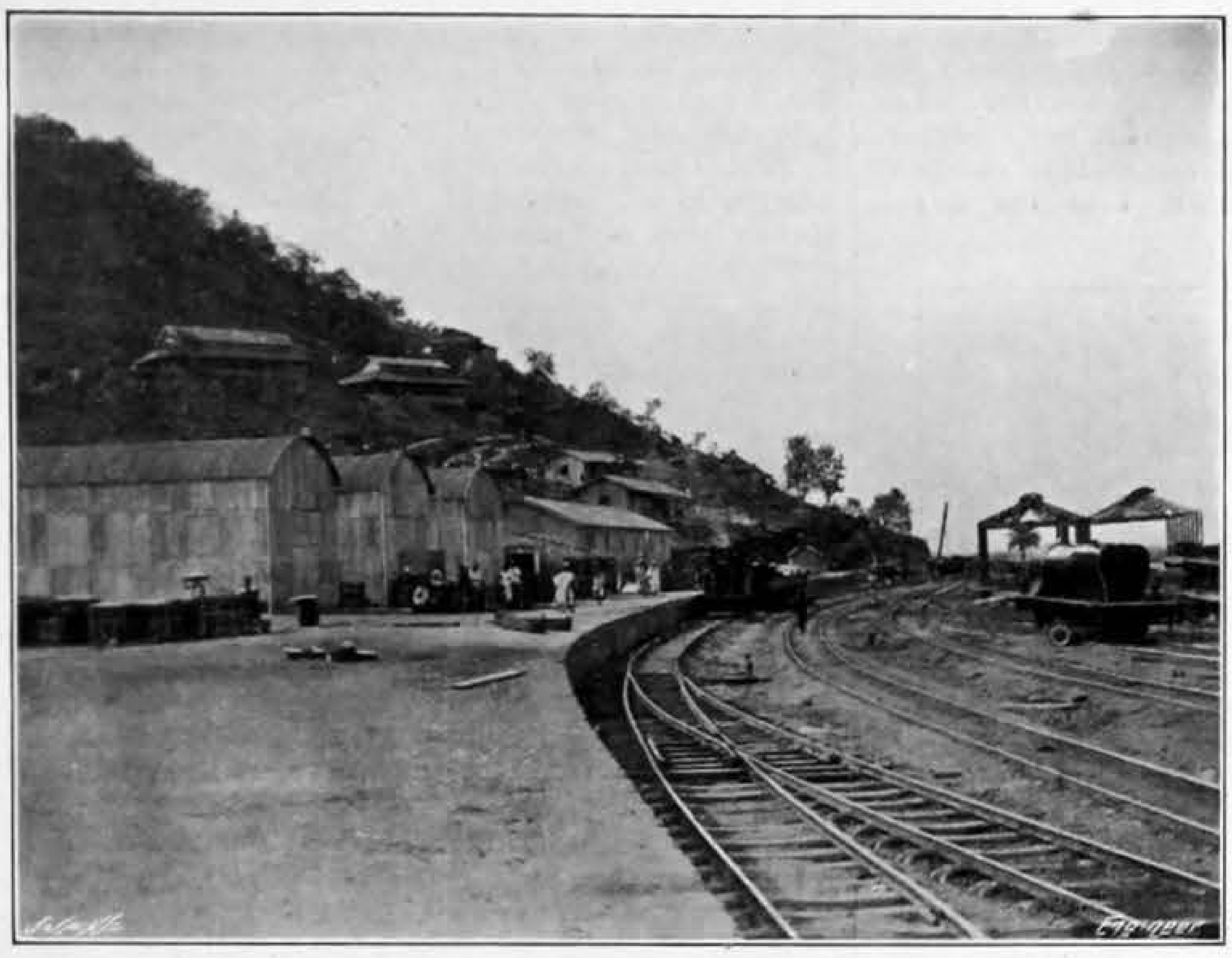
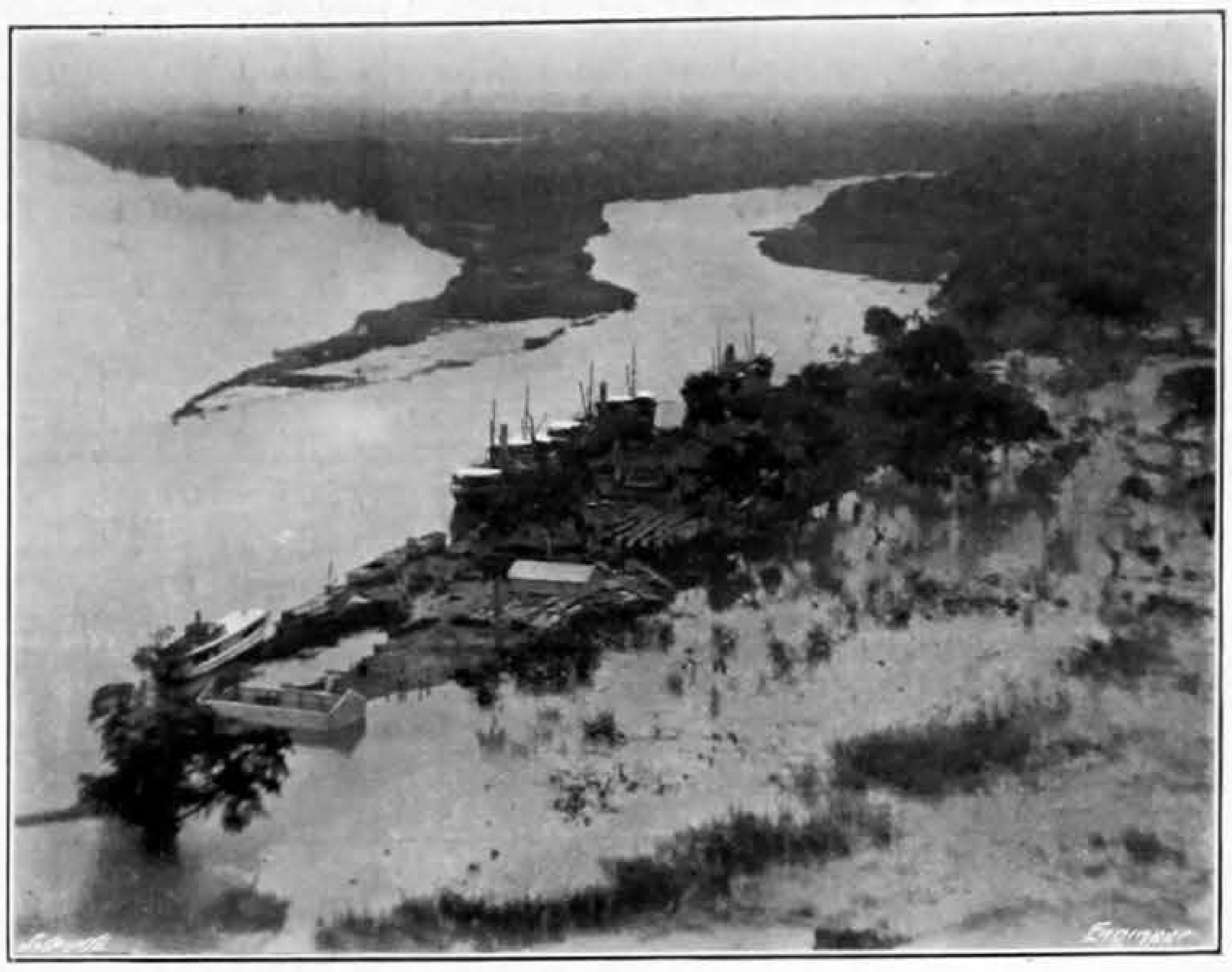
BARO-KANO RAILWAY, NORTHERN NIGERIA



BARO YARD



STEAMERS DISCHARGING AT BARO

illustrations are reproduced. There can be no doubt of the great care bestowed on the work nor of its accuracy. Fig. 7 is a longitudinal section of the river bed. In the year of exceptionally low water, 1902, the mean of the measurements of the minima at different stations gave 410 cubic metres per second. In the year 1899 of extraordinarily high water the mean of the maxima was 1152 cubic metres per second. Two of the diagrams above mentioned co-ordinate the volumetric flow with the water levels in Lake Saima and at Kiviniemi, near the mouth of the river. The former is reproduced in Fig. 8. The mean level in the lake since 1847 to 1902 corresponds with a flow of 565 cubic metres per second, which may be taken as the true average flow. This nearly equals the flow in 1901, which otherwise is found to represent a good average year. It also closely agrees with that given by Max Alfthan, as quoted above, namely 570. Adopting the figure 565, and using the 1901 measurements of fall in level, the following are the horse-powers in the water of the larger of the falls on the Wuoksen, a number of small ones being omitted from the list. It must not be imagined that so much horse-power can be developed either mechanically or electrically. Some of the crude water-power inevitably goes to waste, losses occur in the turbines and in the dynamos, &c., and the plant is generally laid down for the *minimum*, not the *average* flow. Odd hundreds are omitted from the calculations.

	Minimum width.	Fall	Water horse-power.	
	Metres.	Metres.	Average.	Minimum.
Niskakoski	190	1·6	12,000	8500
Tainionkoski...	70	5·9	44,000	31,000
Linnakoski	170	5·0	37,000	26,000
Imatra	20	18·3	138,000	98,000
Kyyrön-Mylly-Wallinkoski	115	10·4	78.000	55,000
Räikkölänkoski	45	8·8	66.000	46,500
Rouhialankoski	60	7·5	56,000	39,500
			431,000	304,500

Of these Imatra cannot be utilised for the generation of power, both because of the difficult and expensive character of the necessary construction, and because it is preserved as a national park visited yearly by scores of thousands of visitors of all nationalities. At Tainionkoski 3000 horse-power is at present being used in paper pulp and brown wrapping paper mills and reel and bobbin turning mills; as also 2000 horse-power in chemical chlorate of potash works. This year the dam has been extended so as to take in more water for 3000 extra horse-power, there being an almost continuous demand for more power here. The paper and bobbin mills were started in 1895-7, and the chemical works in 1898. Further down small mills have been established here and there; and at the village of Enso, the Räiköllänkoski has been utilised to take several thousand horse-power out of the water for a paper pulp mill. Elsewhere the falls are not yet employed industrially. Fig. 9 is a view of the very fine Wallinkoski fall. The mere breadth of channel and depth of fall are, of course, no criterion of the cost of construction or of the advantages to be gained. Many other technical considerations which cannot be detailed here come into such calculations. Exclusive of Imatra, there are over 300,000 horse-power in the river with average flow and 200,000 at minimum flow. With the conversion of this to mechanical and electrical power with cheap distribution to factories, the South Saima and Viborg district may become the busiest and most important industrial part of Finland. There is here abundance of power for the navigation of the Saima canal and for the electrification of the busier sections of the railways, as well as for the new factories springing up on the southern shore of the lake, all these being within easy reach for electric transmission at moderate cost.

RAILWAYS IN NORTHERN NIGERIA.

UNTIL the year 1907 the Protectorate of Northern Nigeria possessed in the way of railways but one light 2ft. 6in. tramway of 22 miles in length, which connected Zungeru, the capital, with Barijuko, the nearest navigable point on the river. In May, 1907, Sir Percy Girouard, the Governor, whose name had already become famous in connection with his splendid railway work in the Sudan and in South Africa, formulated a railway policy in which he recommended the construction by the Public Works Department of the Protectorate of a 3ft. 6in. gauge railway from Baro, on the Niger River, to Kano, a distance of a little short of 400 miles, on an estimate of £3000 per mile, and in August of the same year the Imperial Government sanctioned the construction of the proposed line.

That the Governor and his energetic Director of Railways, Mr. John Eaglesome, C.M.G., have not been idle since that period, is shown by the latest telegraphic report from Northern Nigeria, which shows that on June 10th, 1909, 109 miles of earthworks had been completed, with 190 miles in progress; that bridging had been completed to mile 45, with 105 miles in progress; that track-laying had been completed to mile 99, and that location survey had been finished to mile 195, and preliminary location to mile 220. The total length of the railway is about 380 miles, but the exact distance cannot yet be determined with precision until the final survey of the last section of one hundred miles is available.

Baro, the Niger terminus and the starting-place of the railway, is situated at a point on that river 407 miles from its mouth at Burutu. From Baro the line proceeds northwards and follows the Niger until the fourteenth mile, when it strikes in a north-easterly direction, following the Valley of the Bako—a tributary of the Niger—which stream it crosses at mile 99. Railhead is at present at this point, further track-laying being deferred pending the completion of the bridge over the Bako. Beyond, the line follows a small valley to the summit between the Bako and Kaduna Rivers, near which is the site of the junction connecting the Baro-Kano line with the system which, starting from Lagos, runs *viâ* Jebba, at which place it crosses the Niger. Beyond this junction—Minna by name—which is at mile 112, the Baro-Kano line traverses a number of lateral valleys, and after crossing two large rivers—the Dinia and the Kogi Serikin Pawi—reaches Danguna on an important caravan road. Thence the railway ascends the valley of the Kugo to an altitude of 2100ft., and will cross the Kadunar by a bridge nearly 500ft. in length. Over high ground, the section will then run to the important city of Zaria. Up to this point the survey is complete, and good progress is being made with the alignment beyond. From Zaria to the terminus at Kano is a distance of about 90 miles, and along this section the line will still keep to the high ground. The only important river to be crossed on this part of the system is the Shilloa, situated 10 miles from Kano. This city—800 miles in the interior—aptly named the Manchester of the Central Sudan, with its 12 miles of walls and immensely rich cultivated area, is expected to be reached in 1912.

Inseparably connected with this railway is the question of the navigation of the Niger from the sea to the starting-point of the line at Baro, a distance of 400 miles. Immediately after his arrival Sir Percy Girouard had an elaborate series of soundings made in order to establish the total length of shoal water in the Niger at low river, and it was found that in the whole length of 400 miles the total length of shallow water which would require dredging was not more than about five miles. But for these shallows the river would be navigable along the whole of this section all the year round for vessels drawing 6ft. At high Niger the river is navigable to Baro, and even for 100 miles beyond for ships of 1500 tons. Every year it is possible to count on a period of about ten weeks when these ocean vessels can steam right up alongside the wharf at Baro, a voyage of roughly six days from the sea. For deepening the waterway along this section a powerful dredger built on the Clyde has been constructed, and is now on the Niger. She expects to start work in October next. This vessel is a sand pump self-propelling dredger, having a delivery tube 400ft long.

Baro, formerly inhabited chiefly by mosquitoes and the deadly tsetse fly, is now a busy railway centre. Running down to the river bank is a great swamp that has already been drained, and when filled in with the sand pumped by the dredger from the river bed will be the site for export sheds. Further inland have been erected large workshops, engine sheds, stores, foundries, machine shops, a large band-saw mill, and wood-working plant. In connection with the materials for sleepers, &c., in the cutting of which the natives have now become expert, a valuable forest has been discovered in the vicinity, and already over 2000 logs have been cut down and conveyed to the saw mill. In addition, the construction has just been completed of two wharves, or piers, with the necessary cranes for discharging material from the steamers.

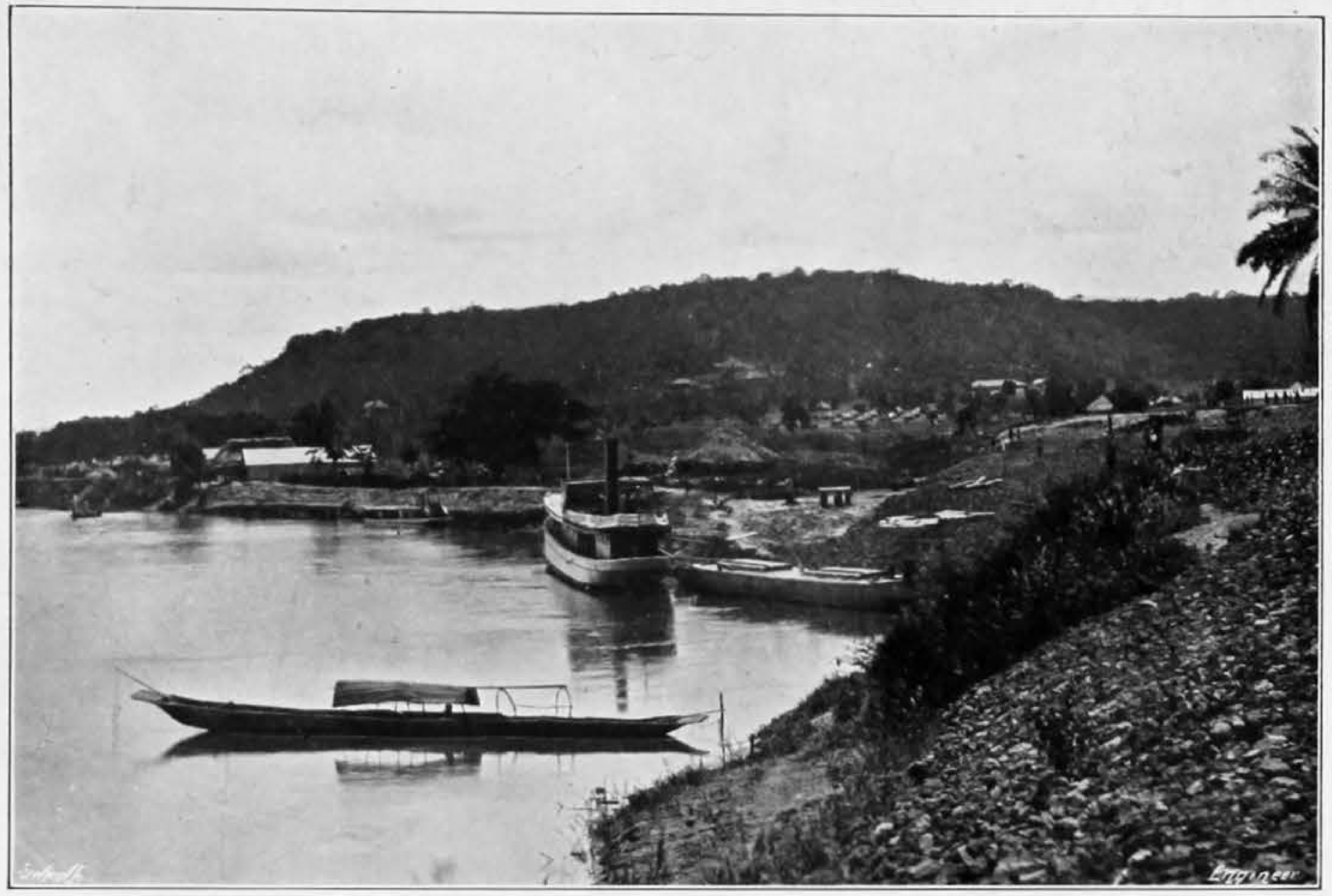
To assist in the delivery of material, three powerful stern-wheel tugs, to each of which 100 ton lighters are lashed alongside, have been at work on the Niger for the past year. The success achieved by these craft has justified the departure from the old system of placing cargo in the hold of the stern-wheeler by separating the cargo from the vessel possessing the motive power. The Baro yard when completed will contain four and a-half miles of rails. In addition to the structures above mentioned, there have been erected on the hill overlooking the railway works brick buildings for the accommodation of the railway staff, accounts and store offices, post and telegraph offices, native clerks' quarters, and a well equipped hospital.

The gauge of the railway throughout will be 3ft. 6in. With the exception of the first 6½ miles, the permanent way material consists of 45 lb. rails laid on steel sleepers. Up to the present 150 miles of rails and sleepers have been delivered, and during high water of this year a further consignment of 150 miles will be landed at Baro. The work of platelaying and the erection of locomotives is in the hands of a detachment of Royal Engineers, consisting of three officers, thirty non-commissioned officers and men, under the command of Captain Mance, D.S.O., R.E.

The country is subject to terrific tornadoes, with heavy rains, which occur almost daily during the wet season, thus necessitating some very heavy bridging. It has been found quite impossible to use masonry piers, except on the larger bridge work, owing to the absence of lime in the lower section of the line, and the employment of steel trestles has become necessary. Except in the first 100 miles, trestle bridges are bolted to blocks of concrete on the rocky beds of rivers. In the Bako Valley, however, much difficulty has been experienced in securing good foundations, except at some depth. Wells, square and circular, have been sunk to depths up to 20ft., and it is believed that on this railway for the first time reinforced concrete has been employed for well curbs instead of the wooden or steel curb usually employed in India and elsewhere. The average number of trestle bridges in the first section is about two every three miles, exclusive of culverts. The largest bridge is that over the Kaduna River, which will be some 500ft. in length. This will consist of through steel girders, of the Central South African Railway type, of 100ft. span. These girders are built on the shore, the cross girders and rail bearers being erected on falsework *in situ*, after which the rails are laid on the approach bank between the main girders and on to the rail bearers. The main girders are then lifted on to two trucks, rolled out, and, when in correct position, drawn together and fastened to the cross girders. Here it may be mentioned that all the permanent way material, together with the steel work for the bridges, is throughout of British manufacture. Apart from the larger bridges—that is to say, those varying from 300ft. to 800ft. in length—there will be an average in the first 112 miles of about 50 lineal feet of waterway per mile. Corrugated iron pipes, which have been sent out in sections for easy transport, are being used as culverts, the weight on all over 3ft. in diameter being relieved by means of rails. Pressed steel tubes are being employed under the heavier banks.

The cost of construction, it is now certain, will not exceed the amount voted by Parliament—about £3000 per mile—which may be regarded as a record. This sum includes the equipment of the railway with 16 locomotives and 200 trucks and wagons. Eleven locomotives have already been delivered. Of these five are

CONSTRUCTION OF THE BARO-KANO RAILWAY, NORTHERN NIGERIA

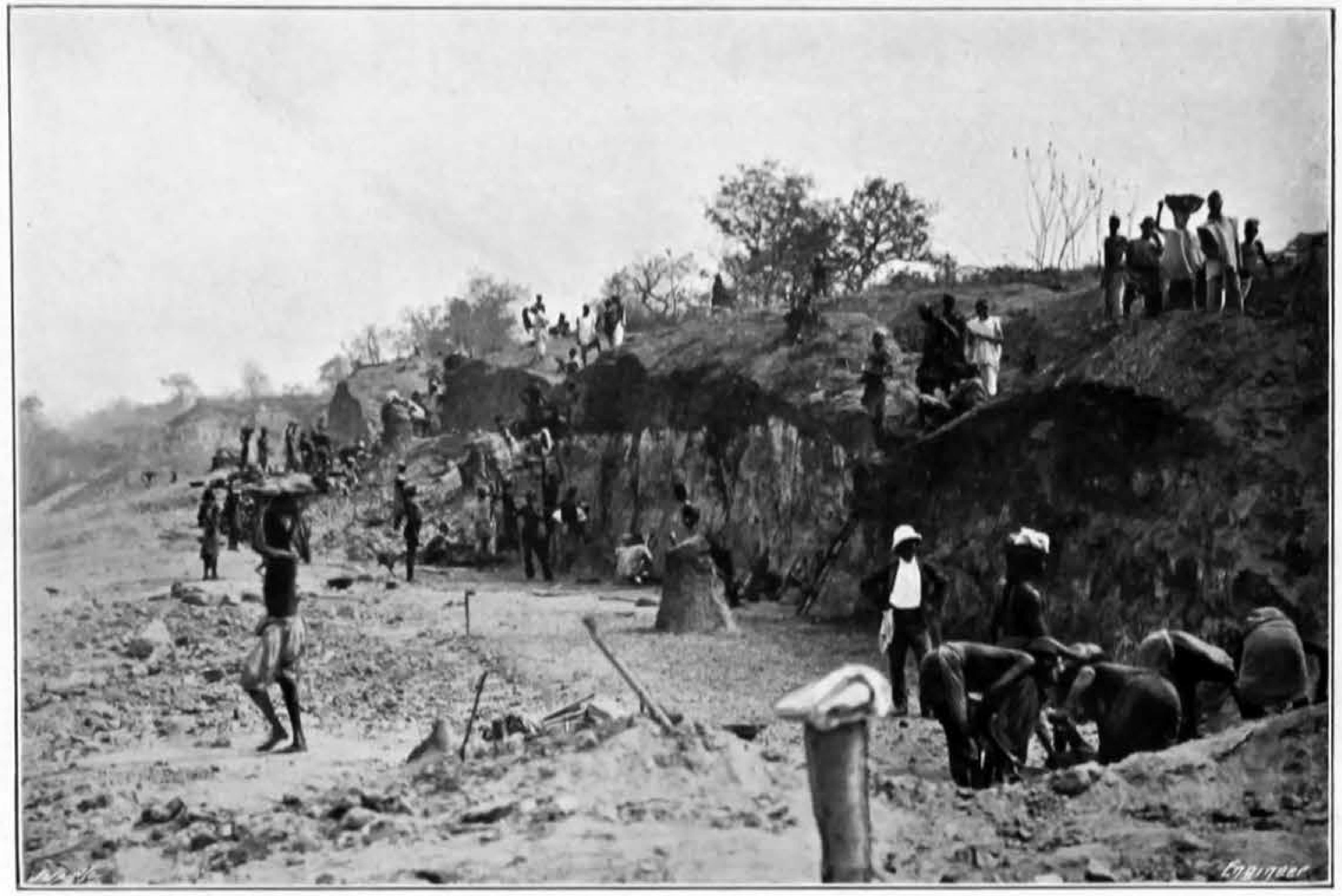


BARO BEACH JUST BEFORE THE RAILWAY WAS BEGUN

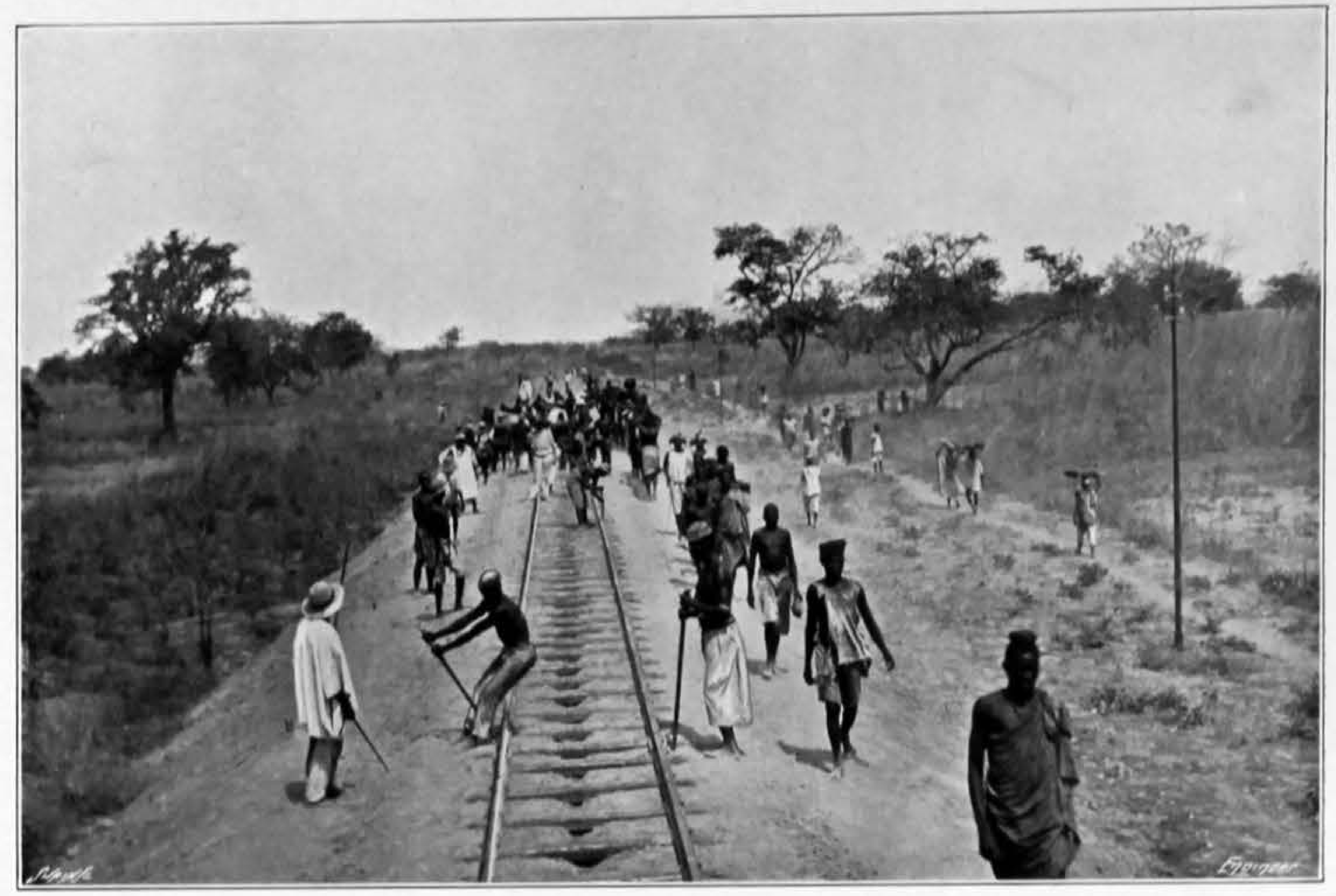
SETTING OUT EARTHWORK AT PATATIFI

TEMPORARY BRIDGE OVER THE BAKOGI RIVER

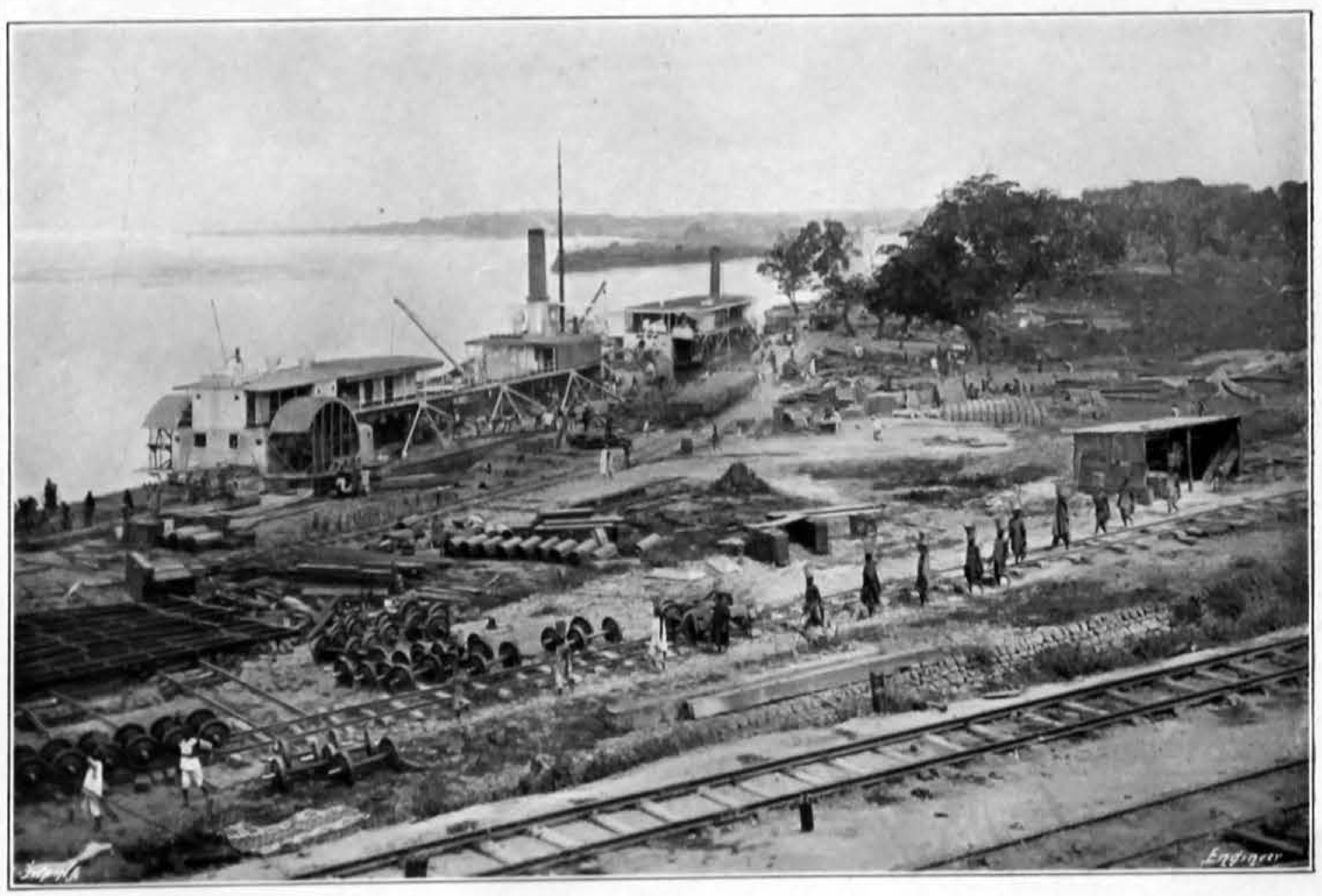
ENGINE OF THE EMIR CLASS ON STEEL BRIDGE



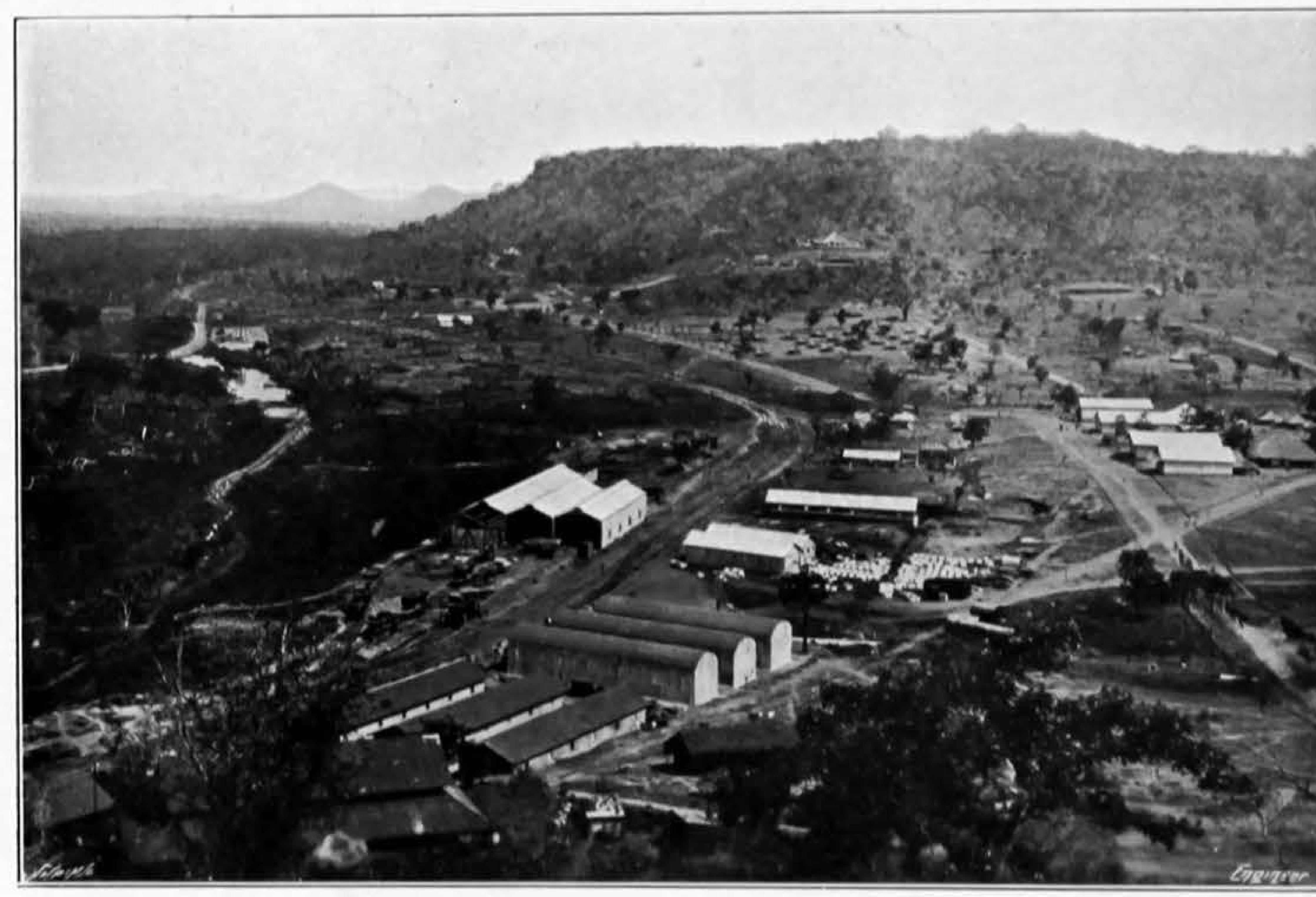
EARTHWORK IN PROGRESS AT PATATIFI BLUFF



STRAIGHTENING ROAD AT RAIL HEAD



NIGER END OF THE LINE—VIEW FROM BARO HILL



GENERAL VIEW OF BARO STATION

a modified Cape class eight-wheeled coupled with a leading bogie, and have been named after the Emirs of the various provinces. These engines have been built by the North British Locomotive Company, Limited, to the special instructions of Sir Percy Girouard. They have an axle load of 9½ tons, which has been found to be by no means excessive for a 45 lb. rail using twelve sleepers to the 30ft. rail. There are two small shunting engines of the Lagos Class 1 type, two of the Lagos Class 101 type (eight wheel coupled), and two are Lagos Class 51 type (six wheel coupled) Five further engines are now in course of delivery, of which two are Lagos Class 51 type, and three are specially designed tank engines (six wheel coupled).

One hundred and ninety low-sided trucks and ten covered wagons will be the total equipment of this class of rolling stock, and of these 100 trucks have been delivered. Three specially designed coaches having four compartments, with folding bunks, are now in course of erection for the use of European officials.

The leading principle of pioneer railway construction being to avoid all unnecessary expense above rail level, there will in the ordinary way be no station buildings, except small iron sheds with rail level platforms. At large centres, such as Baro, Zaria, and Kano, where more traffic is to be expected, there will be station buildings, but here again they will be of the simplest description, and will be supplied with platforms. Small roadside flag stations for the convenience of passengers have been fixed every twelve to fourteen miles, and there will be crossing stations at about every 35 miles.

Track laying.—The formation having been levelled and the centre line pegs having been driven at 50ft. intervals along the level surface, a platform of the best sandy material available 7in. deep and 8ft. wide with a central triangular furrow, is laid with correct superelevations on curves. On this the steel sleepers are placed, being afterwards spaced to true centre and strung to a true centre line. The adoption of this sand ballast platform has resulted in a fairly good road, requiring little upkeep behind railhead. In track laying on this line a record for West Africa has been established, the track-laying parties having laid 1½ miles a day.

It has been found absolutely essential in an undertaking of this nature to carry out as much of the work of the railway as possible on the spot. A completed survey is abandoned without hesitation when it is found on further investigation—all plotting being done in Nigeria —that a better alignment can be secured elsewhere.

With regard to earthworks, these are being made up to a full section of 14ft., with 2 to 1 slopes. The cuttings are 18ft. wide at formation level, including side drains, and are invariably protected by catch-water drains. The sides of the cuttings are sloped according to the nature of the soil, and the edges protected by slope drains. Earthworks have never been exceptionally heavy, and survey parties have been careful to dig trial pits at cuttings to avoid as far as possible meeting hard rock. When the line crosses lateral valleys of great length it has been found advisable to use momentum gradients, thus reducing the quantity of earthwork and height of bridge.

Gradients.—In the first section of 112 miles the ruling gradient is .7 per cent., or 1 in 143 up to Kano, and .6 per cent., or 1 in 166, down from Kano, in which direction the heavy traffic is expected. The sharpest curve in use on this section is 6 deg., or 955ft. radius. Throughout the line the American system of per cent. gradients and degree curves has been adopted in place of the old 66ft. chain.

Native labour.—Work on the railway was originally begun with a gang of 1200 natives, but this number has, of course, been vastly increased. The latest available returns show that for the quarter ending March there were on an average between 9000 and 10,000 natives employed on the line. The number varies in accordance with the season, and the fact that at certain periods the people are employed in their own fields at home. Local labour is paid at the rate of sixpence per day. The local labour gangs work immediately under political officers, who practically act as contractors and deal with the men through their village heads, thus ensuring a continuity of native rule, to which the Administration attaches such importance. Under European training these natives, many of them absolutely untamed, one might almost say wild men, show great adaptability, and turn out really excellent labourers, while the more civilised Nupé has made a good riveter and woodworker.

European staff.—The railway is under the immediate supervision of Mr. John Eaglesome, C.M.G., Director of Public Works, and also Director of Railways in the Protectorate, who is himself directly responsible to the Governor. Under him are a staff of about 170 engineers, firemen, accountants, and storekeepers. The members of the staff come from all parts of the Empire, nearly fifty being retrenched British officials from the Transvaal and Orange River Colony.

We give on page 288, and in a supplement, views on the line.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

No. II.*

THE fifth triennial Congress of this Association, the opening proceedings in connection with which at Copenhagen were reported in our last issue, continued its sittings on September 8th, when work commenced in the three sections devoted to metals, cement, and sundries. As indicated in last week's issue, some eighty papers in all were down for reading and discussion. It is not proposed to deal with the reports and papers presented at any great length, nor, indeed, is it necessary that this should be done. It will be sufficient briefly to indicate the nature of the problems brought before the various sections of the Association and to state some of the results reached at a congress in which many of the notable workers in the field of operations covered by the reports and papers took part.

The most important of the three sections was undoubtedly that devoted to metals. Some forty reports and papers were allocated to that division of the Congress, which met in the fine council chamber of the Copenhagen Town Hall under the chairmanship of Mr. O. Busse, director of the mechanical department of the Danish State Railways.

The first papers to come up for discussion were those on metallography, and the report on progress made in metallography from the date of the Brussels Congress in 1906 up to the commencement of the present year was presented by Professor E. Heyn. It was pointed out in the report that metallographic research during the period under review had been mainly concerned with the following aims :—(1) The fixing of the foundations of a chemistry of inter-metallic compounds by determining the cooling curves of as large a number of alloys as possible; (2) to increase knowledge of the iron-carbon system, the formation of graphite and the components of hardened steel; (3) to study special steels and other alloys; (4) the application of metallographical results to actual metallurgical research work, particularly that relating to metals other than iron; (5) improvement in metallographical research in its special bearing upon the testing of materials and the devising of simple processes for controlling the treatment of metals and alloys. With regard to the iron and carbon system, it was pointed out that the question of the separation of graphite had evoked the most lively interest during the period covered by the report, and the view according to which the system iron and graphite is reckoned as stable, and the white graphite free iron as meta-stable, had established itself more and more. It was stated that although the solubility of graphite in iron is generally accepted, its quantitative determination, as fixed by Benedicks, did not yet appear to be quite reliable. It was necessary that consideration should be given to the question as to whether in the cementation process one had to deal with the iron-carbon system *per se*, and not rather with the three component system iron-carbon-nitrogen, in which other equilibrium relations intervened. If this were solved many points still doubtful would be cleared up. The report contained a long list of publications dealing with the various branches of the subject, and it brought out the application of metallography to practical industry, a subject which was more fully dealt with in the lecture which Mr. J. E. Stead delivered at the final meeting of the Congress on Saturday last.

The general opinion was that the report itself was an excellent summary of progress, but that it was somewhat incomplete, while in the bibliography several important British papers would seem to have been ignored. The discussion, in which Dr. Benedicks and M. Le Chatelier took part, centred rather on the colloid theory of troostite, but Professor Heyn indicated his willingness to accept the views of Dr. Benedicks with certain limitations. M. le Chatelier thought it was a mistake to attempt to bring metallurgy too much into the line with mineralogy, and he deprecated, as did other speakers, notably Dr. Rosenhain, the giving of definite names to too many constituents. He would limit the nomenclature to three constituents—(1) martensite; (2) a combination of troostite and osmondite; (3) combination of sorbite and pearlite. Mr. J. E. Stead pointed out that the researches carried out in this country as to the composition of the carbon iron phosphorus eutectic, and other researches in connection with the iron phosphorus and carbon phosphorus alloys, had been confirmed by the work of Dr. Wüst during recent years.

It is interesting to note that the question of simplifying the nomenclature of metallography was discussed at a private meeting in which most of the eminent metallographists, including MM. Charpy, Guillet, Heyn, Stead, and Rosenhain took part, and it was decided that the only names to be accepted as of international significance should be ferrite, graphite, cementite, austentite, martensite, pearlite, and osmondite, and a resolution was ultimately passed in which the international definitions of these constituents were set out. Copies of these definitions will be circulated in the three official languages of the Congress—French, German, and English—and the results of metallographic investigation in different countries will in future be made more readily comparable.

The second paper in the Metallographic Section was one on "Special Steels," by Professor Leon Guillet. It was pointed out by the author that much had been done in the direction of simplifying the thermal treatment of pearlitic steels. The manufacture of special steels for structural purposes turned more and more in the direction of pearlitic steels, among which the nickel-chrome steels occupied a position of increasing importance. He pointed out that gamma iron steels were losing ground, and that their use for steam turbine blades was being abandoned. Few new types of steel had been created during the past three years, but there had been a great commercial development of vanadium steels, particularly in the United States, and of the nickel steels with or without chromium.

The third paper in this section was by Mr. Lawford H. Fry on "The Heat Treatment of Spring Steel," being an account of a series of tests carried out at the Baldwin Locomotive Works to determine the effect of certain heat treatment on the transverse elastic limit and on the modulus of elasticity of the steel commonly used in America for locomotive carrying springs. The results of the experiments indicated once again that to obtain good and uniform results it is necessary to have means of heating the steel uniformly to the proper temperature, and cooling it at the desired rate in a cooling medium the temperature and heat conductivity of which can be kept reasonably constant.

In the fourth paper Dr. Walter Rosenhain discussed the importance of slag enclosures in steel. He said that, while some metallurgists appeared to regard slag enclosures as practically harmless, he had repeatedly expressed his views as to their dangerous nature, and recent experience of some definite cases of failure arising from the effects of slag enclosures led him to bring the subject before the International Association. While the work of those who had investigated the problem had thrown much light on the nature of these enclosed impurities, there was still room for doubt as to their true nature and origin, and further study of the subject was obviously required. Professor Guillet, in opening the discussion on the subject, said there was no doubt that slag enclosures had been the cause of various failures. He quoted a case of ships' plates of 42 kilos. per square millimetre resistance, with 20 per cent. elongation, where the plates corroded near the rivet holes. They were found to be full of slag and to have no shock resistance even after annealing. Mr. J. E. Stead said he had investigated this subject for a good many years, and there were no doubt great practical difficulties in the way of getting rid of the trouble. The suggestion he had put forward was to take means to prevent air reaching the steel, as, in his view, the enclosures resulted from the introduction of oxygen into the steel either during the melting or the teeming process.

As the result of the discussion, and the general recognition of the importance of the subject, it was decided on the proposition of the author that the Association should appoint a commission to investigate slag enclosures and their effects upon the mechanical properties of metal.

The subject of international specifications for iron and steel was next discussed in connection with the report of the committee which has had this subject in hand for some considerable period. The report was brought up by Dr. Rieppel. The difficulties of the subject are very widely recognised, and up to the present time very little has been accomplished. In order that the subject might be more adequately discussed, a special meeting, under the presidency of Mr. Webster, was held later in the week. It was pointed out by Mr. Webster that what the committee desired to do before taking any definite steps in the matter was to obtain a representative specification from the various countries represented on the committee. A long discussion took place on the various points involved. At the present time the only countries which have arrived at standard specifications for iron and steel are Great Britain, Germany, and the United States, but it appears that in other countries the difficulties are not so great as might have been imagined. Prof. N. Belelubsky, on behalf of Russia, said that no time should be lost in collecting the necessary data and presenting them to the commission, and another delegate from Russia said that the Government and manufacturers were already in co-operation in regard to draft specifications. Inasmuch as the Government took a very large proportion of the total output it was thought there should not be any great difficulty in arriving at representative specifications. M. Adolphe Greiner said that in Belgium the Government were very large buyers of material and their specifications were generally accepted. In Italy he believed the specifications were Government specifications. In France the matter would be somewhat more difficult because the Government had not the strength to maintain what might be termed standard specifications. The matter was, however, under consideration in France, and no doubt the leading manufacturers would be able to arrive at a decision in the matter. Dr. Dudley pointed out that the success attained in this direction in America was due to the work done by committee. Mr. F. W. Harbord said that the object was to push the work forward as rapidly as possible, and what was really wanted was that those countries which had not got standard specifications would follow the example that had been set by England, the United States, and Germany, and form a body which would set up a standard specification for each material. Until each country had agreed upon a specification of that sort no progress could be made, as it would be impossible for a committee to differentiate between various specifications coming from a single country. He moved a resolution that steps be taken to obtain single specifications for each material from each country. Mr. Stead seconded this resolution, and it was carried.

The only definite steps taken by the Congress in connection with specifications up to the time of this meeting was to the effect that the committee take steps to inquire into the possibilities of specifying pig iron by analysis in place of grading by fracture, a subject which evoked a great deal of discussion; but the whole subject came up again at the final meeting on Saturday last, and it was decided to do no more at the present time than obtain single specifications from all the countries interested for each material for the purposes of export trade only, and there was a general recognition of the fact that the framing of international specifications was a task which at any rate should not be entered upon at the present time. There was a feeling that the commercial considerations offered a real stumbling block. The suggestion which had been put forward that this committee should undertake the standardisation of pipe threads was negatived. Mr. Leslie Robertson, who was present at the Congress in a consultative capacity, as representing the Engineering Standards Committee, pointed out that a commission convened by the Society of Gas Engineers in France had recently been sitting in Paris, at which most countries were represented, at which that subject received particular attention. Another conference was to be held in the near future, and meanwhile Germany and the other countries interested were to consider the whole question and put definite proposals before the next Commission. His view was that it would be far better to leave that matter for the Paris Commission. This course was assented to by the Copenhagen Congress.

Another specification brought forward was that of the Copper Committee, which was presented by M. Guillet. This report was generally approved by the

* No. I. appeared September 10th.