The Shannon Hydro-Electric Power Development Scheme.

By Dr. BRYSSON CUNNINGHAM.

ALTHOUGH not quite equal in capacity to the leading modern hydro-electric installations of the North American continent, some of which have been noticed in previous issues of NATURE,[1] the Shannon undertaking, which is now at the point of effective operation for partial development, is a notable enterprise for a country of the size and resources of the Irish Free State. Indeed, it may justifiably be described as a national adventure, ambitious in scope and fraught with momentous economic consequences. On one hand, its promoters and advocates expect it to rehabilitate the industrial activities of the country; on the other hand, doubts have been, and continue to be, freely expressed as to the possibilities of its financial success. The boldness of its conception in unpropitious circumstances and the importance of the rôle which it is designed to play in the resuscitation of Irish industry, entitle it to attention as a remarkable engineering achievement of modern times.

Actually under consideration and execution for the past six years or so, the inception of the scheme really dates back to the year 1918, when the British Government became anxious about the shortage of coal supplies, and, searching for other sources of power, appointed in June of that year a committee to report on the water power resources of the United Kingdom. In the following November a sub-committee for Ireland was nominated with the same terms of reference. As the reports and findings of these committees have already been published and commented upon in NATURE, there is no occasion to say more here than that the Irish Sub-Committee selected four rivers (the Shannon, the Erne, the Bann, and the Liffey) for investigation, and made them the main theme of their Report of Dec. 6, 1920, together with a number of important recommendations on water power development generally.

The matter was further considered by a Commission of Inquiry into the Resources and Industries of Ireland which reported in 1922. The next step appears to have been taken on the initiative of the German firm of Siemens-Schuckwerke, which in February 1924 placed before the Irish Free State Government certain proposals for developing the hydro-electric capacity of the Shannon. In September of the same year the Free State Government referred these proposals to four continental experts (Messrs. Waldemar Borgquist, of Stockholm, Eugen Meyer-Peter and Arthur E. Rohn, of Zurich, and Thomas Norberg Schulz, of Christiania (Oslo)) for consideration. The report of these engineers was favourable, subject to some suggested modification of the plans in detail. The Irish Government thereupon adopted the scheme and initiated legislation in order to give it effect. Passed by Dail Eireann in April 1925 and by the Oireachtas in the following June, the Shannon Electricity Act duly became law, and the execution of the necessary constructional works was forthwith entrusted to the German company.

FIG. 1.—The basin of the river Shannon.

The Shannon is the longest river in Ireland, and, indeed, in the British Isles. Its total length from

[1] NATURE, Aug. 27 and Sept. 3, 1927, and July 27, 1929.

source to mouth is 240 miles; its main stream, exclusive of the tidal estuary below Limerick, is about 160 miles. The catchment area above Killaloe is some 4500 square miles, nearly one-sixth of the area of the Free State. The upper course of the main stream for a length of 125 miles lies mainly on the great central plateau of Carboniferous limestone, running through three great lakes (Lough Allen, Lough Ree, and Lough Derg) which have an aggregate surface area of 65,000 acres. For this part of its course the river is a sluggish stream with a fall of not more than 55 feet, which is less than 6 inches per mile. The lower course from Killaloe to Limerick, a distance of 15 miles, is very different in character. The fall is more than 90 feet, or 6 feet per mile, and it is this section of the river which is being exploited for the production of power.

It has been a fortunate circumstance that river flow data were to hand covering an extensive period. The available discharge ranges from 900 cusecs to 32,000 cusecs, the former being minimum dry weather flow, and the latter, discharge during flood in the winter season. With a rainfall of 946 mm., the average discharge in the lower part of the river is 8500 cusecs.

The Shannon project in its entirety envisages three successive stages of development for the whole river, involving in the later stages impounding works at the lakes in order to increase their storage capacity. As a complete account would take more space than is available at the moment, attention will be confined in this article to the first stage or "Partial Development", which is the extent of the present undertaking. This consists of works below Killaloe and comprises a weir across the river bed to maintain the water level and divert the required amount of flow into the head race, an artificial channel about $7\frac{1}{2}$ miles in length, which conducts the stream at constant level to the power station at Ardnacrusha, with its penstocks and turbines; and finally the tail race, $1\frac{1}{4}$ miles long, which conveys the discharged water back into the bed of the Shannon at a level of about 100 feet below the point of intake.

The weir is situated at Parteen Villa, $5\frac{1}{2}$ miles below Lough Derg, on a site consisting of an outcrop of hard red Devonian sandstone covered with shingle. Lake conditions will be continuous right up to the weir, so that it is anticipated that very little silt will be formed. Before deciding upon the design, which had to make provision for full discharge of the river in case the power station should be closed down, a series of experiments was carried out with various models at the hydraulic laboratory of the Technical High School, Berlin, under the supervision of Prof. Dr. Ing. Ludin. The experiments, in which the effects and characteristics of the flow of the river, taken at its maximum of 920 cub.m. per sec. (32,000 cusecs), were carefully studied, resulted in the selection of an arrangement of six openings, the two central apertures being each 10 m. wide, and two pairs of side openings, each 18 m. wide. The central openings are provided with low sills 10·9 m. below upstream water level, and the other four at first with high sills, or crests, at 2·70 m. below the same datum. Afterwards, the two 18 m. wide openings on the left bank of the river were replaced by two 10 m. wide openings with low sills

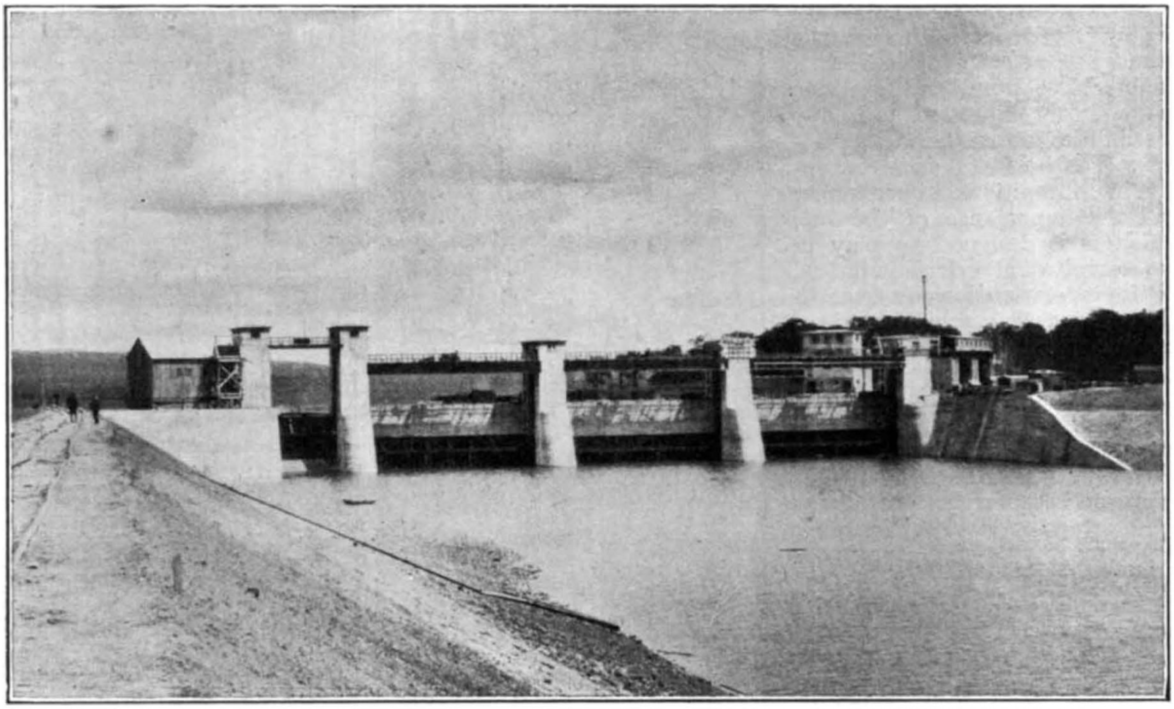

FIG. 2.—View of intake building at Parteen Villa after filling of head race had begun.

similar to the two central openings, thus making four deep sluices and two shallow sluices. A fish-pass is also provided.

The intake works at the entrance to the head race comprise three sluice gates each 25 m. wide and 5·7 m. deep, operated by mechanism from a bridge gangway, and a ship's pass 10 m. wide and 5·9 m. deep. This last is required for navigation purposes, since the old Shannon Navigation Canal will no longer be available. Under the new conditions, boats from Limerick will traverse the Abbey River, then the Shannon for a short length, then the tail race as far as the power house, where a couple of locks rising 100 feet and capable of taking 150 ton craft, will give them access to the head race, whence they can pass into the upper river channel.

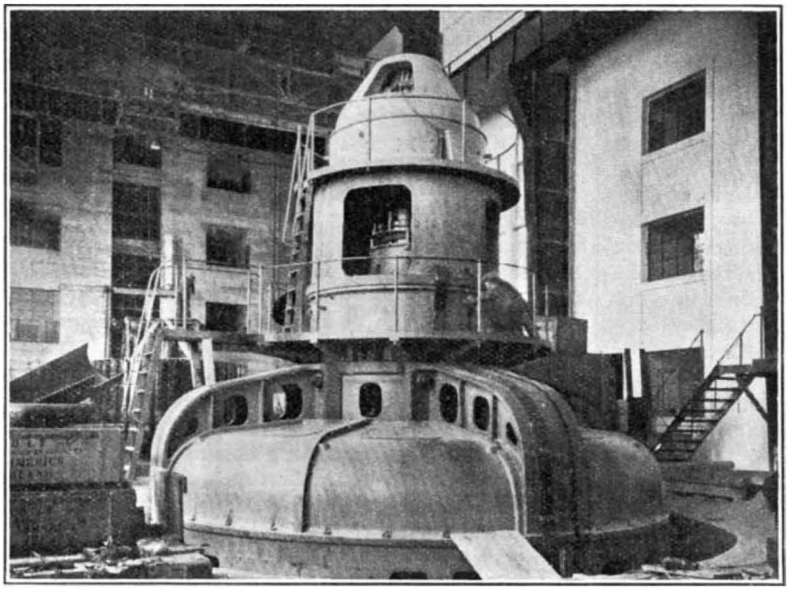

FIG. 3.—Generator I. completely erected.

The power house is at Ardnacrusha, a few miles above Limerick. It is a reinforced concrete building with six openings in the base or dam to admit the flow. For the present, only three are being utilised, and these lead to three penstocks or steel pipe conduits, each 6 m. in diameter and 40 m. long, set at an angle of 59° to the vertical. At the foot they are deflected to the horizontal and taper gradually to a diameter of 4·8 m. as they enter the special casings of the turbines. These are of the Francis type, set vertically and designed to develop from thirty to forty thousand horse-power each, according to the available head, which varies with the tidal level in the estuary, from 86 feet to 115 feet. At normal inner water and mean tide levels the head is 94 feet. The turbines are geared directly to 30,000 k.v.a., 10,500 v. generators running at 150 revolutions per minute with a power factor of 0·7. The three turbines will thus develop some 90,000 horse-power, which is considered sufficient for the demands of the Irish Free State for the present and the immediate future. At a later date, three more turbines can be installed, and the output doubled.

The intention is to supply electricity over the whole countryside by means of a network of transmission lines running north, south, east, and west. The electrical energy generated at 10,500 volts in the power station at Ardnacrusha is there 'stepped up' to voltages of 110,000 and 38,000. At these respective potentials, it is transmitted over three main sets of high tension transmission lines. The 110,000 volt lines form the primary distribution. A six conductor line runs from Ardnacrusha to Dublin, a distance of 116 miles, and a three conductor line to Cork, 59 miles. The 38,000 volt lines are designed to effect loop transmissions, and the 10,000 volt lines are to be used for local distribution, conveying the current to 10,000/380/220 volt transformer stations in towns and villages.

Current was supplied over the transmission lines for the first time in an operating sense on the evening of Oct. 21 last to practically all centres of population in the Irish Free State south of a line drawn between Galway and Dublin. The area north of Dublin will be connected up by the time this article is in print, and, finally, the capital itself within a few weeks will be included in the service controlled by the Electricity Supply Board.

It is this widespread national service which constitutes the serious economic aspect of the question. The scheme contemplates the creation of a universally electrified Free State. But Ireland, at any rate at present, is almost wholly an agricultural country; its manufactures, except in some few detached areas, are of negligible account. Is it possible to create a demand throughout the country which will reimburse the national exchequer

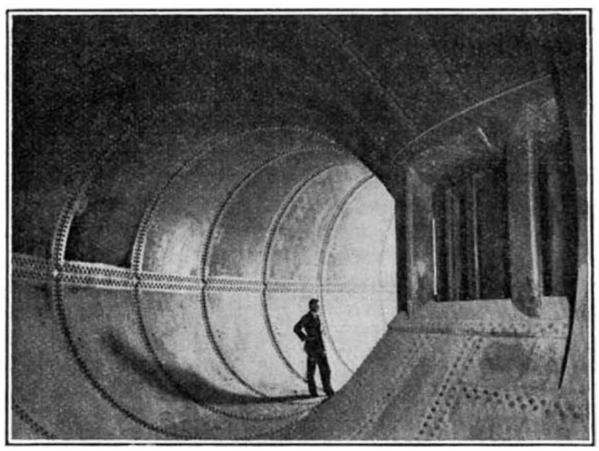

FIG. 4.—Spiral casing of a 36,000 h.p. turbine.

for the eight millions or so of expenditure on the scheme, or, at any rate, meet the capital charges on the outlay, together with expenses of operation? For the moment, the supply is greatly in excess of the demand, which depends almost entirely on consumption for civic and domestic purposes. Even in regard to domestic application, the proposition is not very attractive to the potential consumer, who, as an Irishman, is notoriously conservative in his habits and unlikely to be won over to new methods unless they are accompanied by palpable saving in expense. The idea at first entertained of supplying current to the Dublin switchboards at a cost of about ½*d.* per unit has long since been abandoned, and critics of the scheme now hint at the imposition of rates which may well be considered prohibitive except to the well-to-do householder. Dublin, indeed, will be the chief customer; at present it takes something like four-fifths of the electric current produced in the Free State, largely for its tramways. But the Dublin tramways are already suffering from the competition of motor omnibuses, and the fate of tramway undertakings in Great Britain is not reassuring for a lengthy continuance of this channel of consumption. Practically, the question resolves itself into the problem of the creation or resuscitation of Irish industries requiring large supplies of power and the establishment of manufactories throughout the country; and on this issue few will dare to speak confidently.

Considered as an engineering enterprise, the scheme is a definite success, in that it has undoubtedly been carried to the point of effective realisation, and great credit attaches to those whose duty it has been to work out the manifold technical details associated with an undertaking of this magnitude. Not least among the difficulties have been the problems of transporting and handling heavy pieces of plant and huge quantities of material in localities not altogether favourable for such purposes. The total equipment for the electrical and mechanical part of the installation weighed 34,000 tons, and about 6000 tons of this had to be shipped from Germany, unloaded at Limerick or the vicinity, and transported to the power station and weir with rather inadequate facilities for handling. Excavation operations at the power station involved the removal of a quarter of a million cubic yards of earth and 200,000 cubic yards of blue limestone rock. The concrete dam at the base of the building contains 80,000 cubic yards of concrete. Constructional operations were in the hands of the Siemens-Bauunion, associated with the Siemens-Schuckwerke A.-G., the main contractors for the entire undertaking, to whom we are indebted for the photographs accompanying this article.

The Shannon installation is a convincing manifestation of the confidence of the Free State Government in the future commercial development of the country, and all well-wishers of the Emerald Isle will hope that its anticipations may be realised.

Graptolite Centenary, 1829–1929.

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IT was in 1829 that Adolphe Brongniart first described 'graptolites', two of them, and both from the black carbonaceous shales of the Point Levis cliffs opposite the city of Quebec, Canada. Brongniart was a botanist, and although graptolites are marine animals of the hydroid type, these two forms went the rounds of the different museums of natural history in the Jardin des Plantes, Paris, and at last were described in the *Prodrome* for 1829 as plants. Plants they do certainly appear to resemble, giving leaf-like expansions, venations, moss-like characters, etc., all of which led early palæontologists to ascribe generic and specific names to the graptolites they described —*Phyllograptus angustifolius*, *Dipl. folium*, *Tetragr. bryonoides*, etc.

Graptolites are all extinct forms of life; they abounded all over, and in the waters of the Palæozoic ocean, when that continent 'Laurentia' first exposed its gneissic and granitic mass above the level of the waters, and graptolite remains, by tens of millions, in certain strata of palæozoic age comprising part of the earth's crust which was subjected to intense folding and accompanying distortion and dislocation. The very presence of graptolites in those rock-formations has helped so materially to unravel some of the knottiest problems in stratigraphy and chronological geology which presented themselves to the human mind in many countries, that some notice of the rôle which they played might be considered timely. Thus, graptolites settled the age of the Bendigo goldfields of Australia; they settled the succession of the highly folded Shropshire and other rocks in western England, Wales, etc.; the 'Highland controversy'; the 'Quebec Group' of Logan in Canada; the 'Taconic controversy' of the New England states; and of similar problems in Scandinavia, Bohemia, France, and in the two Americas, north and south, all along that belt of Andean and Cordilleran mountain chains in which palæozoic strata, also carrying graptolites, occur from Patagonia (Argentina and Chile) to Alaska and the Yukon.

Canada is *par excellence* a paradise for graptolites; and graptolites in a remarkably fine state of preservation have attracted British and other palæontologists, whilst Hall's graptolites from Quebec are famous the world over. Canadian species are recognised in Australia, Europe, Africa, and the Americas. Sir Wm. Logan, T. Sterry Hunt, Elkanah Billings, Sir Wm. Dawson, Spencer, and others in Canada; Emmons, Vanuxém, Hall, Walcott, Weller, Ruedemann, and others in the United States, all attacked the difficult problems of the Lower Palæozoic, and graptolites had their say. The 'knights of the hammer' in Great Britain and Wales: Hicks, Ramsay, Aveline,