

(*Paper No. 2086.*)

**“ Machinery for the Manufacture of Nitrate of Soda
at the Ramirez Factory, Northern Chili.”**

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THE production of nitrate of soda has, since 1869, been developed with great rapidity, and its manufacture gives employment to a vast amount of English-made machinery and capital, and many English engineers and mechanics. In 1845 nitrate of soda was produced by extracting the “caliche” or raw material from the ground, and boiling it in copper pans of native manufacture, the fuel employed being carbonized wood dug up from the Tamarugal Pampa, in the province of Tarapacá, formerly in Peru, but recently annexed by Chili, where there are in many parts indications of a sunken forest. Probably owing to the primitive method of manufacture, and the fact that nitrate of soda was not commercially known, the exportation in 1845 was only 6,000 tons. It increased by degrees up to 70,000 tons in 1859, and in 1883 the exportation of this valuable fertilizer reached 12,500,000 Spanish quintals, or 570,000 tons. Such a production would have created an excess over the demand, had not the producers formed an agreement to limit their output, so as to meet European requirements, which at present are 460,000 tons annually. This amount is produced by thirty-seven different establishments or factories, technically known as “oficinas,” and by thirty distinct firms or owners, the production of English companies being 186,000 tons, or 40 per cent. of the whole. The productive capacity of the Oficina Ramirez is 140,000 quintals, or 6,360 tons monthly; but the works are now, like all the other establishments, limited to 40 per cent. of their productive capacity, or 56,000 quintals per month, giving an annual output of 30,000 tons.

The process of manufacturing nitrate of soda, and a description of the machinery of the Oficina Ramirez, which is the largest establishment of its kind in the world, form the subject of this Paper.

In September, 1882, the Author received instructions from the directors of the Liverpool Nitrate Company, Limited, who own 6 square miles of nitrate grounds in the district of Ramirez, in the

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province of Tarapacá, to prepare plans and estimates for the construction of an oficina capable of producing from 6,000 to 6,500 tons of nitrate of soda per month, this total being 1,000 tons more than was in the power of the largest oficina then extant. In January, 1883, the plans and specifications were laid before the directors and approved of, and the Author was instructed to order the necessary machinery (Plate 7). Six steel boilers, 30 feet long by 6 feet 6 inches, double flues, with six Galloway tubes, were constructed by Messrs. R. Daglish and Co., of St. Helen's. Twelve boiling-tanks with steel condensing tubes, ninety crystallizing-tanks, two feeding-tanks, a five-compartment washing-tank, as well as three circular tanks, 25 feet in diameter by 12 feet high, came from the works of Messrs. Preston, Fawcett, and Co. The locomotives and rolling-stock, with a length of $2\frac{1}{2}$ miles of portable railway, as well as two semi-portable engines for the wells, were made by Messrs. John Fowler and Co. of Leeds, and the engines, pumps, machine-tools, &c., by Messrs. Tangye Brothers. And three crushing-machines were made by Messrs. North, Humphery, and Dickinson, of the Tarapacá Foundry, Iquique.

Having seen the contracts for plant properly placed, and having purchased the machinery required for the wells for immediate use, which was sent by steamer, the Author left for Iquique, arriving there on the 15th of May. He at once commenced making the necessary excavations for the foundations for the machinery, which came by sailing vessels on the 10th and 29th of December. The first batch of crystallizing tanks, which were shipped unriveted, reached the oficina on the 23rd of December.

Owing to the salt and other solvents contained in the soil, the greatest care had to be taken in preparing the foundations for the carrying walls, as, if only a small quantity of water should penetrate to the foundations, they would immediately become damaged, perhaps beyond repair, losing their original lines by subsidence, and thus fracturing the steam and other connections resting on them.

In making the foundations for the carrying walls, which are constructed of trimmed igneous boulders found in the locality, the ground was excavated to a depth of 12 feet, over an area of 7,500 square feet, although the walls are only 84 feet long, and 29 feet apart from outside to outside. A layer of broken boulders 2 feet deep was first deposited, and a filling of one-third Portland cement, one-third sharp sand, and one-third hydraulic lime, was run in the interstices. Next a layer of concrete, made of hard

stone, of about 1-inch cubes, with one-half cement and one-half sand, was superposed 1 foot deep, and then three layers of good masonry all cemented. On this the walls were built, 12 feet high, 6 feet wide at the base, and 3 feet 6 inches at the top. This apparently excessive batter is necessary as a safeguard against the frequent earthquakes, which often cause much damage to machinery constructed on weak, straight, or high foundations. A wooden framing of Oregon pine, with the uprights and runners 1 foot square, the uprights being 5 feet 6 inches from centre to centre, was next built, on a wall 2 feet 6 inches high by 2 feet 6 inches thick, in the centre of the space between the two main walls, and parallel to them, in order to obtain a good distribution of the weight of the boiling tanks. On this framing twenty-four iron girders, 10 inches wide, 10 inches deep, and 35 feet long, were laid, and on the top of the girders the boiling tanks were bolted in sections and riveted. The inside carrying-wall is backed up by cemented masonry, 6 feet high and 4 feet wide, with an inward sloping surface, so as to catch any drainage or leakage from the ends of the tanks, from whence it flows into the passage between the two main walls by means of ten drains or conduits of 3-inch pipe built in the main wall. From the north to the south end of the floor between the walls there is a fall of 6 inches, causing all the drainage to flow to the south end, where a canal and tank are provided for its reception. Three parallel walls are built in front of the main walls, on which the washing tank, consisting of five compartments, each 24 feet by 6 feet 6 inches, rests.

The boiler, flues, and setting, are constructed on Livet's system, and give excellent results. They are built in pairs as regards flues, with a chimney 42 feet high by 5 feet in diameter, of iron, having a base of 9 feet for each pair of boilers.

The feed-water tank, fresh-water tank, top mother-liquor tank, and well-water tank, are all erected on substantial masonry built on deep concrete foundations, and rest directly on a bed of cement.

The ninety crystallizing tanks, or precipitating tanks, 16 feet by 16 feet by 3 feet deep on one side, sloping to 2 feet 9 inches on the other, in order to thoroughly drain the precipitated nitrate, are erected on a strong framework of Oregon pine, 6 inches square in section, with longitudinal, transverse, and diagonal stays, 4 inches square in cross-section. Under each crystallizing tank there are six runners of timber, 4 inches square, on which it rests, on the projecting ends of which is a plank roadway for the men in charge of the hot nitrate in solution, known as "caldo," literally

boiling juice. This consists of "caliche" dissolved in boiling mother-liquor. All the crystallizing tanks with framework rest on low stone walls built on a dry rubble foundation, cement being in this case unnecessary, as leakage from mother-liquor or nitrate in solution does not dissolve the ground on which it falls.

The whole of the known nitrate deposits in the world are situated on the west coast of South America, between south latitude 19° and 27° , although there are indications of nitrate in Nevada and California.

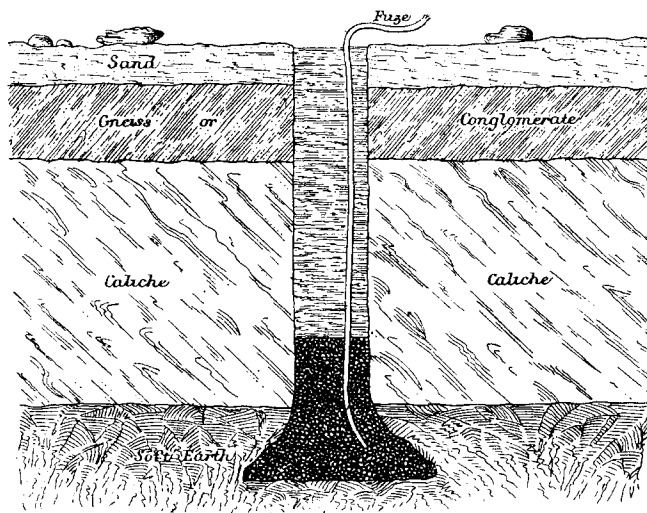
The "caliche," or raw nitrate of soda, is a mineral deposit formed, it is alleged, by the contact of decomposing animal and vegetable matter with the salts left on the retreat of the sea. This theory of its formation is supported by the frequent discovery of guano, sea-birds' eggs, fishes, feathers, birds' skeletons, shells, fossils, &c., in proximity to the caliche, and at a depth of 12 to 15 feet below the surface of the ground, and also by the presence of iodine as iodate of soda, which is peculiar to the sea.

The best deposits are found on the skirts of the Tamarugal Pampa. The caliche lays in beds of a thickness varying from 6 inches to 12 feet, beneath a covering of from 1 foot to 10 feet of conglomerate or pudding stone, or hard rock, principally porphyry, but varying also in character to foliated gneiss, greenstone, and syenite. No caliche beds are known to exist nearer than 15 miles from the sea coast, and the furthest, those in the district of Atacama, are distant about 90 miles. The Ramirez caliche beds, or raw nitrate deposits, comprise 3,270 acres, or nearly 6 square miles, and are situated on the border of the Tamarugal Pampa, 59 miles from the port of Iquique by the line of the Nitrate Railway Company, and 42 miles by direct mule road.

The caliche is plentiful and easy of extraction; its chemical analysis is, nitrate of soda, 51 per cent.; common salt, 26 per cent.; sulphate of soda, 6 per cent.; sulphate of magnesia, 3 per cent.; and insolubles, 14 per cent.

In order to provide caliche sufficient to meet the requirements of so large a system of machinery, at least two hundred and fifty mules and forty carts would be required; to avoid this expense the Author introduced the innovation of a portable railway with two locomotive engines and eighty side-tip cars, thus precluding the necessity of employing more than thirty mules and five carts for taking the caliche to the side of the line which runs out $1\frac{1}{2}$ mile in the caliche quarries. This has proved a most efficient and economical mode of carriage.

The locomotives are four-wheeled coupled side-tank engines, with two-wheel trailing bogie and outside cylinders 8 inches in diameter, and having 12-feet length of stroke. The driving-wheels are wrought-iron with steel tires 2 feet 6 inches in diameter, and 4-feet wheel base; the trailing-wheels are cast-steel, 1 foot 6 inches in diameter; the weight of the engine in working order is 6 tons 15 cwt., and it carries 250 gallons of water and 5 cwt. of coal. The locomotives, as well as the cars, were designed by Mr. David Greig, M. Inst. C.E. The line has a 2-feet gauge, with steel rails and steel sleepers, known as Greig's Patent Portable Railway. The sharpest curve on the line is 60-feet radius, and the steepest gradient 3·15 in 100. The rails weigh 16 lbs.



to the yard. The cars with frames and wheels weigh 5 cwt. each, and carry 1 ton 10 cwt. of caliche. The ordinary load for an engine is fifteen cars, or from 22 to 23 tons per trip.

The caliche is extracted in the following manner:—A shaft about 1 foot in diameter is sunk. Into this a boy is lowered, who forms a recess at the bottom in the shape of an inverted funnel, which is filled with a slow blasting powder (as shown in the above Fig.) made on the works, and is ignited by one ordinary fuze. This causes a dull explosion, breaking and loosening the ground around the shaft for a radius of about 10 yards. The overlying stratum of hard rock, porphyry, gneiss, &c., locally

known as "costra," is removed, and the caliche extracted and split and broken by sledge hammers, steel wedges, and bars, into blocks of about 30 lbs. weight. It is then loaded into the cars and carried into the crushing machines, and there broken into cubes of about 2 inches. The three crushing machines are driven by a 25 HP. Tangye engine.

Cars stand under the mouths of the crushers to receive the broken caliche, and these when fully loaded are hauled up to the turntable by the winding-engine, and from there shoved on and the contents tipped into the boiling tank in course of being charged. The turntable is not in the centre of the six sets of rails serving the twelve boiling tanks with the side tip cars, but is on one side, and is always open to the rails which lead to the two last boiling tanks, so that in case of the winding-engine overhauling, the cars cannot be derailed. The boiling tanks are heated by a 3-inch steel spiral pipe six rows deep, 1 foot off the sides, with steam from the boilers at a pressure of 60 lbs. to the square inch. The steam enters at the top of the spiral, and leaves at the bottom of the tank by a return pipe, which leads to the return valves of the boilers, thus forming a circuit.

The boiling is effected by the well known Shanks' lixiviating system, introduced in nitrate manufacture by Mr. J. T. Humbertstone, causing a continual circulation of the lighter liquid to the other boiling tanks by following the denser and heavier solution. As soon as the solution, which has now become caldo, stands at 110° by Twaddell's hydrometer, it is allowed to settle for a short time and is then drawn off into the first canal, from which it runs into the crystallizing-tanks by means of other canals. The caldo is run off at a temperature of 240° Fahrenheit.

The "ripios," or refuse, in the boiling-tanks is then washed by well water and the washings are run off into the washing tank, taking in solution nearly all the nitrate of soda which may remain in the refuse. The washings are pumped up by a centrifugal pump, and used over again in the next boiling tank. When all the washings have run off, the doors at the bottom of the boiling tank are opened, and the refuse falls into cars placed beneath, and is drawn away and dumped on the refuse heap.

After the nitrate solution has become cool, and the nitrate of soda has crystallized in the tanks, the "agua vieja," or mother liquor, is run off into a set of return canals, by which it flows into the bottom mother-liquor well, which is a round tank 25 feet in diameter and 12 feet deep, sunk level with the surface of the ground. From here it is pumped up by two of Tangye's 4-inch

special pumps to the top mother-liquor tank, from whence it is run into the boiling tanks to undergo a similar process. The mother-liquor stands at 90° Twaddell.

When the nitrate in the crystallizing tanks is fairly drained, it is shovelled out on to the drying-floors, where it soon becomes perfectly dry in the tropical sun, and is put in sacks weighing about 3 cwt. each when full, and loaded on the railway cars, which are run on to the drying-floors by a siding in each floor, one hundred sacks being carried on each car. It then goes to Iquique by rail, and is exported to Europe and the United States as the well-known fertilizer and article of commerce, nitrate of soda.

The cost of the machinery, plant, and construction of these works amounted to £110,000. The whole was finished and was producing nitrate on the 23rd of May, 1884, or in the short space of six months after the arrival of the first lot of machinery. The celerity with which the machinery was placed in a state of complete efficiency is partly due to the choice of good mechanics and artisans brought out by the Author from England, and to the firms who supplied the machinery, and especially to the able assistance rendered by the manager and resident engineer, Mr. James Anderson. The disadvantages of working in a desert 60 miles from a town considerably increased the difficulties of constructing these works.

There is but one oficina on this coast with more boiler-power than Ramirez, namely that of Antofagasta, designed and constructed by Mr. J. F. Spencer, M. Inst. C.E., assisted by the late Mr. Adamson, Assoc. M. Inst. C.E.; and it is probably the finest piece of plant engineering in South America; but it has never produced more than 4,500 tons of nitrate per month, owing to the very low grade of caliche belonging to the works, the average now only containing 20 per cent. of nitrate, the remainder being salt and insolubles. The refuse thrown out from Ramirez tanks, contains only 3 per cent. of nitrate. This could be extracted by more washing, but it would cause a superfluity of weak washings and a reduction in the strength of mother-liquor, so as to need further evaporation in order to reduce the volume and raise the density. During the past six months the ratio of nitrate produced to coal consumed was as 12 to 1; or for every ton of coal burnt, no less than 12 tons of nitrate of soda were manufactured.

One of the most serious questions in the nitrate districts is the supply of water. The water found in wells in the Pampa collects in hard cavities by constant percolation from the melted snow on the Andes or Cordilleras. The course of this water is, however,

very irregular; and there are some oficinas which have to pump the necessary water over a distance of from 4 to 5 miles. Fortunately, in Ramirez the supply of water is practically unlimited. The two wells are 82 yards deep, by 9 feet by 10 feet, timbered all the way down with 12 inches by 2 inches lining, and 6 inches by 6 inches frames at every 4 feet to bear the thrust of the lining, and to carry the guides for pump-rods. They are worked by three-throw Tangye pumps, 3 inches delivery in each, and each well can deliver 70,000 gallons in twelve hours. This water, however, is contaminated by salt and alkaline matters, which necessitates the cleaning of the boilers every two months.

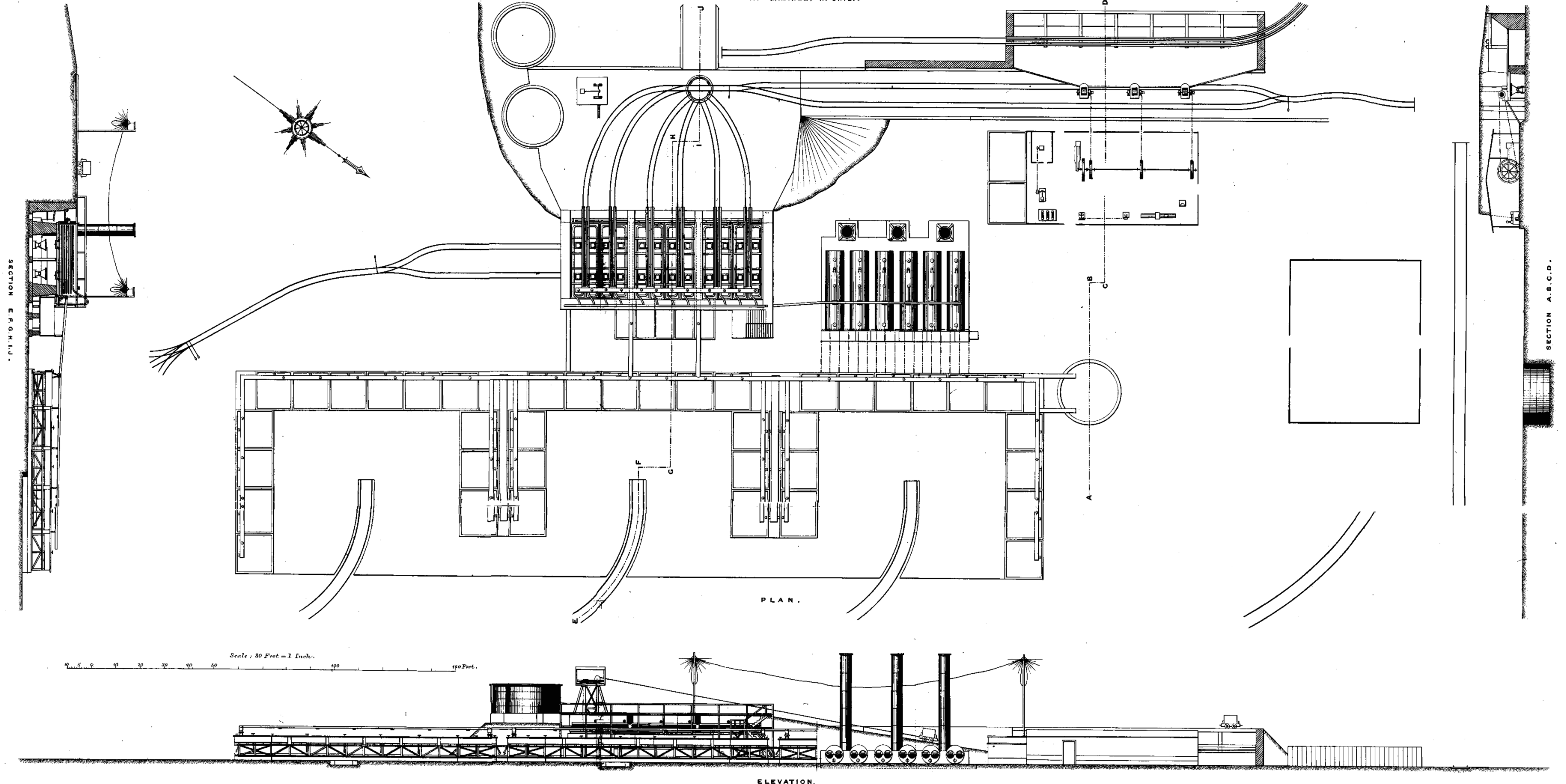
In Ramirez well-water is conveyed in pipes from the large tank to the centre of the square for workmen, for culinary and household purposes, but as this is unfit for drinking, soft water is provided by condensing the exhaust steam from the large engine and steam-pumps.

Owing to the reduced production before alluded to, only three hundred men are now employed on the works, but there is living accommodation for six hundred workmen with their families in a large "plaza," or square, and two streets. The work in this establishment is carried on both night and day, and at night the works are lighted by two 6,000 candle-power arc lights, provided by a Siemens' A dynamo, driven by a 4-HP. Tangye engine. There is also telephonic communication with Pozo Almonte, the nearest telegraph station to Iquique, 17 miles from Ramirez.

The Paper is accompanied by several drawings, from which Plate 7 and the figure in the text have been engraved.

THE MANUFACTURE OF NITRATE OF SODA,
AT RAMIREZ, N. CHILI.

PLATE 7.



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THOS KELL & SON LITH. 40, KING ST COVENT GARDEN