BUENOS AYRES SEWAGE PUMPING ENGINES.

The pumping engines illustrated by the engravings on pages 281 and 284 have been made to the designs of Messrs. Browne and Boby, of 11, Queen Victoria-street, London, for pumping sewage in two of the outlying districts of Buenos Ayres, and form a portion of the improvements in that city which are being carried out by Mr. J. F. La Trobe Bateman, M.I.C.E., for the Argentine Government. The constructors are Messrs. Thornewill and Warham, of Burton-on-Trent.

The engines have to fulfil a number of requirements, which may be stated as follows:—(1) The sites at disposal for the engine-houses being exceedingly limited, it is necessary that the engines should occupy very little space. (2) Fuel being expensive, economical working is imperative, and under great differences of speed, as for several hours of the day the engines are required to do their full work, and for the remainder of the twenty-four hours only about one-fifth of that amount. (3) As the engine-houses are situated in populous suburbs, and in the close vicinity of dwelling-houses, condensing engines are desirable for quietness of working, but no water is available for the purpose of condensation. Messrs. Browne and Boby's designs were selected by Mr. Bateman as meeting all these requirements.

The engines contain several novel and very ingenious and noteworthy details. They are compound condensing, constructed on Messrs. Browne and Boby's patented system, and have hand variable expansion valves on the high-pressure cylinders. The action of the steam-moved slide-valves is of a positive character, so that the engines can be worked, when necessary, at as slow a speed as may be desirable. For economy of space, the high-pressure cylinder is superimposed on the low-pressure cylinder, the pistons of both being connected by their piston and connecting rods to one end of a bell crank, the other end of which actuates the pump. The pumps are placed down the well, close to the sewage level; and the delivery pipes, just above the

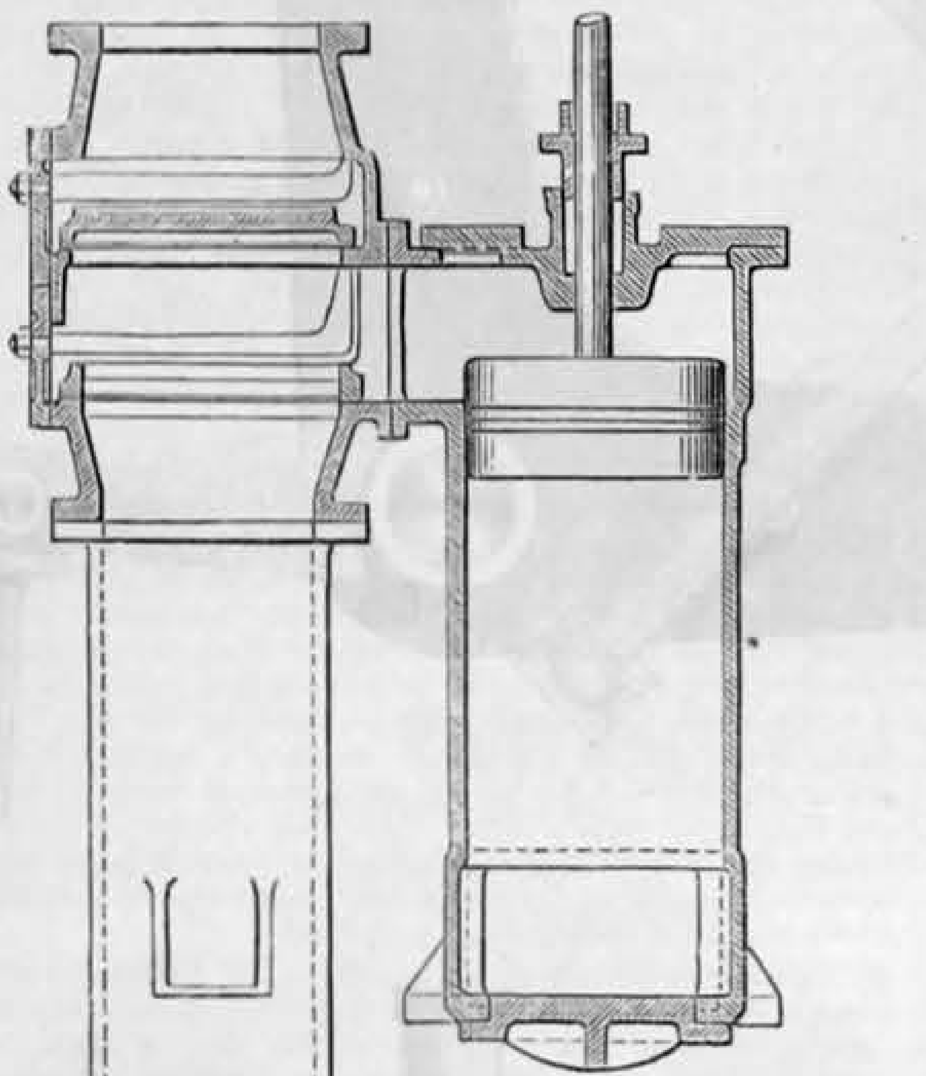

FIG.5.

pumps, have surface condensers formed in them, the sewage forming the cooling fluid, and passing through four tubes whose united sectional areas are slightly in excess of the area of the main delivery pipe. Curved deflectors are attached inside the end covers of the condensers, to prevent undue friction in the flow at these angles. The air-pumps are worked from levers keyed to the shafts of the bell cranks. They stand at a lower level than the condensers, so that a good fall is obtained for the condensed water to their suction-valves. The whole of the condensers, air-pumps, and delivery connections to main are placed below the floors of the houses for economy of space. Four sets of engines, boilers, and pumps have been constructed, two to each of the two houses; and in each case one set of enginge boilers, and pumps is to work continuously, the other set beins, provided as a stand-by. The maximum work to be performed is in one case the raising of 1029 gallons per minute, against a total head of 26ft.; in the other case, 658 gallons per minute, against a head of 35ft.

The details of the engines are arranged with a view to securing uniformity of length of stroke under varying loads, and also very small clearance between the pistons at the ends of their strokes and the cylinder covers. The pistons are also caused to rest momentarily at the ends of their strokes, so as to allow the

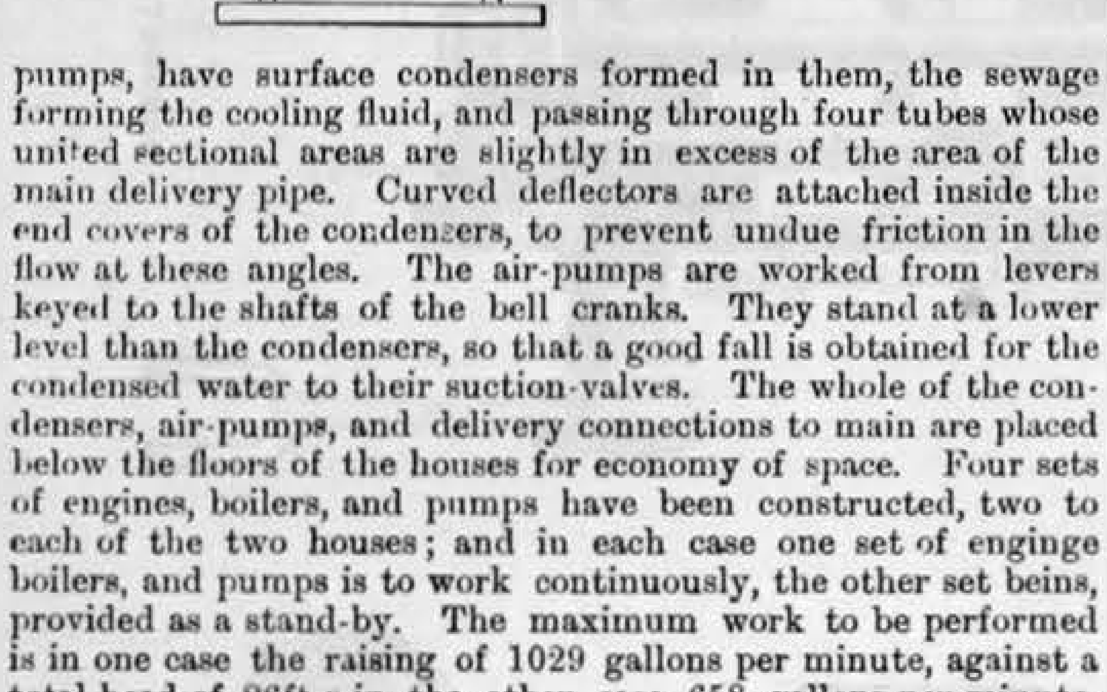

FIG.6.

pump valves to seat themselves before the reversal of the current. In raising the minimum quantity the vacuum will perform the greater part of the work. Under these conditions, the exhaust side of the low-pressure piston being entirely free from steam, it becomes necessary to cushion it by means of steam introduced direct to the low-pressure cylinder at about the end of the stroke, and to ensure uniformity of length of stroke this cushion must be independent of the reversal of the main slide, and consequently the steam must proceed from a source other than the high-pressure cylinder. The steam from the boiler enters the expansion valve chest, as shown on the side elevation of the engine at Fig. 1. This valve chest is shown in detail at Fig. 3. It consists of a cylinder with two piston valves cutting off by their inner edges, the steam being admitted at the centre of the chest. The outer valve is forged in one piece with its rod, upon which is attached a hand wheel, and by turning this wheel both valves are revolved and the cut-off adjusted by means of the right and left-hand threads, as shown. The valves take their motion direct from a lever on the rocker shaft, seen in Fig. 1. The chest is constructed with a liner at each end, by means of which a very narrow annular port is formed all round its bore, giving a sharp cut off, and maintaining the balance of pressure round the valves. The expansion valve chest is attached to the inner ends of the two main slide chests of the high-pressure cylinder, the steam passing into these latter through passages leading from the annular ports. The main steam ports in both high-pressure and low-pressure cylinders enter at a short distance from the cylinder ends, so that the pistons cover them before their strokes are completed. A small amount of the exhausting steam is thus imprisoned in the case of the high-pressure cylinder, and to some extent forms a cushion, which, however, would not be sufficient to be depended upon with so short a cushion space. To form the necessary amount of cushion the device shown on the section of the high-pressure cylinder, Fig. 5, is adopted as follows:—A passage is drilled from the pressure side of the piston, leading out to the centre of its periphery, and a corresponding passage is drilled leading from the bore of the cylinder to its end. At the time that passage in the piston corresponds with this port, steam is admitted from the driving to the exhaust side of the piston, and as the stroke is continued the passages are shut off and the steam confined and compressed, forming an absolute cushion; the main steam port is covered by the piston at the moment that the two passages commence to open into each other. A small port from the main slide face is provided, which, upon the reversal of the main slide, is opened, and steam is admitted through it to start the piston slowly on its return stroke. A small valve is provided in the cushioning passage to prevent steam passing through to the exhaust side as the openings of the ports repass each other.

The cushioning of the low-pressure piston is accomplished by admitting exhaust steam from the small supplementary cylinder which actuates the main slides; this supplementary cylinder is shown in detail at Fig. 4, and it will be seen that it has a slide valve with two exhaust cavities, and working on a face in which are two exhaust ports, which are connected respectively to the ends of the low-pressure cylinder. The small slide is actuated by a rocking lever taking its motion from a pin on the bell crank, and which comes in contact with adjustable stops, as shown, upon the spindle of the double-ported slide. The stops are set so that when the pistons are just covering the main ports the small slide commences to release the steam in one end of the supplementary cylinder, and consequently its admission to the end of the low-pressure cylinder. The low-pressure cylinder is provided with small restarting ports controlled by its main slide as in the high-pressure cylinder. From the above description it will be seen that the cushioning in both cylinders is quite independent of the reversal of the main slide valves, also that the steam used in cushioning and in driving the piston of the supplementary cylinder does not in any way detract from the economy of working, as it is afterwards utilised in the main cylinders. It is evident that the engines cannot commence to cushion till the main ports are closed, so that only a very slight variation in the length of stroke can occur under any circumstances. The principal dimensions of the engines are as follows:—High-pressure cylinder, 7½in. diameter; low-pressure cylinder, 13in. diameter; stroke, 30in. Diameter of pumps in one house, 18in.; diameter of pumps in other house, 14in.; the stroke being 30in., as in the engines. The low-pressure cylinders are steam jacketted. The engines when tested under steam in this country were necessarily run light, and the indicator diagrams given on page 284 illustrate the action of the engines under these circumstances.

In diagram No. 1, page 284, it will be seen that a considerable amount of vacuum existed in the high-pressure cylinder—a condition very unfavourable for cushioning, and which could not occur if any load were on the engines; but even under these circumstances a good cushion is formed in the low-pressure cylinder. Diagram No. 2, taken with the exhaust passing to the atmosphere, shows the sharpness of the cut-off by the expansion valves. In this diagram it will be seen that but little cushioning takes places at the "crank end," the reason of which is that when moving in that direction—which in this case was at a slower speed than when the vacuum was in action—the pistons have to raise the unbalanced weight of the arm of the bell crank, &c. In actual work the engines will make their in-stroke more quickly than the out-stroke, which is, of course, not in any way detrimental to their efficiency, while the space which would be occupied by a balance weight is saved. The vacuum for purposes of trial was obtained with a temporary condenser. For convenience in starting, a connection is arranged from the centre of the expansion valve chest to the steam inlet of low-pressure cylinder, so that high-pressure steam can be turned into it.

The pumps, of which a section is given in Fig. 5, are double-acting, and fitted with pistons having cast iron packing rings. A detail of the valves is shown at Fig. 6. These are of cast iron, of the hinged form, but free to lift as far at the hinged as at the free side. The seatings are wedged into the valve-boxes with wooden wedges. The foot valves are of similar construction. The boilers of the vertical type are fitted with Field tubes. Each boiler can be placed in communication with either engine, and the donkey pump on each boiler can be steamed from either, and also will feed into either, as may be desired.

TUNNEL FOR FOOT PASSENGERS IN STOCKHOLM.

In The Engineer of December 4th we drew attention to the recent employment of a cold air machine for freezing wet gravel in the construction of a tunnel at Stockholm. Through the courtesy of the contractor, Captain Lindmark, of the Swedish Royal Engineers, we are now in a position to place before our readers further particulars of this interesting and novel work.

The most populous part of the Swedish capital is situated on the north shore of the lake Mälaren, and is divided into two districts, of about equal extent, by an elevated ridge of stones and gravel, the ridge, which runs in a northerly direction from the lake, and which in some places attains a height of 70ft., constituting a great impediment to traffic.

In order to afford an improved communication between the two districts, Captain Lindmark applied to the municipality of Stockholm for powers to construct, on his own account, a tunnel for foot passengers through the hill, and to levy a toll of 2 öre, or ·27 of a penny, on each person passing through, for a period of fifty years, the tunnel afterward to become the property of the town without any indemnity whatever. This application was strongly opposed, not only by the owners of adjacent houses, but by engineers, who stated that driving a tunnel through loose stones and gravel, as proposed, would necessarily cause great subsidences in the ground, and consequent damage to the buildings above. The municipality, however, considering the great benefit that would result from the realisation of the project, granted the concession, and in the summer of 1884 the works commenced.

As shown by the engravings, Figs. 1, 2, and 3, on page 281, the tunnel follows the direction of a narrow street, scarcely wider than the tunnel itself. This plan, though perhaps not the best for the safety of the houses during construction, being adopted in order to avoid appropriation of valuable property. The tunnel has a length of 758ft., a height of 12ft. 8in., and a width of 13ft. 2in. The works were commenced from the east end by driving a heading at the bottom level—a matter which offered no difficulty, as the heading passed entirely through granite which was blasted by dynamite. The enlargement of the heading, however, caused considerable trouble, because the crown of the tunnel in several instances passed into fine sand lying close to the rock. At such places explosives could not be used, and the rock had to be broken by means of wedges, which was a slow and expensive method. The driving of the tunnel from the west end introduced difficulties of a more serious nature, because the ground to be pierced consisted entirely of coarse gravel, intermixed with large stones and a small quantity of wet clay. Fifty feet from the mouth the tunnel passes between two valuable houses, five stories high, built on the slope of the ridge. The distance between those houses was so small that the side walls of the tunnel had to be constructed right under their foundations, which extended down to within 10ft. of the top of the arch. The foundations of the houses could not in this case have been brought down to the bottom of the tunnel by underpinning—partly on account of the great depth, but chiefly from the loose nature of the ground. The system invented by the Austrian engineer Rziha was from the beginning adopted as being the safest under such difficult conditions. Moreover, an iron wall of plates, 12in. square, as shown in Figs. 5, 6 and 7, was made to place against the face of the tunnel as the excavation advanced. Notwithstanding these precautions, the results were not satisfactory. It was found that the gravel, on account of the water and clay it contained, had no cohesion whatever, and would pass freely through even a very small opening. The consequence was that a subsidence took place in the ground above; and the excavations had not advanced more than 40ft. when the works had to be stopped, experience showing that if it was proceeded with the houses would in all probability come down.

Under these circumstances Captain Lindmark decided to freeze the earth before making the excavation by means of cold air, and for this purpose he procured from Messrs. Siebe, Gorman, and Co., London, one of Lightfoot's patent dry air refrigerators capable of delivering about 25,000 cubic feet of cold air per hour, which was erected in the tunnel as close as possible to the part to be operated on. The position and arrangement of the machine is shown in Figs. 4 and 5. The inner part of the tunnel was formed into a freezing chamber by means of a partition wall made of double planking filled in with charcoal.

In the middle of September last year the works were renewed. By running the refrigerator continuously for sixty hours the gravel inside the freezing chamber was frozen into a solid mass to a depth varying from 5ft. near the bottom of the tunnel to 1ft. near the top. At the crown no freezing took place, and though the temperature at the bottom was as low as 40 deg. below zero Fah., the thermometer would indicate 32 deg. above zero at the top, or 16ft. above the floor. This circumstance, however, did not occasion any inconvenience, but rather the reverse, as in any case it would have been necessary to support the roof with planking, which it would have been almost impossible to drive in if the gravel had been frozen. The work was now proceeded with as before, in sections of 5ft., the excavation commencing at the top, and the iron wall being built up from above downwards as fast as possible. But the great difference was that now the whole mass of gravel and stones was solid; indeed, for some 8ft. or 9ft. from the bottom the iron wall was dispensed with, the gravel forming such a hard and compact mass that it had to be cut away with special tools. After the first commencement it was sufficient to run the refrigerating machine on the average from ten to twelve hours every night, though after heavy rains, when much water percolated through the gravel, it had to work somewhat longer. The machine delivered the air at a temperature of 67 deg. below zero Fah., and worked admirably all the time without a single hitch or stoppage of any description. The temperature in the freezing chamber was generally from 6 deg. to 15 deg. below zero Fah., after ten or twelve hours' working, but it soon rose to freezing point when the workmen commenced their operations inside.

After two sections had been excavated the partition wall was removed forward, thus the contents of the freezing chamber varied from 3000 to 6000 cubic feet. The arching of the tunnel was completed as quickly as possible close up to the partition while the earth was still frozen. In this way a great deal of the planking could be removed, and the cavities filled up with masonry. In the top of the tunnel the planking could not be removed. The masonry is made up of concrete in the proportions of one of Portland cement to two and a half of sand and six of broken granite. By using concrete all the cavities were quickly and well filled, and subsidences avoided.

About 80ft. of the tunnel was driven by the aid of the Lightfoot refrigerator, with perfect success. In the residential house on the north neither subsidence nor cracks were perceptible two months after completion of the work at this point. In the house to the south the front has subsided about 1in., producing some small cracks in the walls. It is, however, to be observed that this house was not so well built as the other, subsidences having taken place in it long before the construction of the tunnel was commenced.

The daily progress while using the freezing method averaged 1ft. Since then the excavation has been carried out on much more favourable ground, consisting of pure sand, which possesses considerable cohesion, and can be safely cut away without being frozen. The daily progress now averages 2½ft.

In the middle of May it is expected that the tunnel will be completed and opened for public use. It will be lighted by means of Wenham's patent regenerative burners. The total cost of the undertaking, including all expenses, amounts to about £14,000, and to pay 10 per cent. on this sum, after clearing the working expenses it will require that 4400 persons should pass through every day.

Naval Engineer Appointments.—The following appointments have been made at the Admiralty:—Alfred Wood, fleet engineer, to the Northumberland; J. Stephens, staff engineer, to the Superb.

Leadbeater's Chair.—In our impression for June 12th, 1885, we described and illustrated Leadbeater's railway chair, in which a cast iron wedge and wrought iron key take the place of the ordinary wood key. A mile and a quarter of line on the Great Northern Railway has been laid within the last few weeks with this chair near Finsbury Park station, and about 300 yards near Holloway station.