in 1871, and immediately commenced operations, which lasted during five months, and resulted in a complete survey of the country through which communications were required, and the collection of all the necessary data.

To overcome the obstacle to navigation presented by the first cataract, at which there is a difference in level of about 12 5 ft. at high, and 15 ft. at low Nile, Mr. Fowler departs from the proposal made in 1865 by Mr. Hawkshaw, and suggests a new and striking method of reaching the higher waters of the river from the foot of the cataract. He suggests the construction of a ship incline nearly two miles in length, on the right bank of the river, commencing at the bottom of the cataract between the Island of Sehayl and the river bank, and terminating on the higher level in the harbor of Shallali, north of the celebrated island of Philœ. Rails would be laid upon the incline, and suitable carriages would be constructed to run upon them. The vessel to be raised or lowered would be floated upon these carriages or cradles, the ship and carriage being then drawn over the incline by hydraulic engines which would be driven by water at high pressure, pumped into huge accumulators at the summit of the incline by a pair of large water-wheels placed upon pontoons, and moored in one of the rapids of the cataract. A speed of from 4 to 7 miles an hour can be imparted to the vessel, according to the height of the Nile, and weight of vessel.

When the first cataract is passed a long stretch of free navigation is available, until, indeed, the second or great cataract is approached, an obstacle of too much magnitude to be dealt with by a ship incline; before it is reached, therefore, the river has to be abandoned, and a new means of transit provided by the proposed railway, which would extend southward into the Soudan. In deciding upon the route to be taken by this line two alternatives presented themselves. Between the second and the sixth cataract, near Khartoom, the Nile takes a sweeping course of nearly 800 miles in two great irregular reverse curves, the northern of which skirts the Nubian Desert, and the southern, the smaller desert of Bahiuda. The southern terminal point of the line would be, of course, the most central that could be selected with a view to the converging traffic from all parts of the Soudan. This point is found at Metemmah, a village on the left bank of the Nile (16° 40' N. latitude, and 32° 25' E. longitude). This village is just opposite Sheady, on the right bank of the river, to which town the numerous camel routes converge, whilst 100 miles down the river is Berber, and about the same distance up stream is Khartoom, at the junction of the Blue and White Niles. As the river navigation for the 200 miles between Berber and Khartoom is obstructed only during two months in the year by rocks which are about to be removed, it will be seen that a better position for the southern terminus could not be selected. To connect the southern with the northern terminus the line could be either carried from Metemmeh across the Bahiuda Desert for a distance of about 180 miles, until it again meets the Nile at Ambukol, and skirts the banks to below the second cataract, or the south en bend of the river could be followed from Metemmeh to a point called Aboo Hammed, and the great Nubian Desert traversed until the Nile was again overtaken at Korosko, about 90 miles below the second cataract.

There was little difficulty in selecting the former of these routes. Had the latter been chosen, some 90 miles of good river navigation between the ship incline and the second cataract would have been lost, an altitude of about 1900 feet above the water level of the Nile would be traversed, as compared with 393 ft. on the other line, and the drift sand would prove a very serious obstacle in crossing the Arabian Desert, where no water suitable for locomotives is to be found.

The line, then, as laid out, commences at Wady Halfa, on the right bank of the Nile, which it skirts for a distance of about 160 miles, then by a bridge crosses the river and forms a chord 32 miles long to a small bend in the stream, which it again touches and follows on the left bank as far as Ambukol, at the 375th mile; then commences the stretch across the Bahiuda Desert which terminates the line, after a course of some 950 miles.

The engineering difficulties connected with the work are comparatively small, there will be no tunnels, and but little rock cuttings, expensive works being avoided by the curves and gradients adopted, the minimum radius of the former being 500 ft., and the maximum inclination of the latter 1 in 75. The bridge crossing at Kohé will doubtless be an expensive undertaking, and might be avoided by following the left bank of the river for the whole distance, while the nature of the bank would perhaps allow of a better line being laid out, but on the other hand, the drift sand prevalent on the left bank as far as Kohé would make it difficult, if not impossible to maintain the railway.

One of the special characteristics of the Soudan Railway is the gauge which Mr. Fowler has adopted—the same which Mr. Phil has established with so great success in Norway. And in the choosing a narrow gauge for this important line, Mr. Fowler has not been guided by any estimates of probable insignificant traffic. On the contrary, the existing trade is considerable, and will be enormously developed when the line is made, as well along the banks of the Nile as in the Soudan itself, which, with inexhaustible natural resources, now lacks an efficient outlet for its produce. Grain, cotton, sugar, and all the varied animal and vegetable products of a tropical region, will be the staples descending the railway towards the north, whilst the return traffic will consist of machinery, fabrics, tools, and generally, the mixed freight required by a producing, isolated, territory.

Moreover, it is not anticipated that the Soudan Railway shall be simply a local line, built to connect the Soudan with Upper Egypt, but that ultimately it shall form only one link of a great through railway, extending to Massowah on the Red Sea, and opening an alternative and more direct route to India and the East. By establishing a service of steamers, suitable for passing over the ship incline at the first cataract, there would be a saving of one day effected as compared with the Red Sea route, whilst the inconveniences and dangers of that passage would be avoided. Looking further to the future, when the line is extended from the existing Egyptian railway system to the terminus at Wady Halfa, three days would be saved in the journey to India. We may thus consider it probable that before the lapse of many years, there will be constructed a great through narrow gauge railway route across Egypt, competing directly and successfully with the Suez Canal, and carrying, besides, the whole of the local export and import traffic. That Mr. Fowler should, after long consideration, have adopted a gauge of 3 ft. 6 in. for a line of so great immediate and future importance, is, we consider, a striking answer to the many arguments and objections urged against narrow gauge railways so persistently during the past few years, and it affords us satisfaction that so eminent an engineer should have adopted principles we have so strenuously advocated.

The general plan on page 32, which we reproduce from *Engineering*, will be found of considerable interest as it indicates the course of the intended railway.

TRIAL OF STEAM TRAMWAYS AT BUCKHURST HILL.

The question of working tramways by means of locomotive engines and light rolling stock is at present in course of receiving a practical solution in the kingdom of Portugal, where two lines of considerable length are now being made by the Lisbon Steam Tramways Company (Limited.) One line runs from Lisbon to Cintra, a distance of seventeen miles; whilst the route of the other is from Lisbon to Torres Vedras, about sixty miles. The first line is nearly completed; whilst the works of the second have progressed for about two-thirds of its length. The tramway consists of a central 42 lb. rail of the Vignoles section, flanked on either side at a distance of about 20 in., with timber longitudinal sleepers, the three being secured to transverse sleepers, also of timber. Upon this triple line run engines and carriages, having one pair of broad wheels placed central to their length, and running on the timber sleepers, and at either end a bogie frame carrying, for the engine two, and for the carriages one, double-flanged wheel, placed central to the width of the carriage, and working on the iron rail. In the locomotive the pair of broad wheels are the drivers, the small central wheels acting mainly as guides. In the carriages, however, the exact reverse of this arrangement is observed, the bearing being taken by the bogie wheels; whilst the outer broad wheels act simply as guides. They are allowed a very wide margin of vertical play by means of American springs made with an India-rubber core surrounded by a spiral steel spring. The bogie wheels are also carried by six springs of the same character. The carriages, in fact, are therefore, it will be seen, steadied, and prevented from overturning laterally by the outer wheels. The gauge of the line is determined by the outer wheels, which are 4 ft. 2 in. from centre to centre of tyres.