities and in industry.

British T.A. Programme

It was clear in 1942, that even though granted very high priority, the scale upon which T.A. research and development could be undertaken in the United Kingdom must be far smaller than in America. A large proportion of the qualified physicists was occupied in other urgent war work and the industrial resources of Britain were engaged, at that time in war production to a much greater extent than was the case in the U.S.A.

Consequently it was necessary to limit the field of T.A. investigation. Broadly, the programmes chosen were :—

Determination of essential nuclear physical data.

Theoretical investigations into the chain reaction in an atomic bomb, the dimensions and design of a bomb and its blast effect.

The gaseous diffusion U.235 separation process. This included theoretical and experimental research on the process, the design and construction of prototype machines, the manufacture of materials needed, studies on materials of construction, &c.

Investigation of slow neutron divergent systems, especially with "heavy water" as the slowing-down medium.

The manufacture of uranium metal for the slow neutron systems or "piles."

The manufacture of "heavy water."

Location of Work

Experimental Determination of Nuclear Physical Data.—The research teams at Liverpool and Cambridge universities were considerably strengthened and small programmes were started at Bristol and Manchester universities. Professor Sir James Chadwick exercised general supervision over all this work.

Slow Neutron Systems.—This work continued at Cambridge under Drs. Halban and Kowarski, with the collaboration of Dr. Bretscher.

Theoretical Investigations into Chain Reaction, &c.—Professor Peierls and his team continued their studies at Birmingham, with collaboration, on special problems, with Professor Dirac, of Cambridge. Later, when Professor Peierls moved to U.S.A., Dr. A. H. Wilson led this group.

The Gaseous Diffusion Process—University Research.—The experimental work was under the general direction of Dr. Simon. His extended team at the Clarendon Laboratory had, as leaders, Mr. Arms and Drs. Kurti and Kuhn. The theoretical study of the process remained in the hands of Professor Peierls and his group at Birmingham. Also, as Birmingham University, Professor Haworth, who had been very active in T.A. from the days of the Thomson Committee, had a group working on a number of chemical problems connected with the diffusion project.

Research and Development in Industrial Establishments.—The Metropolitan-Vickers Electrical Company, Ltd., accepted a contract for the design and construction of certain prototype machines embodying the principles worked out by Dr. Simon and Professor Peierls. The successful construction of these machines was a considerable technical achievement in view of the novel features contained in them. They were later abandoned in favour of a simpler design, which offered certain advantages in operation.

Imperial Chemical Industries, Ltd. (I.C.I.), were entrusted with the contract for the development of the diffusion plant as a whole, and the work was carried out by the Billingham Division of that company. This programme was a very extensive one, as it covered everything involved in the design of a complete plant, including the working out of flow sheets, research on materials of construction, and the development of new types of valves, instruments, &c., to meet novel conditions.

In this work they were assisted by the Metals Division of the I.C.I., which studied various manufacturing processes. I.C.I. Metals, Ltd., had, as sub-contractors, Percy Lund Humphries and Co., Ltd., and the Sun Engraving Company, Ltd., co-ordinated by Dr. Banks, whose services were made available by the Printing and Allied Trades Research Association. Metallisation, Ltd., also made a valuable contribution to this section of the work.

Processes for the manufacture of the many special chemicals required were worked out by the General Chemicals Division of I.C.I., assisted by the Dyestuffs Division.

The Mond Nickel Company, Ltd., under a separate contract, made a very successful investigation of certain metallurgical problems.

Although some of these research programmes will be carried on a little longer, largely in order to establish optimum conditions, I.C.I., Billingham Division, has been able to close down the main programme after producing flow sheets and designs for diffusion plants operating over a fairly wide range of conditions.

In broad outline the plant is, of course, similar to the American diffusion plant now in operation, but it embodies certain novel features.

The Manufacture of Uranium Metal.—I.C.I. (General Chemicals), Ltd., undertook the manufacture of uranium metal and succeeded in developing a satisfactory method. The conversion of the metal into rods, as required for a "pile," was tackled by I.C.I. Metals Division. It soon became apparent that many problems required study in connection with the physical, metallurgical, and chemical properties of the metal. Research on these points was undertaken by the National Physical Laboratory, Dr. Simon at Oxford with a sub-group at Birmingham, the British Non-Ferrous Metals Research Association, Dr. Orowan at Cambridge, and the Alkali Division of I.C.I.

Heavy Water.—I.C.I. Billingham Division, which had some experience in the separation of "heavy water" on a laboratory scale, was asked to prepare a scheme for the production of this material on a large scale. After examining various methods they reported that the most suitable process to adopt in this country, if speed of construction and certainty of operation were paramount, was the electrolytic process incorporating the vapour phase catalytic exchange principle introduced by Professor Taylor, of Princeton University, U.S.A. Flow sheets and designs were prepared for a plant in which the exchange system was of a novel design, believed to be simpler and more efficient than any of those hitherto used or suggested.

Electro-Magnetic Method.—Through the interchange of information we were aware of the remarkable development work which was being carried on at the University of California under Professor E. O. Lawrence, with the object of coverting the mass spectrograph, used for the separation of isotopes in minute quantities, into a large-scale production apparatus. But it was decided not to start any corresponding research in this country as the physicist most suitable, for this work, Professor Oliphant, of Birmingham, was engaged in other urgent war work. In July, 1943, it was possible to release him from that work so that it was decided to start a research programme at Birmingham on this method. Before work had really started, Professor Oliphant visited America in connection with discussions on a closer integration of British and American T.A. efforts, in which it was agreed, as described below, that the most efficient course to follow, in the joint interest, was for Professor Oliphant and most of his team to move to U.S.A. The British electro-magnetic programme was therefore abandoned.

After Professor Oliphant's return to this country in March, 1945, it was decided to arrange for research to be started on some of the electrical engineering problems involved in this type of plant. With this object, research contracts have been placed with the British Thomson-Houston Company, the General Electric Company, and Metropolitan-Vickers Electrical Company. In addition, the first and last of these companies had already given considerable assistance by lending to the British T.A. organisation the services of Dr. K. J. R. Wilkinson, Dr. T. E. Allibone, and other physicists and engineers.

Co-ordination of Programmes.—It will be seen, from the account of the diffusion plant research project, that many university and industrial teams were concerned, so that proper co-ordination of the work became an important matter. The same applied to the work on the production of uranium metal and its metallurgy. It was also evident that some of the chemical research carried out for one project would be of interest in connection with another. To ensure satisfactory co-ordination of the work, certain committees and panels were set up.

Research Contracts, Patents

The contracts under which research is carried on in university laboratories contain clauses reserving exclusively to the Government all discoveries, inventions, and other results arising from the work. In the case of researches carried on by industrial firms, all results, inventions, and developments in detail applicable within the T.A. field became exclusively the property of the Government. Where an invention is also usable outside the T.A. field, provision has been made whereby its use outside the field can be made available to industry. It is within the discretion of the Government to decide whether or not a particular use is within or without the field. Questions relating to inventions and patents are dealt with by a small Patents Committee.

Joint British-Canadian-American Slow-Neutron Project in Canada

Towards the end of 1942, it was decided that the slow-neutron research in progress at Cambridge would proceed more quickly and efficiently if it were transferred to a place geographically nearer to Chicago, where the corresponding American work was being carried out. A proposal was made to the Canadian Government that a joint British-Canadian research establishment should be set up in Canada, to work in close touch with the American group. The Canadian Government welcomed the suggestion, with the result that, at the beginning of 1943, a large research establishment was set up in Montreal under the general direction of the National Research Council of Canada.

Practically the whole of the Cambridge group, under Dr. Halban, was moved to Montreal, where the research staff was rapidly augmented by many Canadian scientists, several new recruits from the United Kingdom, and a certain number from the United States. The laboratory was at first directed by Dr. Halban. He resigned this position early in 1944 and Professor J. D. Cockcroft was appointed to succeed him. During the spring of 1944, the Americans joined actively in that project. Its scope was enlarged and in 1944 a site was selected on the Ottawa River, near Petawawa, Ontario, for the construction of a pilot scale pile using "heavy water," supplied by the U.S. Government, as the slowing-down medium. This joint enterprise in Canada has been described more fully in statements issued by the Canadian Government. It represents a great contribution, both in men and money, by that

Government to the development of this new branch of science and its application.

TRANSFER OF BRITISH T.A. RESEARCH GROUPS TO U.S.A.

In August, 1943, Sir John Anderson visited America and discussed with the U.S. authorities the means by which the co-operation between the two countries might best be placed upon a more formal basis. Further discussions took place subsequently between President Roosevelt and Mr. Churchill, which led to the setting up of the Combined Policy Committee in Washington.

Professor Sir James Chadwick, who was appointed Scientific Adviser to the British members of this Committee, examined, with those responsible for the scientific and technical direction of the American project, the question whether there were any further steps which could be taken, in the pooling of scientific and technical effort, which would accelerate the production of atomic bombs in the U.S.A.

As a result of these discussions it was decided to move to America a large number of the scientists working in England on T.A. in order that they might work in the appropriate American groups.

At this time Professor Bohr escaped from Denmark and the British Government appointed him as an adviser on scientific matters. His scientific advice on the T.A. project has been available both in this country and in the United States to the two Governments. Professor Oliphant and his team from Birmingham University were moved to Berkeley to work with Professor Lawrence's group engaged in research on the electro-magnetic isotope separation project. They were joined by other physicists from Britain, including Professor Massey, of University College, London; Dr. T. E. Allibone and Dr. K. J. R. Wilkinson, who worked partly at Berkeley and partly at the electro-magnetic separation plant itself.

Dr. Emeleus, of Imperial College, London, Dr. J. P. Baxter, and others were transferred to the electro-magnetic plant. Dr. Frisch, from the Liverpool nuclear physics group, and Dr. Bretscher, from the corresponding Cambridge section, together with some members of their teams, were moved into the great American T.A. research establishment at Los Alamos, which is described in American statements on the project. They were joined, at that time or later, by a number of other British scientists, including Professor Peierls and Dr. Penney, of Imperial College, London University. Professor Sir Geoffrey Taylor also paid several visits to this establishment.

The effect of these transfers, and others which were made to the Montreal project, was to close down entirely all work in the United Kingdom on the electro-magnetic process and to reduce almost to nothing the nuclear physical research.

Neverthless there is no doubt that this was the proper course to follow in the light of the decision which had been taken to give the highest priority to the production, in the shortest possible time, of an atomic bomb for use in this war.

The History of Radar

No. II—(*Continued from page 135, August 17th*)

WE continue below the story of Radar development begun in last week's issue by giving excerpts from a number of documents on the subject supplied to us by the Ministry of Information.

BRITAIN AND THE U.S.A.

All the enemy Powers have used Radar, but their application of this principle has always lagged behind that of the Allies. They have been beaten in the battle of research and application. More nations than one were experimenting between the wars on techniques of detecting objects such as aircraft by radio reflections. The methods differed, and there is little point in making claims to priority. Britain does not claim to be the "first and true" inventor of Radar any more than any one country can claim sole credit for the motor-car; but in Britain ten years ago the work of the United Kingdom scientists was seized on and developed as the first line of defence. Radar went into the air exercises of 1937 and 1938 and stood behind the apparently few British preparations for the impact of war at the time of Munich; it had, in fact, by that time completely altered the strategy of our air defence. In that step Britain was first and alone. She took the initiative in August, 1940, when she stood alone against the Axis, in giving all her secrets freely and unconditionally to the United States.

The U.S.A. had already developed independently some of the devices of which we informed her in 1940. The cause of the greatest revolution in Radar, however, and a common stem from which grew the British and American modern developments on wavelengths of a few centimetres was the British magnetron valve, devised during the war and capable of generating radio energy of many kilowatts. Since those first days the co-operation in Radar research and development has been so close that it is happily impossible to separate out the British and American shares. Canada, too, responded in generous fashion to the need for radio research and production outside Britain, and trained many operating and servicing crews of the Royal Canadian Air Force who came to this country and manned a proportion of our Radar installations.

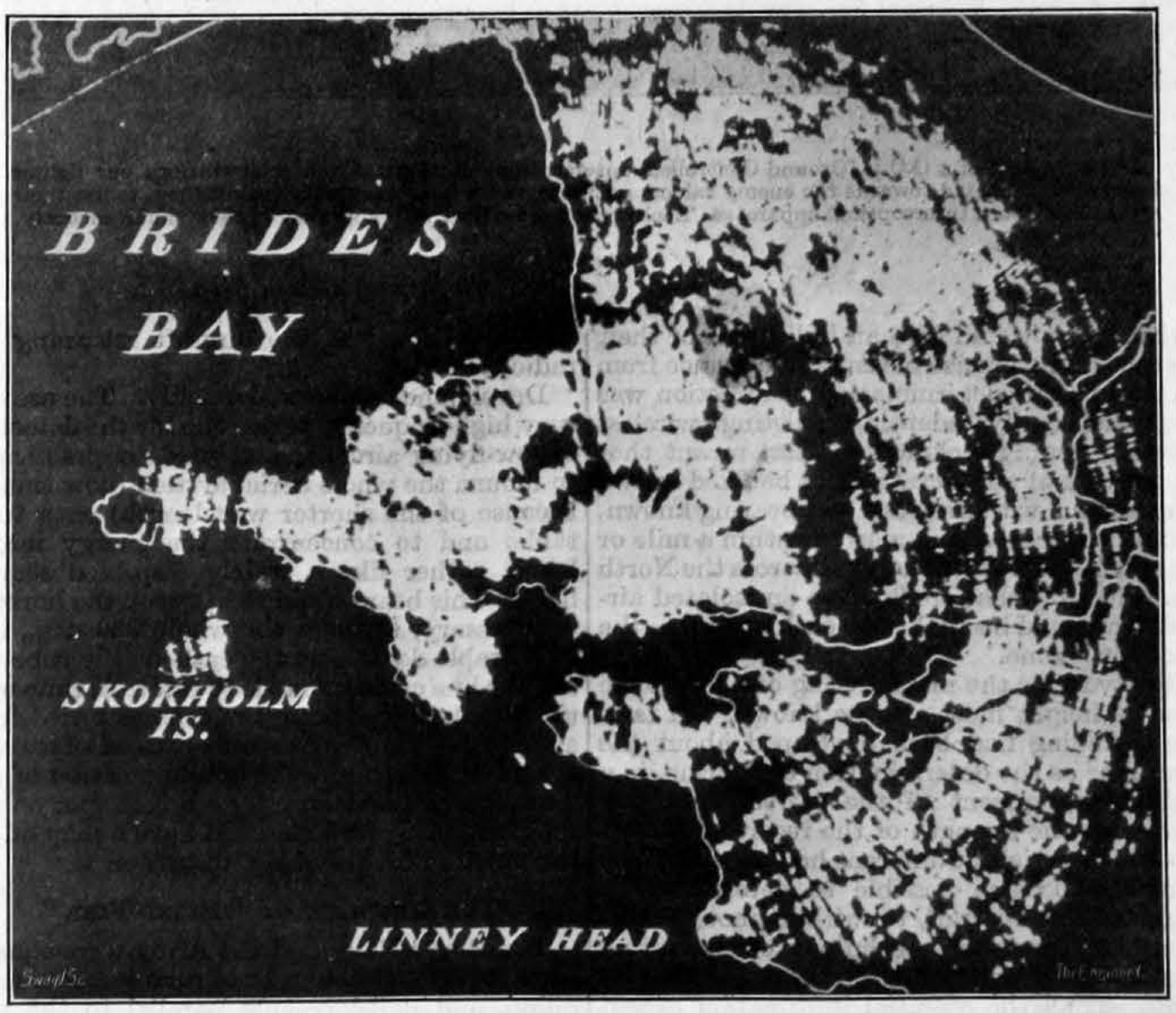
THE BEGINNINGS OF RADAR

Soon after the first of the two Great Wars, the height of the Heaviside layer, a "shell" of atmosphere which acts as a radio reflector 60 miles above the earth's surface, was found out by means of high-powered wireless pulses reflected from them. Those experiments, which in England were carried out under the auspices of the Department of Scientific and Industrial Research, may be said to be the first in radio range-finding. In 1934, there were scientific men at the Air Ministry deeply distressed because there were no known means by which the country was likely to be successfully defended against air attack. Late in that year the Air Ministry decided to begin a new attack on the problem of air defence and set up the Committee for the Scientific Survey of Air Defence, and one of its officials informally approached a member of the National Physical Laboratory regarding the possibility of a death ray. The response of the National Physical Laboratory scientists was immediate and definite; there was no early hope of a death ray, but energy re-radiated from an aircraft ought to suffice for location. An experiment demonstrating this fact was instigated by the Committee. It was successful, and Radar was born.

One of the next steps was the first meeting, in April, 1935, of a special Air Defence Research Sub-Committee of the Committee of Imperial Defence, containing senior representatives of all three Services and of the Departments of State concerned. By December of that year the experimental work was sufficiently advanced for the Air Ministry to decide on establishing a chain of five Radar stations on the East Coast of England, and this was, in fact, the first operational Radar system installed anywhere in the world. In August, 1937, authority was given for fifteen additional stations to be added to the chain, giving complete cover to the whole East and South-East Coasts of Great Britain.

In September, 1938, at the time of Munich, every available experimental equipment was put into operation, manned by research workers and chosen men from the Services. By that time £2,000,000 had already been spent by the State on the new project.

With the immediate crisis past, work on finishing the chain facing the Continent was urged forward by the Air Ministry. The building of a continuous chain of stations from Scotland to the Isle of Wight was accomplished by

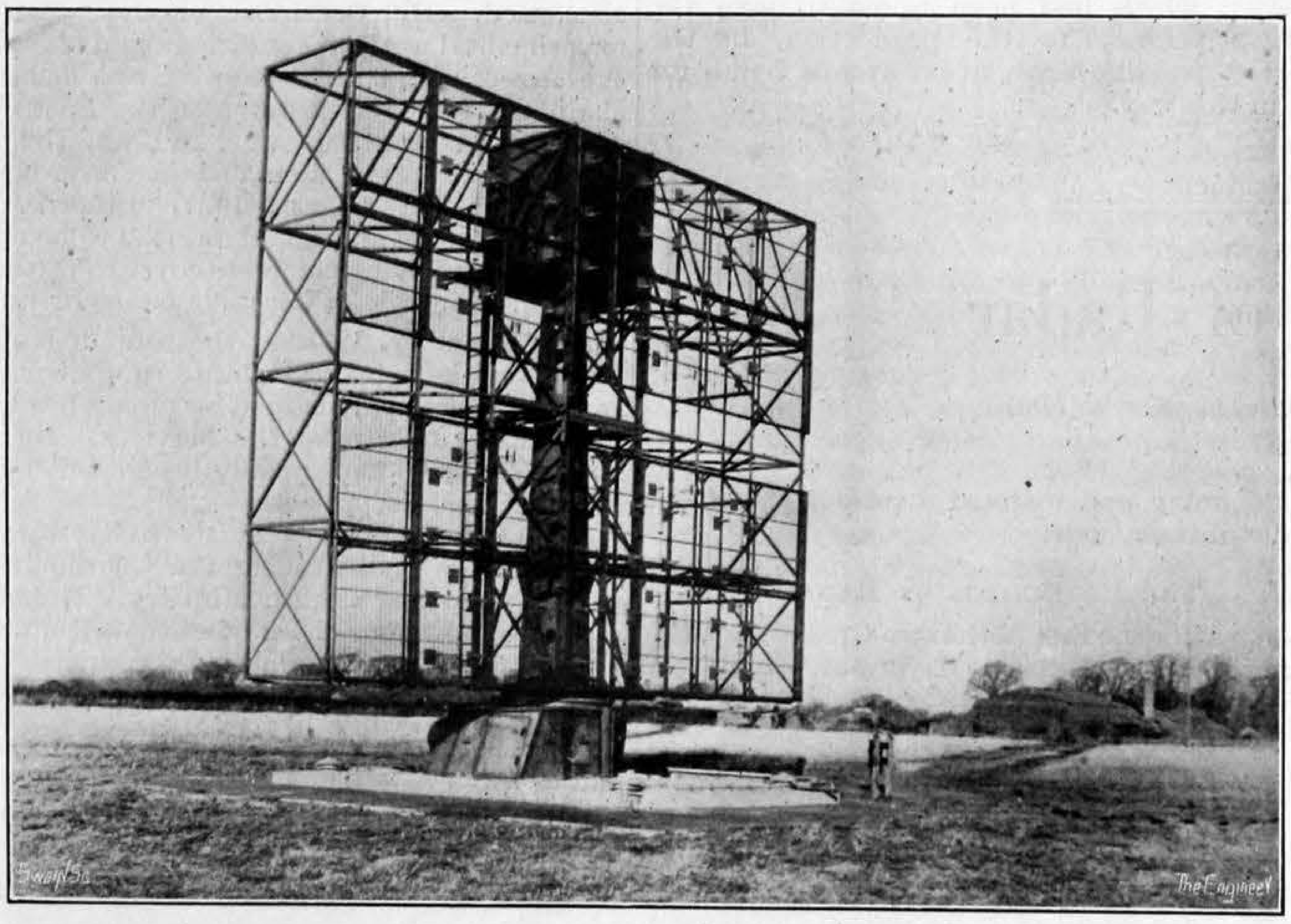


Radar Map as seen on the cathode ray oscilloscope screen by a night bomber fitted with H2S apparatus. The area shown is a portion of South Wales, the inlet being that on which Milford Haven and Pembroke stand. The outline of the shore has been added to the map.

March, 1939. In order that the warnings of enemy air attack could be flashed from the Radar stations to the R.A.F. controllers, and so to the civil defence and the public, a new network of telephone lines thousands of miles in length had to be specially laid by the G.P.O. Ever since that Easter before the war, when Italy invaded Albania, a twenty-four-hour watch has been kept on the North Sea approaches and the great majority of the aircraft approaching our eastern shores tracked and plotted. Soon after war began, the rest of the coastline of the United Kingdom was covered, completing the last link in the home chain.

The great testing time of the chain's capacity and value was the Battle of Britain. Each station was a combined transmitter and receiver. Its powers were the measuring of distance, and height of aircraft within its very considerable range, besides differentiation between friend and foe.

As soon as the principle had been clearly established that pulses of energy on about 10 m. wavelengths and a few millionths of a second duration could be transmitted to "flood-light" a wide space and that all aircraft



Aerial System of a G.C.I. (Ground Controlled Interception) Station. From such stations our fighter aircraft were directed towards the enemy raiders until they were near enough to permit them to use their own A.I. (Airborn Interception) apparatus. Each station could deal with a number of raids simultaneously.

in that space would give an indication of their presence and a precise measure of distance from the station, the determination of direction was accomplished by adapting existing wireless direction finding technique. That meant that the position of an aircraft could be fixed in two dimensions: with its range and bearing known, it could be located on a map to within a mile or better while it was still halfway across the North Sea. Nor was that confined to an isolated aircraft, but could be applied to each in turn in the "floodlit" zone.

However, for the manœuvring of fighters the enemy's height must also be known. In fact, height finding had been developed about the same time as the determination of bearing, in a manner reminiscent of the stereoscope. By comparing the strength of the received echo at two sets of aerials at different heights above the ground it became possible to determine the height of the aircraft to within about 500ft. This, together with a technique of estimating the number of separate aircraft in a formation, completed all the essential information except whether the aircraft were hostile or not; this key problem of identification in the operational use of Radar was tackled by providing a device in friendly aircraft which gave a Radar echo characteristic of the friend.

The Need for New Valves

It had already been recognised, early in 1935, that while the detecting stations could observe without fail all aircraft flying at normal heights, there would be a region extending to a few hundred feet above sea level where an enemy could creep close in before being detected. Therefore equipment had to be developed for the detecting of low-flying aircraft, and this involved the design before the magnetron era had been reached of a whole new series of radio valves, capable of generating radio energy on a wavelength of 1½ m.

The indicator used to show the signals returned from aircraft has been, all along, the cathode ray tube, an item familiar in television receivers. The earlier techniques of Radar involved a display in the form of a bright line across the face of the cathode ray tube, the aircraft echo being shown by a V-shaped projection above or below the line. The distance of this projection from one end of the line (which was in fact a distance scale) was an accurate measure of the distance between the Radar station and the aircraft returning the radio echo.

Developments followed quickly. The use of a very high-frequency technique for the detection of low-flying aircraft next made it practicable to mount the whole aerial system (now smaller because of the shorter wavelength) on a turntable, and to concentrate the energy into a beam, rather like a widely dispersed searchlight. This beam could then sweep the horizon, if necessary, through the whole 360 deg., and by suitable devices on the cathode ray tube the display line could be made to rotate in time with the aerial. By making the echo returned from an aircraft brighten this line, instead of causing a V projection on it, the actual position of the aircraft could be shown by a bright spot on the tube, the face of which could have a map of the surrounding land and sea drawn on it.

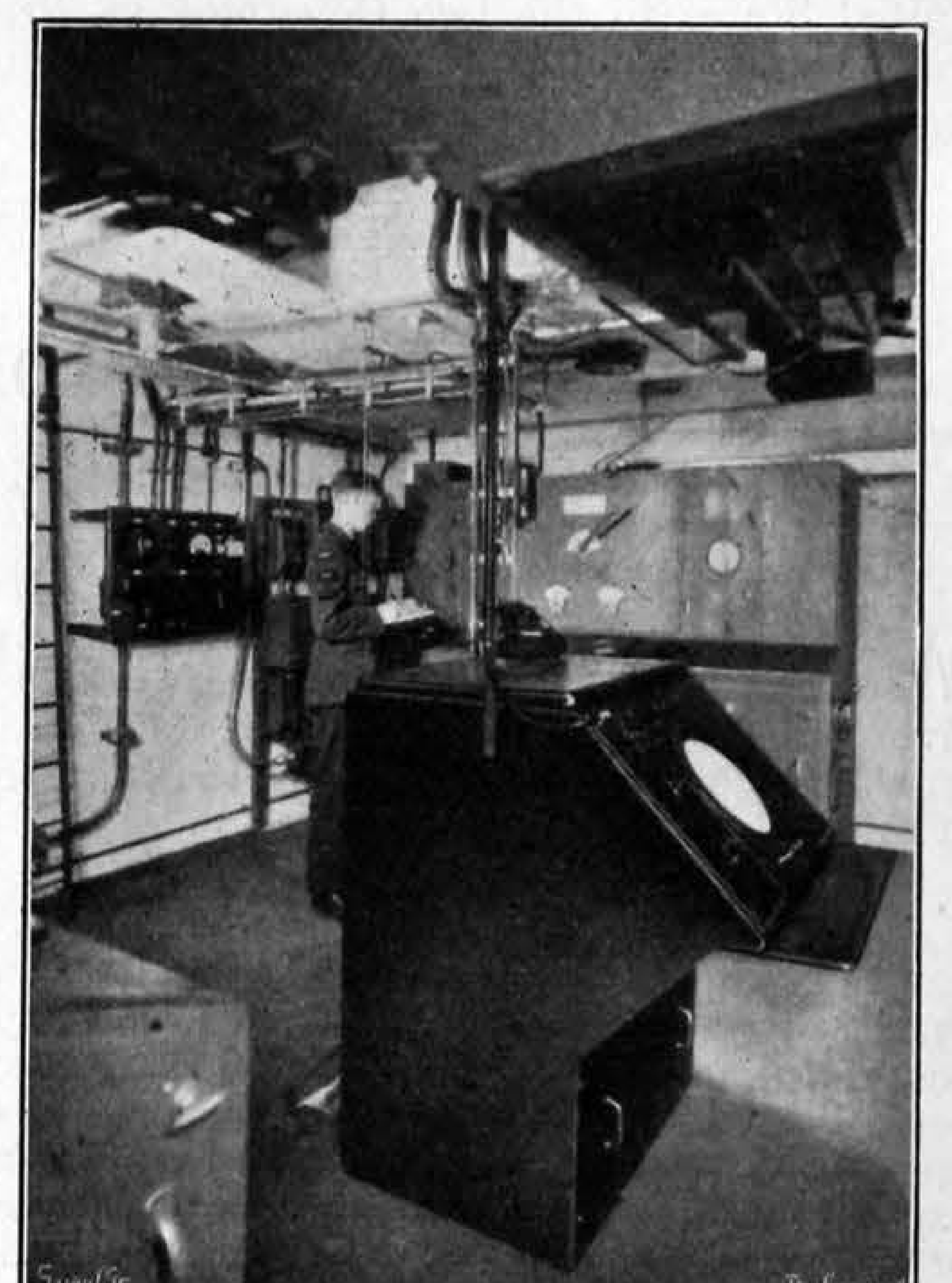
The Problem of "Blind Fire"

The Royal Navy and the Army were equally alive to the possible uses of echo-location technique, and developments parallel to the raid warning chain served their purposes. The large aerial system used for the coastal defence stations could not be adapted for naval or military purposes. Shorter waves, and so smaller aerials, made possible compact equipments which could be mounted on the masts or super structure of ships, in mobile trailers, or on searchlights. The measurement of range on land and at sea by visual means was soon outstripped by its radio rival, and with further refinement in the naval application of the new technique this led to the complete solution of the "blind fire" problem. Starting with an attachment to the air warning equipment, separate sets for fire control have been in service in His Majesty's ships since 1940, enormously increasing their striking power.

Detection of enemy warships from aircraft, the warning to our ships of enemy aircraft approaching, the defence of harbour and coasts against small enemy vessels, the feeding of gunnery data from Radar equipment into predictors, the control of searchlights by Radar so that they could unmask when already sighted on the aircraft; all these had been accomplished at the laboratory stage by the outbreak of war, although the operational techniques were to be improved and far-reaching new devices produced later on.

Defence Against the Night Bomber

The early Army sets could not give the position of the enemy aircraft quite as exactly as the guns required, and visual correction was not always possible, particularly in cloudy



The transmitter and receiver of a Ground Controlled Interception Station. This equipment was placed underground near the aerial system. On the circular screen of the cathode ray oscilloscope the positions of the raiders and our night fighters were shown, our own aircraft being distinguished from the enemy's by a periodic modification of the returning wireless echo.

weather. The struggle to improve the sets became intense, and gradually the anti-aircraft fire began to achieve a higher and higher toll of the raiders. In this it was assisted by the Radar-controlled searchlights.

Radar-controlled anti-aircraft gunfire thus played a ground *rôle* in the victory over night raiders, the aerial complement to which was provided by ground-controlled, Radar-carrying night fighters, which achieved remarkable and growing successes. This fighter *rôle* was early foreseen as one of the applications of Radar to the offensive in defence; if fighter aircraft could be made to carry a complete miniature Radar station, they could seek out and even fire on enemy aircraft in cloud or on the darkest night, provided they were directed by ground Radar stations to within suitable range for detection. The 1½-m. wavelength equipment was adapted for this purpose, although the need for aerials projecting from the wings of the small fighters was a sore point with aircraft designers. The night fighter crew had a hard enough job to attend to flying and fighting, and to undertake what amounted to a complicated laboratory experiment as well, was almost the last straw.

Another remarkable development used in one version of the system was the device of making the enemy echo itself as a spot which grew wings as the enemy approached, moving up or down to port or starboard, just as the appearance of the enemy itself would have done had it been visible. On many occasions successful interceptions were marked by, first, the appearance of the telltale green spot somewhere away from the line of flight of the fighter ; then the pilot's rapid adjustment of his course and altitude to bring the spot seen by his observer ahead and centred ; then the appearance of wings as the distance lessened. Finally the pilot would see the real enemy, a dark shape in the night sky, in a position corresponding to the green patch which hovered in the miniature Radar "picture."

The Radar-controlled Army searchlights were also extensively used to assist the fighters to intercept. Great skill was shown by the operators of these searchlights in illuminating the enemy and keeping him in the beam in such a way that the fighter could close to the kill without himself being illuminated while having every opportunity to see and surprise the enemy. The 1½-m. Radar in fighters was limited in range, however. Reflections from the ground obscured target aircraft at ranges greater than the flying height, and it was necessary to develop a pencil beam to probe the sky, avoiding the ground. That could only be done by much shorter waves, and the solution was to come with centimetric Radar.

CENTIMETRIC RADAR

During the war a group of research scientists at Birmingham University devised the modern magnetron valve, which proved to be the gateway to the great new fields of centimetric Radar. It was, in fact, the outstanding development since the original chain took shape, and it remains the keystone of the greater part of modern Radar. Until 1938, the single research team working on valves specifically for the three Services' use, had been that at the Admiralty Signals School, but the pace quickened towards the outbreak of war and in the autumn of 1939, extra teams were called in for work on behalf of all the Services, still sponsored by the Admiralty, on what appeared then to be the distant goal of designing valves for centimetric Radar. The Birmingham team's achievement was such that the magnetron is now used as the transmitter in all the centrimetric Radar equipment which makes possible the present applications in the air and sea war.

Centimetric equipments not only solved the problems of the range and definition needed by night fighters' Radar ; the new techniques brought in their train such inventions as the moving map-like device which served our bombers in obliterating German targets, and they have served similarly to increase radically the accuracy of equipments used in hunting the enemy at sea and in many other branches of warfare. Centimetre waves have enabled the target data to be fed into A.A. predictors and coastal artillery batteries with such great precision of range measurement, and accuracy of bearing and elevation, as to surpass the inherent accuracy of the guns themselves. The success of these methods can be gauged from the story of the flying bomb attacks, by the end of which Radar-aided anti-aircraft guns were accounting for between 80 and 100 per cent. of the bombs reaching them.

It was appreciated, right from the start of this war, that the detection of surfaced submarines demanded some means other than ASDIC ; but Radar equipment designed for the detection of aircraft was inadequate in this case, and for detection of submarines both from the air and from surface ships, it was the centimetre-wave equipment which provided a decisive solution. The problem it solved was no less than finding, on a pitch black night in an area of many square miles of sea, a piece of metal projecting from the surface of the water by little more than the height of a man.

Before that time it had been apparent that for most naval purposes small aerial systems, capable of producing narrow beams, would be essential ; intensive research into the use of shorter wavelengths by all Services which was applied to naval problems bore an early fruit in 1938. At that time experimental equipments for the detection of aircraft were installed in a battleship and a cruiser and it immediately became apparent that the Navy could provide its own cover against air attack, a factor of vital importance in maintaining our sea power.

Still other centimetre-wave devices can, as already indicated, find towns for our bombers on the darkest, cloudy night and even display a moving map of harbour details, railway lines, and similar features. The immediate success which followed the application of centimetre-wave Radar to long-range bombing deserves particular mention.

The sound strategic decision to withhold the use of such devices until enough had been produced to make a succession of devastating attacks on Germany's great industrial centres, was well repaid. The premature loss of one such equipment to the enemy might have destroyed that element of surprise which, in fact, made impossible any effective reply by the enemy. The proportion of bombs falling on worthwhile targets was greatly increased, and the other offensive and defensive functions of aircraft fitted with Radar devices made more effective by centimetre techniques. It has been shown by statistical analysis of operations that airborne Radar apparatus multiplies by more than five times the value of an air fleet costing ten times as much as itself, quite apart from reduction in the numbers of crews needed and the safeguarding of valuable lives.

At sea and in the air, Radar navigation by these and by other longer-wave devices is now possible with an accuracy which makes the finest achievements of stellar navigation seem inaccurate by comparison. A ship's navigating officer can fix the position of a ship at sea by the stars or solar observation to within about a mile of her true position ; an aircraft can seldom rely on better position finding by astronomy than to within 10 miles of her true position. Yet it is now possible, by various devices, to have continuous indication of the position of a ship or aircraft to within a few tens of yards of her true place on the earth's surface. Indeed, no map or chart can be printed with sufficient accuracy or permanency to vie with the accuracy possible with the equipment.

(To be continued)

Plastic Armour

By DR. J. P. LAWRIE,*

THIS is the story of "plastic armour," a product of naval scientific ingenuity which saved thousands of lives and tons of steel.

In the grim days of Dunkirk, it was observed on some of the "little ships" with bituminous flooring, that bullets from attacking aircraft failed to penetrate, but were retained in the deck composition. Examination showed, that although these stopped bullets were probably almost spent, or had arrived at an angle, the composition of the deck sheathing tended to prevent penetration, and an investigation of the possibilities of developing a "plastic armour" was begun.

The deck sheathing mentioned is usually a form of mastic asphalt, consisting primarily of bitumen and limestone powder to which is added some grit. Heated, the ingredients form a soft paste, which, spread in position, hardens when cool. In peacetime it is mainly used for covering flat roofs, floors, or as a road surfacing.

In August, 1940, the Admiralty requested the Road Research Laboratory of the Department of Scientific and Industrial Research to carry out an investigation to ascertain whether a bituminous mixture of this nature could be produced which would provide superior protection against aerial attack to the sand-cement concrete slabs then in use on merchant ships. Concrete, used thus to protect wheel-houses and gun positions, was found to be ineffective and very dangerous, on account of flying fragments.

Experience with bituminous road materials and in the development of structural materials to resist attack by shell splinters and projectiles provided a valuable background for the investigation. Their research on concrete led the laboratory to the belief that the use of larger particles of stone would improve the resistance of plastic armour. Trials showed that, using a larger stone in the ratio of 50 per cent. to the asphalt, 0·303 armour-piercing bullets were stopped by a protection weighing only 38½ lb. per square foot, compared with 50 lb. per square foot for concrete.

As the weight of solid mild steel to give protection against 0·303 A.P. bullets is 36 lb. per square foot,† it was apparent that in view of the acute shortage of steel and armour plate then prevailing a stone-filled mastic asphalt offered good possibilities as a protective armour.

Further investigations were conducted to ascertain whether plastic armour would give the same protection at extremes of temperature, whether high temperatures affected its resistance to flow, and whether it was likely to catch fire during an attack.

Satisfactory results were obtained, a working specification was drawn up, and under the joint supervision of the Admiralty and the Laboratory, exactly one month after the research had been begun work was commenced on the armouring of vital parts of a merchant ship.

This first *in situ* plastic armour had the following composition :—

	Per cent. by weight.
⅝ in. granite chippings	55
Limestone powder	37
Soluble bitumen	8

The "plastic" for plastic armour is made by mixing the stone and bituminous mortar in a normal 4 to 8-ton capacity mixer, as used in the asphalt industry, for three to four hours, after which the mixture is run off and poured into the space between wood or steel shuttering and the surface to be protected. Removal of the shuttering, leaves the plastic in position. In the early days of plastic armour prefabricated 2½in. slabs with a ⅜in. mild steel backing, were produced by spreading the plastic in horizontal wooden moulds. These slabs were used around wheel-houses, radio rooms, machine gun posts, or any other position requiring protection, especially where vision slots, ports, or vents were required. The steel walls of deck-houses provide ready-made backing for *in situ* plastic armour, but when precast slabs are used a steel backing plate is provided to the slab.

Towards the end of October, 1940, when initial difficulties of manufacture and application had been overcome, a more detailed investigation into the principles of design of plastic armour was begun. The first tests were chiefly concerned with stopping A.P. shot, but tests were later made with bomb and shell splinters and 20 mm. H.E. shells.

Plastic armour consists of a packed mass of stone particles held together with a bituminous mortar and backed with a mild steel plate. The stone particles break or turn the bullet or projectile, and the ductile steel back plate stops the relatively slow fragments of shot and stone which would otherwise be projected from the back of the plastic. The bituminous mortar plays little part in the protection beyond holding the stones in position.

PLASTIC PROTECTIVE PLATING

It was soon obvious that the type, size, and amount of stone were the most important factors affecting the protective qualities of plastic armour. Experimental targets of plastic armour were first made therefore with some fifty different types of stone. The results of tests made with 0·303in. A.P. bullets showed that

* Royal Naval Scientific Service.
† About ⅞in. Thick—Ed., THE E.

certain flint and quartzite gravels gave the best protection. The granite, which was then in use, was immediately superseded by these new materials.

The next factor investigated was the best size for the stone particles. Tests were made with 0·303in., 0·55in., and 20 mm. A.P. shot on plastic containing as wide a range of stone size as possible. It was found that best protection was obtained when the size of the stone particles was twice the diameter of the shot to be stopped. Later tests with bomb and shell splinters showed that against this type of attack the size of stone in the plastic had no effect on the efficiency of protection.

When tests were made to find how the proportion of stone to bituminous mortar affected protection, it was found that, when special methods of consolidation were used, 70 per cent. by weight of stone could be packed into the plastic, resulting in a considerable improvement in protection over the existing plastic, which contained only 55 per cent. of stone. Unfortunately, plastic with such a high stone content, could not be consolidated behind shuttering or by hand in moulds. Advantage was taken of this discovery, however, in the development of a new form of plastic armour, known as "plastic protective plating."

Plastic protective plating is made by consolidating the hot plastic by vibration into "trays" of thin sheet metal, and then bolting on the back plate to the open side of the tray. In this way the plastic is totally enclosed in metal. This gives the plastic protective plating a much greater resistance than plastic armour to incidental damage from attack and during transport, and, what is more important, it allows the best proportion and size of stone to be used.

Special Light-Weight Plastic

In 1942, at the time plastic protective plating was introduced, it became desirable to reduce imports of bitumen, and the problem arose as to whether pitch could be used in its place. When tests were made it was found that the use of pitch allowed better consolidation of the plastic. Advantage was taken of this fact to develop a special light-weight plastic consisting of pitch, fine sawdust, and lime for use in plastic protective plating.

Plastic protective plating was not only lighter in weight and more efficient and of better appearance than plastic armour, but it lends itself particularly to factory mass production; by the end of 1942, the majority of gun positions were being protected by plastic protective plating instead of *in situ* plastic armour. Since then the proportion of plastic protective plating used has increased steadily.

Plastic protective plating first went into action in the Dieppe raid, when 2½in. non-magnetic plastic protective plating with ¼in. brass backing, used to protect the helmsman, was hit by small arms A.P. shot, 20 mm. H.E. shells, and at least one 4in. mortar bomb. Only one splinter from the mortar bomb perforated the protection and everything else was stopped. This result confirmed the suitability of plastic protective plating for use on landing craft and resulted in its wide use in preparation for D-day.

The protective qualities of plastic protective plating compared with steel armour plate varies to some extent according to the type of weapon with which it is attacked. Against A.P. shot it is better than mild steel, but not as good as armour plate. For example, if the weight per square foot of plastic protective plating required to stop A.P. shot is represented by 100, the weight for armour plate is 75 and that for mild steel is 116 and that for plastic armour of the original type 122. (The actual weight of plastic protective plating required to give protection against 0·303in. A.P. bullets at muzzle velocity, is 30 lb. per square foot.) Against bomb splinters the degree of protection varies with the speed of the splinter, *e.g.*, for splinters at 5000ft. per second, say, from a 500-lb. bomb or large shell, plastic protective plating is more efficient than an equal weight of steel armour. Against splinters striking at 3000ft. per second, say, from a German S.D.2, butterfly bomb, plastic protective plating and steel armour would give equal protection; at a striking velocity of 1500ft. per second, such as would be expected from fragments of an "S" mine, plastic protective plating gives equal protection to mild steel, but is inferior to steel armour.

The good resistance shown to splinters from large shells and bombs has been proved on a number of occasions on ships passing through the Straits of Dover during the shelling.

By May, 1943, approximately 100,000 tons of P.A. and P.P.P. were being produced annually, and it was being made in Canada, South Africa, India, and the Middle East. In 1941, officers specially instructed in its manufacture were sent to the U.S.A., where production was immediately begun.

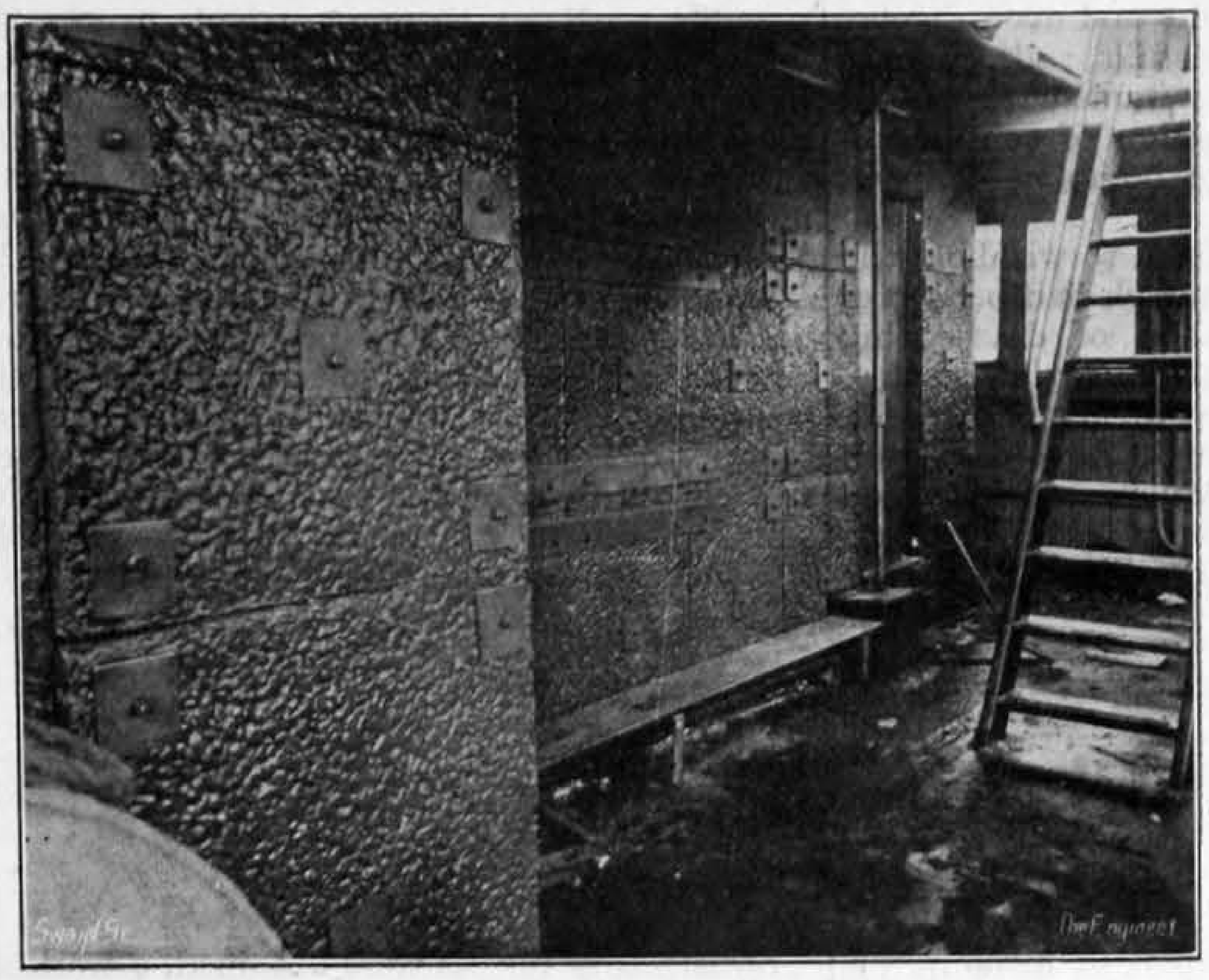
Preparing for D-Day

During the "Battle of the Atlantic" the plastic armour used was of the *in situ* variety, while P.P.P. was installed on ships in preparation for D-day in enormous quantities. Special plates were made for use on bulldozers and flame-throwers to give protection to their drivers. In practice it has been found that the protection offered is in excess of that anticipated. Parts of "Mulberry" prefabricated harbour were also fitted with P.P.P. and there have also been land uses, such as portable blockhouses, for which 137,000 plates were made.

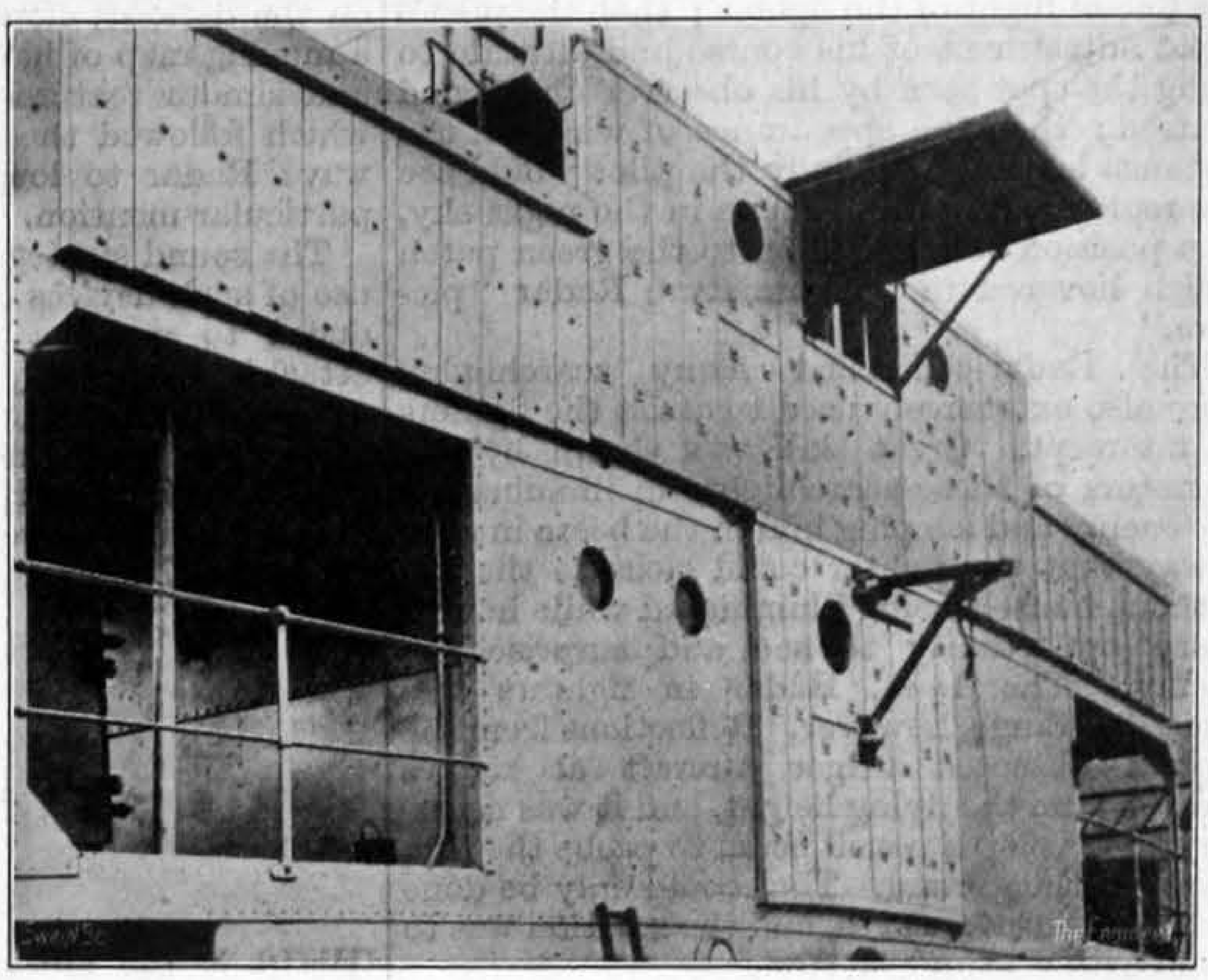
Special barges fitted with large tanks for carrying petrol and water were protected by a framework of steel carrying P.P.P. over the top part of the tanks and with large quadrant slabs at the ends.

As enemy aircraft were sneaking over and firing at our coastwise railway engines, experiments were made to protect the locomotives, and at Eastleigh the cab of the engine "King's School, Wimbledon," was fitted with 2½in. P.P.P. special size slabs, but the matter was not furthered as these raids ceased during December, 1942.

It is highly satisfying to record, albeit briefly, this history cycle of a development sponsored by the Royal Navy, which, while saving lives and steel, has done much to foster and maintain the high morale of the Merchant Navy.



Plastic Armour Slabs for Bridge Protection



Plastic Protective Plating for Bridge Protection

Plastic Protective Plating for Lorry

Damage to P.P.P.—No Casualties

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer

Iron and Steel Production

After an interval of six years, publication has been resumed of the monthly production figures of pig iron and steel ingots and castings in the United Kingdom. Weekly average figures for each month from the beginning of this year to July, with the annual production rate given in parentheses, are as follows :—Pig iron, January, 127,000 tons (6,611,000 tons); February, 136,700 tons (7,109,000 tons); March, 141,400 tons (7,354,000 tons); April, 137,600 tons (7,154,000 tons); May, 128,200 tons (6,668,000 tons); June, 132,800 tons (6,906,000 tons); July, 134,800 tons (7,010,000 tons). For steel ingots and castings the figures are :—January, 216,300 tons (11,245,000 tons); February, 241,400 tons (12,553,000 tons); March, 246,100 tons (12,799,000 tons); April, 236,600 tons (12,302,000 tons); May, 210,800 tons (10,962,000 tons); June, 238,200 tons (12,386,000 tons); July 213,800 tons (11,118,000 tons). It should be noted that steel production figures for July were affected by holidays in many of the steel-making districts, and that output in May was down on account of the VE and Whitsuntide holidays.

Pig Iron

There are no substantial changes in the pig iron position, and the desirability for starting up additional blast-furnaces to meet a growing demand is accentuated. Fuel supplies, however, continue to present a difficulty and are an important factor in any consideration of increased pig iron output. Shipments of high-grade ores from Sweden and also North Africa are now reaching this country, and are making the raw material position easier. High-phosphorus iron is the principal demand at present, and it is not easy to meet the increasing requirements of consumers. The light castings trade, although limited by a labour shortage, has become more active in recent months, chiefly on account of an expanding demand for castings wanted for building operations and for allied domestic purposes, and progress with housing and other building schemes must inevitably bring greater pressure upon the light castings foundries. Other grades of pig iron, although by no means plentiful, have recently been in better supply. General engineering and jobbing foundries in most districts are fairly well employed, but now that contracts for castings required for armament work have been completed, they are in a position to take on other orders. Nevertheless, the present production of low and medium-phosphorus irons is steadily taken up, but the supply position is not so tight as it was a few months ago. The hematite position is also a little easier, but the available tonnages are still allocated carefully, and refined iron is employed as a substitute where possible. Business in the market for ferro-alloys has not been at all active in recent weeks. Now that the holiday period has been generally concluded, a little more interest is being shown, but the probable suspension of war contracts will most likely mean restricted business in this market for the present.

Scotland and the North

The position of the Scottish iron and steel industry is steadily improving and the victorious conclusion of the war will, it is hoped, soon lead to a fuller development of civilian trade. During the last six years the needs of the war have, of course, been the primary concern of the iron and steel industry and, up till the time of victory in Europe, there was little opportunity to give attention to civilian business. In the last two or three months, however, a gradual transition to work of a peacetime nature has begun, but the industry has been maintained on a wartime basis to meet any needs of the Japanese campaign which might arise. Consequently, many departments have not been recently employed to their normal capacity. Existing war contracts will now be reviewed, but there is a big potential demand both on home and overseas account for iron and steel. Export inquiries are increasing, and home needs for reconstruction work of various kinds are considerable. Fuel supplies continue to give anxiety to iron and steel producers, and will certainly need to be improved if outputs are to be maintained. Whilst there is not, at present, very much call for heavy steel joists and sections, business in steel plates is making headway. Merchant shipbuilding orders have imparted greater activity to the plate mills, and locomotive and rolling stock builders are absorbing fair quantities. Producers of light-gauge black and galvanised sheets continue to be fully employed, and there is little likelihood that orders recently placed will be delivered until Period IV of this year or the beginning of next year. The re-rolling branch of the industry is not very busy at the moment, and in the past few months there has been a decline in orders for small bars and sections. When it becomes permissible for re-rollers to take more export business for bars and sections under 3in. diameter, some increase of activity may be expected. In the Lancashire iron and steel trades no development of outstanding note has taken place in the last week or two. Although there has not been much market activity following the Victory holiday, there is a fair amount of work in hand. Fairly good tonnages of steel plates are being taken up, although rollers of light and medium plates have been mainly concerned with Government contracts, which may be reviewed now that the war has ended. Makers of light-gauge black sheets are well booked and in some cases are now committed until the end of the year. Business in mild steel bars is steady, and there is a regular demand for black bars for bright drawing. There is an active trade in most semi-finished steels. Good tonnages of blooms and billets are taken up by forge masters and crankshaft makers, and the wire mills keep up a regular demand for rods and billets. The Lancashire foundries are moderately busy, and there is a regular demand for most grades of pig iron. A certain amount of new business has been taking place, but there has not been any general increase in the tonnages licensed. Business in finished iron has shown little change. Both best-quality and Crown bars are in regular request.

The Midlands and South Wales

Increased activity in the Midlands iron and steelworks has been generally maintained since the annual holidays, and although the immediate demand may now be influenced to some extent by the end of the war with Japan, there are indications of fuller development of business in coming months. The growing number of inquiries from overseas points to an expansion of export business, and the export orders already placed will do much to ensure active operating conditions for some time. As readjustment to peacetime production proceeds, it will no doubt be possible to increase the tonnages available for export, and when the growing demand is also taken into consideration it will be realised that busier conditions in the iron and steel industry may be confidently expected. Many sections of the steel trade now have a good volume of work in hand. The demand for plates has strengthened in recent weeks, and the sheet mills are working to capacity. Pressure for deliveries of light-gauge black and galvanised sheets has increased during the last few months, and sheet makers for the most part find themselves fully committed for the remainder of this year. Re-rollers of bars, strip and light sections are fairly well employed, and with indications of a bigger demand are anxious to improve their supplies of billets. Since the cessation of imports of semis at the end of last year, users have been mainly dependent upon home production, which is being maintained at a high level. Stocks have become depleted, and re-rollers are readily taking up suitable defective material as well as such tonnages of primes as they are able to acquire. Rails and colliery arches and bars have a brisk demand, and there is some improvement in the request for special steels. The foundries continue to be fairly well employed, and producers of light castings are receiving an increasing amount of work. There is no change in supplies of high-phosphorus pig iron, which continue to be just about equal to the existing need of the light castings foundries. General foundries which have been primarily engaged on castings for armaments are now in a position to take on more work. Low and medium-phosphorus pig irons are in better supply, and there is also less stringency in allocations of hematite. The finished iron industry has sufficient work in hand to cover the present period. Best bars are in regular request, especially from railway wagon builders, and business in Crown bars is moderately good. A sustained demand for semi-finished material is the outstanding characteristic of the South Wales steel industry. Producers of soft and other steel billets are not finding it at all easy to keep pace with this keen demand, although big outputs are maintained. Makers of steel sheet and tinplate bars are also working at considerable pressure. In finished steel, there has been an improvement in the demand for heavy plates and sections during the last few weeks, which is resulting in the placing of additional orders. Business in steel sheets is very brisk and many of the sheet mills are unable to take on fresh orders except at considerably extended delivery dates. The tinplate market has resumed its activity following the holiday period, and a satisfactory amount of business has been transacted during the last week or two. Home users have now placed most of their requirements for the present period, and recent bookings are for later delivery.

North-East Coast and Yorkshire

It is, of course, too early to say what effect the conclusion of the war will have upon the North-East Coast iron and steel industry, but conditions will undoubtedly change to some extent as it becomes possible to undertake the big volume of business which will arise in the period of world reconstruction. In recent months contracts associated with the actual needs of the war have been declining, but they have nevertheless been the industry's primary concern. The demand for what may be termed peacetime products has, however, been strengthening, and production is at a high level. Home civilian business is steadily increasing, and the amount of export orders so far permitted indicates a busier time for plants which have not recently been fully occupied. Foundries engaged in the production of light castings continue to be as actively employed as their labour strength permits, and their commitments will obviously increase with the growing demand for castings needed for building purposes. Present allocations of foundry pig iron are scarcely sufficient to meet requirements, and although there has been an improvement in supplies of hematite, careful control continues to be exercised. Restricted supplies of coke make it difficult to start up additional blast-furnaces. Business in finished steel is being very satisfactorily maintained. The demand for heavy steel joists is becoming more active, and can be reasonably expected to improve as reconstruction schemes proceed. The placing of new shipbuilding contracts has resulted in a growing number of orders for plates and other shipbuilding material, while mills producing steel rails and other permanent way material have considerable work on hand both for home needs and for reconstruction on Continental railways. Another prominent feature is the regular demand for steel arches, props, and bars required for maintenance work in the collieries. Business in sheets is at the high level which has been so pronounced since the beginning of the year. Big tonnages of light-gauge black and galvanised sheets are being absorbed for a number of purposes, both at home and on the Continent, and producers are now fully booked for the rest of this year. The demand for sheet bars therefore remains very strong, and big quantities are passing continually into consumption. Supplies of sheet bars appear to be better in many instances than those of other semis and there is a good deal of pressure for increased deliveries of billets and blooms. Defective material is being taken up readily, in addition to primes. The amount of business reaching the Yorkshire iron and steel trades is satisfactory, and makers of various steel products have a good deal of work in hand. Shipbuilding material departments, in particular, are well booked, and makers of agricultural machinery are another active branch. Export inquiries are numerous and a fair amount of overseas business is now being handled, although a shortage of labour in many departments is hindering development. Trade in basic steel remains moderately active, and acid-carbon steel is also in regular request.

Consumption of Non-Ferrous Metals

On this page of our issue of June 22nd, a summary was given of the detailed figures issued by the Ministry of Supply relating to the consumption in the United Kingdom during the war years of metals coming within the scope of the Non-Ferrous Metals Control. These metals are copper, zinc, lead, tin, nickel, cadmium, antimony, cobalt, and manganese, and the figures were given up to the first quarter of this year. The Ministry has now made available figures relating to the second quarter of 1945, and the total consumption figures of virgin metal only are given in tons, in the following table. For comparison, figures for the year 1944 and for the first quarter of 1945 are repeated. It may be noted that in the first half of 1945 consumption in most metals, especially copper and nickel, was below the 1944 total reflecting the reduced demand for munitions :—

	Year 1944.	First quarter, 1945.	Second quarter, 1945.
	Tons.	Tons.	Tons.
Copper	348,139	81,103	72,378
Zinc	184,241	45,411	43,109
Lead	205,385	51,517	55,265
Tin	18,435	3,949	4,067
Nickel	12,420	2,431	2,214
Cadmium	377	114	121
Antimony	4,772	1,265	1,348
Cobalt	787	195	168
Manganese metal	861	144	134

Notes and Memoranda

Rail and Road

THE LATE MR. LOFTUS ALLEN.—We note with regret the death, on August 10th, of Mr. G. H. Loftus Allen, advertising and publicity officer of the London Midland and Scottish Railway and chairman of the Railway Executive Publicity Committee.

"CYCLO-TRACTORS."—In an article entitled "The Mobilisation of Muscle," a correspondent of *The Economist* says:—"Clearly worth considering among other instruments which correct analysis and purposive development will call into existence, are suitably geared bicycle type structures, though with four wheels, seating twenty to thirty men, to get moving on railway and road every mobile vehicle from those of least resistance such as goods wagons, down to carts, pending the production of further and perhaps more appropriate vehicles. With such "cyclo-tractors" on railway tracks, men exerting one-eighth of a horsepower each could move 45 gross ton-miles (30 ton-miles of freight) a head in an eight-hour day, assuming the wagon to be always fully loaded. That is 90 to 110 times the 0·4 to 0·5 ton-miles which a trained man can accomplish by portering, *i.e.*, without any equipment. To arrive at the transport capacity of relatively primitive equipment, the writer arranged a test with a Covent Garden barrow, itself weighing 2¾ cwt., and carrying a load of ½ ton. With this a porter, possibly of over average strength, moved by road 11¾ gross ton-miles (9 ton-miles net) in an eight-hour day—23 to 29 times what can be done without equipment."

RAPID RAILWAY CONSTRUCTION.—It is interesting to note from *The Railway Gazette* that the longest section of railway line opened on the same day, one hundred years ago, was that between Bishops Stortford and Norwich, upon which public traffic began on July 30th, 1845. This line had been promoted by three companies, the section from Bishops Stortford to Newport by the Northern and Eastern Railway that from Newport to Brandon by the Eastern Counties Railway (which had leased the Northern and Eastern), and the remaining portion from Brandon to Norwich (Trowse) by the Norwich and Brandon Railway, which became the Norfolk Railway before the line was completed, and was absorbed by the Eastern Counties a few years later. All these lines eventually formed component parts of the Great Eastern Railway, which in 1923 became a constituent company of the L.N.E.R. The firm of Grissell and Peto, which erected the Houses of Parliament and the Nelson Column in Trafalgar Square, was the contractor for the greater part of the line. The 10-mile portion between Bishops Stortford and Newport had been authorised in July, 1843, but the remaining 46 miles to Brandon was sanctioned by Parliament only in July, 1844, and, by completing this section within twelve months—nearly a year before the time specified in the contract—the contractor earned a bonus of £25,000 to cover the extra outlay involved. The 37¾ miles from Brandon to Norwich (Trowse) was a double line built in fourteen months, at a cost of £8283 a mile.

Air and Water

THE "QUEEN ELIZABETH."—The Cunard White Star liner "Queen Elizabeth" arrived at Southampton from New York on Monday morning, August 20th, with service and civilian passengers on board. It was the first time she had docked in her home port. Since 1940, the "Queen Elizabeth" has steamed 447,054 miles, carrying 688,425 Service men of the Allied Nations.

Miscellanea

INSTITUTE OF METALS.—The autumn meeting of the Institute of Metals will be held at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, on Wednesday, September 12th. The morning session will begin at 10 a.m., and after the formal business the following papers will be presented:—"An Electron-Diffraction Study of the Atmospheric Oxidation of Aluminium, Magnesium, and Aluminium-Magnesium Alloys," by L. de Brouckère; "The Application of the Vacuum-Fusion Method to the Determination of the Oxygen, Hydrogen, and Nitrogen Contents of Non-Ferrous Metals, Alloys, and Powders," by H. A. Sloman; and "Some Effects of Oxygen in Silver and Silver Alloys," by J. C. Chaston. A buffet luncheon, price 4s., will be provided for those members who apply for tickets, and an afternoon session will begin at 2.15 p.m., when papers will be presented on "Microporosity in Magnesium Alloy Castings," by W. A. Baker; and "The Properties of Some Magnesium-Aluminium-Zinc Casting Alloys and the Incidence of Microporosity," by F. A. Fox.

CORK FOR PRESS FORMING.—An American company has developed a cork composition for use as a forming medium on presses in a similar manner to that in which rubber is being used. Known as "Hydrocork," the material is said to have great compressibility and, as it transmits pressure to the work in straight lines, does not need to be confined in a retaining box in the same way as a rubber pad.

GREATER LONDON PLAN.—A preliminary edition of Sir Patrick Abercrombie's Greater London Plan was issued to the local authorities concerned and to the Press in December, 1944. It was then explained that a fully illustrated edition with coloured maps, diagrams, and photographs would be published as soon as practicable. Copies of this complete edition may now be obtained from H.M. Stationery Office, York House, Kingsway, W.C.2, price 25s. (inland postage 8d.).

PREPARATORY WORK FOR POST-WAR TRADE.—Manufacturers wishing to undertake preparatory work for post-war trade have hitherto had to make individual application to the Board of Trade. It has now been decided that it will no longer be necessary for manufacturers to obtain this specific authority before undertaking preparatory development work of this kind, but it will still be necessary for firms to obtain licences for raw materials which may be required for development work and for actual manufacture where this is subject to control. Shipbuilders and boat builders are reminded that their obligations under the Restriction of Construction of Ships Order are not affected. Demands for draughtsmen and certain other types of skilled workers required for design and development work are likely for some time to exceed available supply. Manufacturers should continue, therefore, to do as much of their development work as possible with existing staff, but where important development work is likely to be seriously retarded on account of shortage of staff, vacancies for draughtsmen and other workers required should be notified to the Ministry of Labour and National Service. The supply of workers against such demands, however, will be dependent on the extent to which such labour is required for other priority work. The request for permission to undertake development work has afforded to the Board of Trade valuable information especially where development of production of manufactures normally imported is intended. The Board accordingly hopes that industry will continue to keep it informed of important new developments in their early stages.

ADMISSION OF NON-MEMBERS TO MEETINGS OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—In September, 1943, the Council instituted a scheme for making the technical meetings of the Institution accessible to those who may be interested in the proceedings, but who may consider that their technical experience and educational attainments do not suffice to admit them to any form of Institution membership. In providing this facility, the Council had particularly in mind the injunction of Clause 4 of the Royal Charter (". . . to promote the general advancement of electrical science and engineering and their applications and to facilitate the exchange of information and ideas on those subjects amongst the members of the Institution and otherwise. . ."). The Council has recently reviewed the working of the scheme during the past two sessions and is satisfied that it has performed a useful function. It has decided that it should be continued for the coming session, and has accordingly ordered that a person in the category outlined above who is interested in the proceedings at ordinary meetings, section meetings, local centre meetings, and informal meetings, shall be provided by the Secretary with an application form, on the completion of which and on payment of a fee of 10s. to cover administrative costs, he may receive notices of meetings and an invitation card which will serve as a title of admission to the technical meetings of the Institution to be held during the forthcoming session in London and in the provinces. The possession of the invitation card will not confer upon the holder any status within the framework of the Institution, nor will he have the right to join in the discussions without special permission from the chair. Those interested in this new facility, whether they reside in London or in the provinces, should apply to the Secretary of the Institution for further details and form of application.

FUEL-SAVING AND FUEL-BURNING EQUIPMENT.—In order to assist the changeover of industry to peacetime production, the Board of Trade has for some time been engaged in simplifying the licensing control on the supply of individual items of plant and machinery. Wherever practicable, the Board of Trade is now issuing bulk licences to the machinery manufacturers, authorising them to supply controlled machinery and plant up to a value related to the capacity expected to be availbale for a period ahead. The system of bulk licensing is now to be extended to those items of fuel-saving and fuel burning equipment which the Ministry of Fuel and Power has been authorised to license during the past eighteen months. The Board of Trade therefore proposes to issue bulk licences to the manufacturers of most of the controlled goods affected, and, as these are granted, it will no longer be necessary for purchasers to obtain individual licences from the Ministry of Fuel and Power in order to acquire goods from the licensed manufacturers. After September 30th, 1945, no further licences will be issued by the Ministry of Fuel and Power, but supplies by manufacturers will be subject to licence by the Board of Trade—Industries and Manufactures (Engineering) Department, Millbank, London S.W.1. While it is hoped that this alteration in licensing procedure will be accompanied by an increase in the production of fuel-saving equipment, so necessary to meet the coal position during the coming winter, the Ministry of Fuel and Power Regional Fuel Efficiency Committee secretaries will make every effort to assist purchasers who find difficulty in securing delivery of such equipment.

Personal and Business

MR. J. G. GIRDWOOD has been appointed a director of William Beardmore and Co., Ltd.

MR. JAMES PRATT, general manager, and Mr. E. F. Edwards, secretary, have been appointed to the board of Rubery Owen (Warrington), Ltd.

DAVID BROWN AND SONS (HUDDERSFIELD), Ltd., have opened an area office at 109, Pilgrim Street, Newcastle-upon-Tyne.

DR. W. T. GRIFFITHS has been appointed chairman of the Mond Nickel Company, Ltd., and of its subsidiary companies, in succession to the late Mr. D. Owen Evans, M.P.

SIR LEONARD BROWETT has been appointed director of the National Union of Manufacturers, in succession to Sir Charles Hipwood, who has retired in consequence of indifferent health.

DR. A. H. MIDDLETON has retired from his executive position after forty years as head of the coke and brickworks department of Consett Iron Company, Ltd. He has been succeeded by Mr. G. M. Nave, previously manager of the company's Fell coke works and for the past three years Dr. Middleton's chief assistant.

MR. T. E. NIXON, Director of Light Metals Control (Sheet and Strip) at the Ministry of Aircraft Production since 1941, is returning to Northern Aluminium Company, Ltd., as from September 1st. He will take up the position of assistant manager of the London area sales office, which will be reopening in October.

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 on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meetings is to be held should be clearly stated.*

Cornish Engines Preservation Society

Saturday, Sept. 8th.—Council Chambers, Municipal Buildings, Falmouth. "The Place of the Cornish Pumping Engine in the Development of the Steam Engine," H. R. Lupton. 3 p.m.

Institute of Marine Engineers

Tuesday, Sept. 11th.—85, The Minories, E.C.3. "The Operation of Water-tube Boilers at Sea," Major W. Gregson. 5.30 p.m.

Institution of Production Engineers

Saturday, Sept. 1st.—HALIFAX SECTION: Technical College, Halifax. Special meeting. 2.45 p.m.

Wednesday, Sept. 5th.—MANCHESTER SECTION: College of Technology, Manchester. "Radiology as Applied to Production," R. W. Eade. 7.15 p.m.

Saturday, Sept. 8th.—SHREWSBURY SUB-SECTION: Technical College, Shrewsbury. "The Theory of Ferrous Heat Treatment," B. Thomas. 3 p.m.

Monday, Sept. 10th.—COVENTRY SECTION: Technical College, Coventry. "Some Post-War Uses of Wrought Aluminium Alloys," E. G. West. 6.45 p.m.