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THOMAS HAWKSLEY, Vice-President,
in the Chair.

No. 1,172.—“The Suez Canal.”¹ By Colonel Sir WILLIAM
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THE varying reports of the character of this work made the Author desirous of inspecting it on his way home from India. In order to do this, as thoroughly as time would permit, letters of introduction to the French Engineers were obtained from the authorities of the Company, and to Her Britannic Majesty's Consul-General from the Secretary of State. Consequently, on arriving at Suez, it was found that every facility would be afforded for inspecting the works of the Canal, and that means would be provided, by the different authorities, for securing conveyance to Port Saïd, and from thence to Cairo, after the inspection of the works had been completed.

Although furnished with copies of the correspondence between the late Mr. R. Stephenson and M. de Lesseps, as well as of Mr. Hawkshaw's Report, it was thought that it would be wiser to inspect the Canal, and to ascertain the views of the French Engineers employed upon it, and then to form, as an Engineer, an independent opinion, so far as such a mere hasty inspection would allow, before attempting to deal with questions which have assumed a mixed character—partly political, partly economical, and partly professional. Accordingly, while the aspect of the work was fresh in the Author's memory, such remarks as occurred to him were committed to writing, and the following notes comprise the substance of the opinions formed while inspecting the works. Allusion will afterwards be made to the report and correspondence before mentioned.

The scheme of the Suez Canal may be said to comprise two distinct undertakings. The first, and principal, is the construction and maintenance of a broad and deep salt-water channel on one level between Port Saïd on the Mediterranean, and Suez on the Red Sea. (Plate 13.)² The second, preliminary in point of time,

¹ The discussion upon this Paper occupied portions of two evenings, but an abstract of the whole is given consecutively.

² The plan and sections of the Suez Canal (Plates 13 and 14) have been compiled from “Compagnie Universelle du Canal Maritime de Suez. Carte générale de l'Isthme, etc., 1866,” and the plans of Port Saïd and of the Port of Suez from “Perçement de l'Isthme de Suez. Actes constitutifs de la Compagnie Universelle du Canal Maritime de Suez avec cartes et plans. Documents publiés par M. F. de Lesseps.” 6^e Série. 8vo. 1866.

and indeed essential to the construction, as well as to the beneficial use of the Canal, is the maintenance of a supply of fresh water sufficient for the wants of the population congregated along the line of canal, and specially at its two extremities.

The arrangements for the second of these undertakings have been completed. A canal, commencing at a place called Zagazig, to which water is brought from the Nile by one of the many branches from the main stream, has been carried to Suez, passing within about a mile or two of Ismaïlia, the central point of the main Canal, and the head-quarters of the establishment of the Company. It is navigable for the whole distance, the fall from Zagazig to Suez being overcome by locks. From the point where the Canal turns southward to Suez, a branch is carried first to Ismaïlia, where it provides a supply for the inhabitants, and for some hydraulic machinery, by which water is forced into a double line of 9-inch pipes, through which fresh water is carried along the side of the Canal, supplying the various establishments along the line of about 50 miles in length, and a population at Port Saïd already numbering upwards of 10,000; and secondly, for a distance of about a mile to the east of Ismaïlia, within which distance it is made to drop by two detached locks to the level of the Mediterranean. During the dry season the supply of fresh water is hardly sufficient to keep the navigation of the canal open; but it is proposed to carry a supplementary branch to Zagazig, from a point on the Nile above the "barrage" at Cairo. When this is completed, there will be an ample supply of fresh water at all times and for all purposes. At the Suez extremity the fresh-water canal terminates in a lock, by which vessels drop into the creek which brings goods and passengers from the anchorage to the town.

In the immediate vicinity of the anchorage a dry dock, capable of taking in the largest steamer, is nearly completed. The caisson to close the entrance was ready, or nearly so, when the Author visited the work, and the Engineers were employed in fixing the engine and pumps for emptying the dock. In front of this dock an "avant port," or basin, is in course of being dredged to a depth sufficient to receive large vessels. These works, however, are altogether distinct from the Canal, and are being carried out by a separate agency.

The salt-water Canal will commence to the south-east of this "avant port," the ground being dredged out to the necessary depth, and to a width sufficient to give ample space for the exit and entrance of vessels. From the character of the excavation for the dock, it is believed that the lower portion of the excavation for a depth of, say, 6 or 8 feet, will be hard enough to stand at a high angle. The Canal will sweep away in a curved line towards the north, passing to the eastward of the fresh-water canal through

the lowest portion of the land, which is, in point of fact, very little above the level of the Red Sea.

Nothing, however, has as yet been done towards the commencement of the salt-water Canal, at the Suez end of the line, for the first 10 or 12 miles. At this distance from the sea, the line crosses a sort of spur from some hills to the westward, at a place called Chalouf, and there about three hundred men were at work upon a cutting, consisting partly of a bed of hard conglomerate, 8 or 10 feet in thickness, below which were strata of sand and clay. The surface of the soil at this cutting was said to be about 12 feet above the salt-water level, so that the total depth of excavation will be 38 or 40 feet. The slope of the side was 2 to 1, and there was a "bench" about 12 feet in width, 3 feet above the surface of the water; while another bench, 12 feet below the water, and 9 feet wide, formed a sort of base for the stone work with which it was proposed to face the upper part of the slopes. The stone was procured in part from the excavation itself, and in part from quarries on the west shore of the Red Sea a few miles south of Suez. The work here was carried on with a good deal of method. Inclined planes were cut in each bank, up which the wagons filled with spoil were hauled by steam engines, and then drawn to spoil banks at convenient distances. Pumps discharged the drainage water into a portion of an old salt-water canal, said to have been excavated by one of the Pharaohs, and the work was being pressed forward at a fair rate. Three hundred men, however, could not make much impression upon a work of such magnitude; the section of which is equivalent to about 350 cubic yards per lineal foot, the whole, it must be remembered, having to be lifted to the top of the bank.

Soon after leaving this cutting the Canal has to pass through the Bitter Lakes, the surface of the water, or soil, in which is nearly on a level with the Red Sea. Here the cutting will not exceed the ordinary section of the Canal; nothing, however, has been done to the work as yet.

The fresh-water canal passes at too great a distance from these lakes, and indeed from the rest of the line as far as Ismaïlia, to allow of the Author personally examining the line, or ascertaining what work was done, or doing. He was told that some dredging machines were at work, water sufficient to float them being admitted from the fresh-water canal.

The distance between Suez and Ismaïlia is about 50 miles, and it took twenty hours to get to the latter place, the average speed being $2\frac{1}{2}$ miles per hour, but exclusive of stoppages about 3 miles per hour.

A little east of Ismaïlia the branch from the fresh-water canal came to an end, and the boat dropped, as before stated, by two

single detached locks to the level of the Mediterranean, into a salt-water canal about the same size as the other. For some distance this was only a branch, but at about 2 miles from Ismailia the branch enters the line of the main Canal, which turns sharp to the left or northwards, and passes through a heavy sandbank from 40 feet to 60 feet above the level of the surface water in the Canal. The line did not seem to be well laid out here; it wound about, apparently to avoid cutting, but the result of this would be to render the passage of long vessels difficult. It was said that this portion of the work would be rectified.

The works here were in active progress; the Contractor was cutting down the face of the excavation, loading the spoil into wagons, trains of which were constantly in motion, being drawn by locomotives obliquely up the slope of the hill, and thence to spoil banks at some distance on the west side of the Canal. Some dredging machines were also at work deepening the channel; the soil raised being discharged into wagons and hauled up the bank. The amount of work to be done here was very great, as the sandbank or ridge extended about 5 miles.

To the north of the sandbank the Canal entered the beds of some lakes—the soil of which cannot be more than a few inches above the Mediterranean. Here, in places, the soil had evidently a disposition to slide into the Canal; as the trifling load of an embankment, sufficiently high to cover the fresh-water pipes, had forced the bank out, in spite of some piles and sheeting, which had been driven and fixed to support it. This sort of work extended the greater part of the remainder of the distance to Port Saïd, about 10 miles from which the Canal entered Lake Menzaleh, a shallow sheet of salt water, through which the line was marked, by slight embankments, distant apart the full width of the Canal. At several points between the deep-sand cutting and the shore of Lake Menzaleh, the Canal was opened to its full width. Dredging machines were at work both widening and deepening it, and some amount of activity was shown.

The dredging machines appeared to be well put together. They were worked by powerful engines, and a variety of expedients had been devised, for the purpose of adapting them to the work they had to perform, in lifting the spoil from a great depth, and discharging it at a point above the engine. Still, however, the impression conveyed, after watching carefully the working of these machines, was that the work must be expensive, and that any estimate of cost, deduced from the work done in shallow water, would be most fallacious, if applied, without very large allowances, to determine the cost of excavating the lower portions of the Canal, say the last 10 feet from the bottom.

The main work in progress at Port Saïd (Plate 14) was the jetty,

or breakwater, which is to protect the port against the action of the north-westerly, or prevailing winds. This jetty is formed of blocks of concrete, rectangular in form, and weighing 20 tons. Experience has shown, that a block of this size (10 cubic metres) and of this weight, is sufficiently massive to withstand the action of the heaviest sea. The concrete is composed of sea sand, dredged from the harbour, and of good hydraulic lime procured from Marseilles, the proportion of lime to sand being about 350 lbs. of the former to a cubic metre of the latter, or about one to thirteen. Sea water is used to mix the ingredients, which are well worked and amalgamated in mills, ten of which are driven by one steam-engine. The mixture is poured into cases, or frames, of wood, where it is allowed to remain four days; the cases are then removed, and the blocks are subjected to the influence of an Egyptian sun for two months, by which time they are solid enough to withstand the action of the sea. Each mill can turn out three blocks per day.

The Contractor has engaged to furnish the blocks, and to deposit them at appointed spots, for 400 francs for each block. This sum is to cover the interest of capital upon the whole cost of the plant, the cost of dredging the sand, importing the hydraulic lime, mixing the material, and interest upon all this outlay for two months. The cost of conveying the blocks to the breakwater, and of depositing them, is paid for at the rate of about $1\frac{1}{2}$ franc per cubic foot.

The mass will of course stand at a much steeper slope than it would were the blocks of smaller dimensions, and there will be a large space between the blocks, which will eventually be filled with sand drifted in by the sea. Still, however, it will not be safe to calculate the average section at less than 1,500 cubic feet, or the cost at less than 2,000 francs, per lineal foot.

At present a length of about 300 yards of the western arm is above water; and although the action of the sea on it is heavy, the material appears to stand well. Sand is accumulating rapidly along the western face; and it may be expected that a portion of the sand, which now chokes up the space marked out for the harbour, will be removed by the action of the easterly drift. A very large amount, however, will have to be dredged out. The cost of excavation by dredging machines is dependent upon a variety of contingencies. The French Engineer admitted that the cost of dredging was heavier than that of excavating by manual labour. The latter, however, cannot be got; while dredging machines and steam power are procurable to any extent which can be paid for.

It is true that, in theory, the whole expense of providing and maintaining the 'plant' is thrown upon the Contractor; but it may be surmised that advances must be made by the Company, for there were at Port Saïd forty large dredging machines, either under con-

struction or repair, while sixty were said to be at work at different parts of the Canal. The cost of these cannot have been less than a quarter of a million sterling, and the establishments at Port Saïd, which had the appearance of a large dockyard, were maintained in great measure at the expense of, or at all events, principally for the use of, the Contractors. The cost of these must be very heavy, and fall upon the Company either immediately or eventually.

The result of this inspection of the works of the Canal is an opinion, that it will not be possible to maintain the section adopted by the French Engineers; that the slope of the bank, or sides, is far too steep to maintain itself against the action of the water, even when faced with stone, unless indeed the work can be done with better materials, and at a much heavier cost, than estimated; and that the estimate for maintenance, that is, principally, for removing drift sand and deposit, will be largely exceeded.

The effects produced upon the banks by the small vessel in which the Author was towed along the Canal, at a maximum rate of 3 miles per hour, were very marked. Not only were the banks cut away, but the *débris* assumed a slope differing, of course, according to the character of the soil, but in every case approximating nearer to that of an ordinary beach, than to that of the section proposed. As, therefore, most of the excavations will have to be taken out by dredging, in which case it will not be possible to protect the irregular slope left by the machine with any hard material except at an enormous expense, the Author cannot but think, that it will be found necessary to augment, largely, the surface width, and to give to the sides a slope of nearer 6 to 1 than 2 to 1. By thus widening the surface of the Canal, the action of the water raised by the passage of vessels will not be so injurious to the banks, as the wave would not be so high,—the section of the vessel bearing a much less ratio to that of the Canal than according to the present section. There are other advantages which would result from the increased width of the Canal to which it is unnecessary to allude.

The correspondence between M. de Lesseps and the late Mr. R. Stephenson, in which the late Mr. Rendel, Mr. McClean, and Mr. Manby appear to have taken part, was principally as to the relative merits of a canal according to the proposed construction, and of one at a higher level, drawing the water required for lockage and waste from the Nile, and dropping by locks into the sea at each end. The whole gist of the arguments lies in the statement made by the English Engineers, that an open canal upon a level between the two seas was “an impossibility.” To this view the Author cannot yield assent.

The second document referred to is the Report of Mr. Hawkshaw, dated February, 1863. While adopting generally the statements

and opinions therein expressed, especially those dealing with the engineering objections to the present scheme, the Author is inclined to think that the difficulties to be encountered, and the cost of maintaining the work, have been under-estimated.

The opinion the Author has arrived at, based upon what he saw and heard during his visit to the Canal, and upon a fair consideration of the correspondence and report before alluded to, may be stated as follows :—

1st. That (subject, of course, to the condition that the relative levels of the Red Sea and the Mediterranean are as stated by the French authorities) there will be no extraordinary difficulty in carrying an open salt-water channel from the Mediterranean to the Red Sea of the depth proposed, namely 8 mètres.

2nd. That no special difficulty in maintaining this channel need be anticipated.

3rd. That it will be necessary to modify the section proposed by the French Engineers, making the side slopes much more gradual.

4th. That the cost of maintaining the above-mentioned depth of water will be found at first to be largely in excess of the amount estimated. Eventually, it is by no means impossible that means may be found to fix, or check the drift of sand, or to shut it out from the Canal. But for some years it must be expected, that the ordinary action of the atmosphere, which has filled up former excavations made in this dry desert, will have the same effect in the new Canal.

Looking at the work as an Engineer, there does not appear to be any difficulty which a skilful application of capital may not overcome.

[Sir W. DENNISON.]