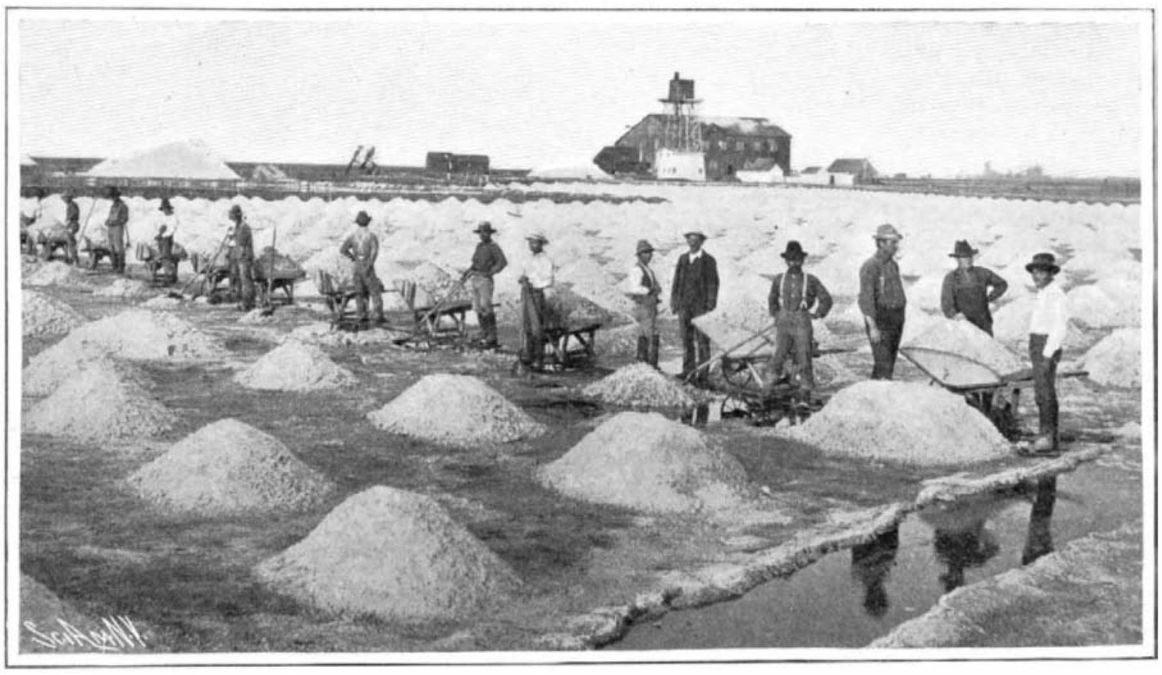
## SALT MAKING ON SAN FRANCISCO BAY.

BY ENOS BROWN.

The great natural deposits of rock salt found in various localities in the vast region west of the Rocky Mountains, are not, commercially speaking, of any particular value, owing generally to their remoteness from distributing markets and, necessarily, to the high cost of transportation. Except for a small local demand from ranchers the yield of these deposits is too minute to figure in general statistical records.

The vast amount of salt consumed on the Pacific Coast is derived therefore from the sea by evaporation in quantity only limited by the demand. The cost of evaporated salt is but one-fifth of the lowest rate of transportation on rock salt from the nearest source of supply to the most accessible ocean port.

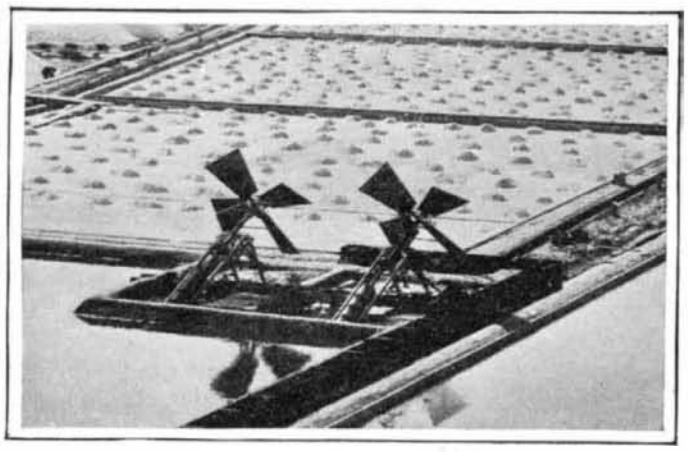
The locality which enjoys a practical monopoly of salt making on the Pacific Coast of the United States is Alvarado, a town of Alameda County and 20 miles from San Francisco. At this point, which lies on the east side of the southern extension of San Francisco Bay, exist certain peculiarities in the lay of the land which, united with climate and a favorable character of the soil, combined to make the locality especially adapted for this particular industry.



Gathering Salt From Settling Pond.

Long intervals of cloudless skies, the low humidity, and high temperature all favor rapid evaporation, while the soil, a stiff clay, is well adapted for levees and making water-tight reservoirs. The land would be submerged at high tide but for the levees that prevent. The highest point in all this tract of 1,000 acres, two miles from mean tide level, is not more than four feet, the low altitude allowing the reservoirs, for the most part, to fill with sea water by gravity alone. Moreover, the southern section of the bay is contaminated by no considerable affluents to dilute with supplies of fresh water the saltness which comes in with the tides of ocean.

Scraping Salt From Hollow Settling Basin.



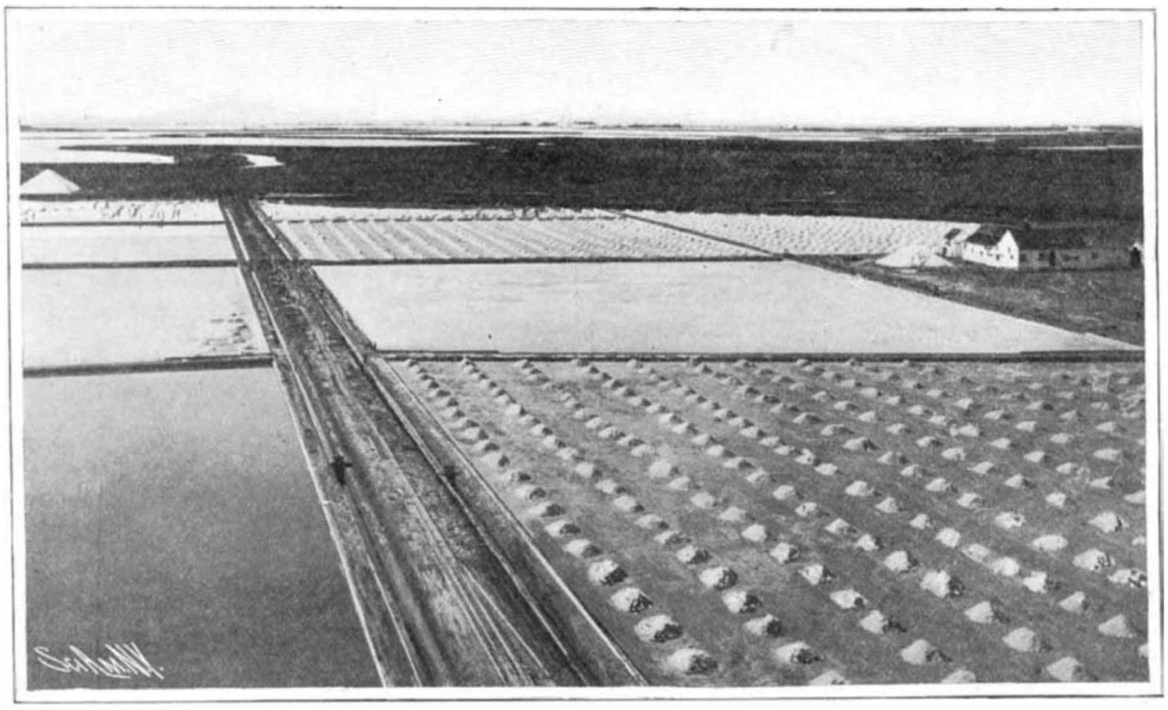
Windmills Raising Brine.

The largest as well as most thoroughly equipped of the several corporations engaged in the business is the Continental Salt Manufacturing Company, which has thirty reservoirs covering 1,000 acres. This company has constructed from first to last 12 miles of levees, 2,600 feet of flumes and 7½ miles of ditches. A slough meanders through the tract, which is navigable for vessels of considerable draft and affords excellent and economical facilities for shipping.

A large mill, well equipped with the best machinery for washing, drying, grinding, sifting, and bolting the finished product is a prominent feature of the works. Twenty Dutch windmills and two Chinese pumps raise altogether 200,000 gallons of brine each minute. The entire plant presents to the observer a miniature Netherlands with the distant ships on the bay appearing as though floating in the air. The transformation of this low, half-drowned district, covered for the most part with a dense growth of swamp vegetation, has been effected by a large expenditure of time, labor and money. To eliminate the vegetation requires three years' time. First the levees have to be built and the inclosed land kept flooded for thirty-six months, when the plants die to the roots and the trace of iron left in the soil is washed out. Afterward the bottom of the new reservoir is first leveled and then made tight by heavy rollers being drawn over the surface, securing a strong and firm foundation. Flumes, sluices, and ditches to connect with other reservoirs are then constructed and the new inclosure is ready for salt making. The manufacture of salt from ocean water is a constant progression from one reservoir to another, transfer being made as the brine reaches a certain density to the next. Reservoir No. 1 covers 305 acres and is surrounded by a 4-foot levee. Its outward boundary is upon a slough flowing from the bay. As the tide rises, twelve gates are opened and allow the sea water to flow in to a depth of 3 feet. The gates are then closed. The average strength of the sea water is from 4 to 7 deg. and remains in reservoir No. 1 until the strength increases to 30 deg. By means of windmills reservoir No. 1 is emptied into reservoir No. 2 and the brine is exposed to the heat of the sun until it reaches a density of 50 to 60 deg., which may take three weeks. The brine is then pumped into reservoir No. 3, where it attains a strength of 75 to 80 deg. It then goes into reservoirs Nos. 4, 5, 6, 7, and 8, known as settling ponds, where the brine voluntarily parts with the lime which it contains and becomes almost a saturated solution at a strength of 90 deg. It is then conveyed to the twenty-two salt ponds where it is exposed to the fierce heat of the sun, and in about twenty days the salt is deposited and the pickle allowed to run off. Two crops are gathered, one each in August and October. After precipitation the salt remains exposed for a few days, when it is first piled in heaps and then wheeled in barrows into great pyramids on the banks. Boards are laid upon the bottom of the reservoirs to prevent the ground from being cut up by the wheels. Dump cars running on temporary tracks are also employed. After the salt is removed the reservoir is carefully cleaned of all surplus dirt and the bottom passed over by heavy rolls to harden the soil and prevent percolation. It is then ready for the next operation. The pyramids of crude salt remain on the bank exposed to the weather until it is shipped as "crude" or passes into the mill to be refined. The demand from tanners is supplied from the lowest grade. The first operation is the washing, by jets of water thrown against the cubes of salt as they pass from a hopper to the upper story of the mill, whereby all visible impurities are removed and leaving the salt, after it is dried, white and ready to be ground into assorted grades.

This process is not dissimilar in its methods to the manipulation of wheat as made into flour. The small remnant of lime, magnesia, and potash is eliminated from the salt crystals by air suction. The salt, when it emerges from the various processes, is of a purity of 98 to 99 per cent.

Levee making, inclosing new ponds, is proceeding at all times. A ditch 12 inches deep is first excavated, and a dirt wall 4 feet wide, built of cubes of clay sod and mortared together by



A General View of the Salt Fields.

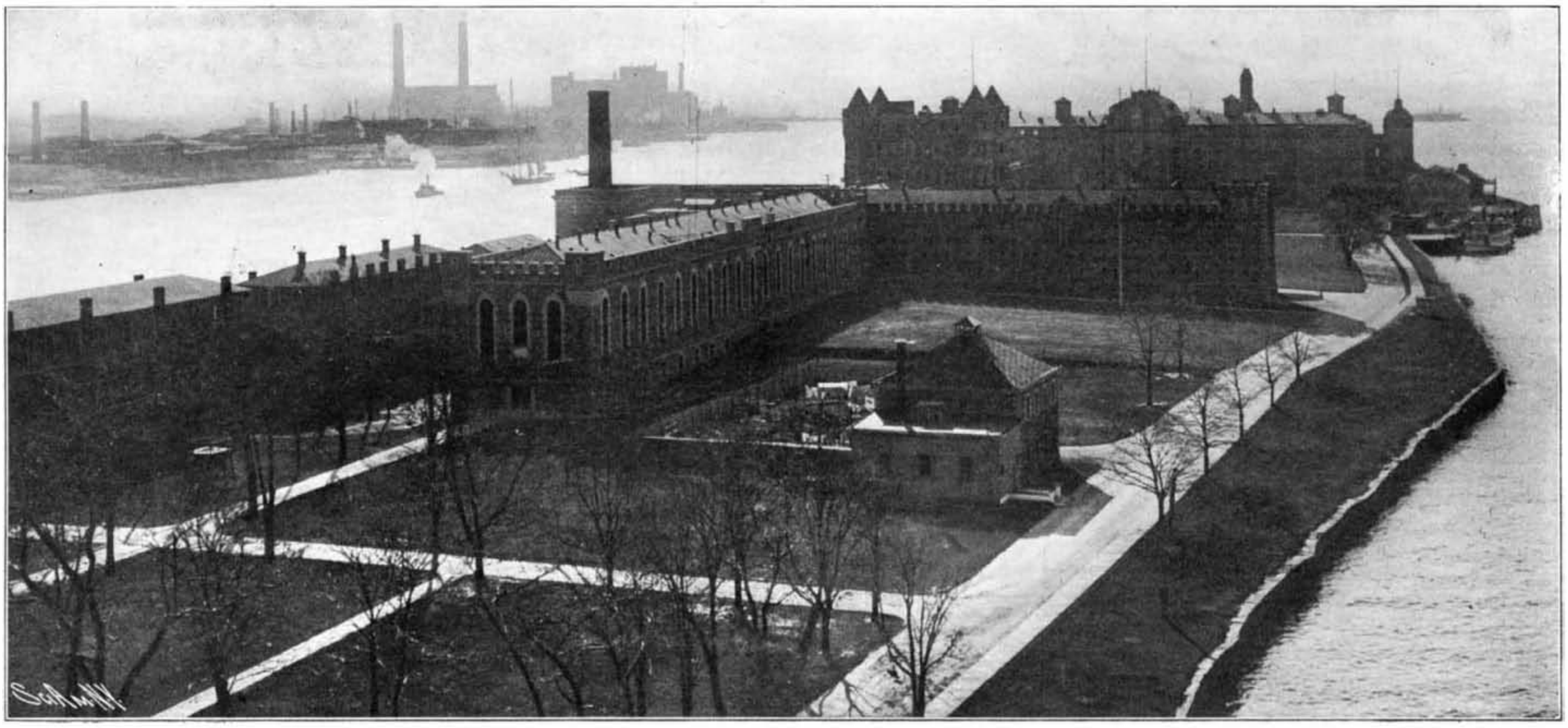
SALT MAKING ON SAN FRANCISCO BAY.

Pier on the Long Island Waterfront Looking Toward Blackwell's Island.

Constructing the Electric Gantry Crane for Erecting Blackwell's Island Span.

Pier on Westerly Shore of Blackwell's Island.

Inshore Pier on Long Island.



View Looking South From the Top of One of the Island Piers.

CONSTRUCTION OF THE BLACKWELL'S ISLAND BRIDGE OVER THE EAST RIVER.—[See next page.]

wet earth, is built to a height of 4 feet. Well constructed, the levees last indefinitely. In time vegetation springs from the outside of the adobe, and its verdure adds to the picturesque aspect of the place.

◆

## THE BAROSSA DAM, SOUTHERN AUSTRALIA.

BY EMILE GUARINI.

The dam recently finished at Barossa, near Gawler, in Southern Australia, is entirely of concrete and the largest of the kind that exists in Australia. This gigantic work, which presents peculiarities other than that of its dimensions, was constructed under the supervision of Alex. B. Moncrieff as chief engineer.

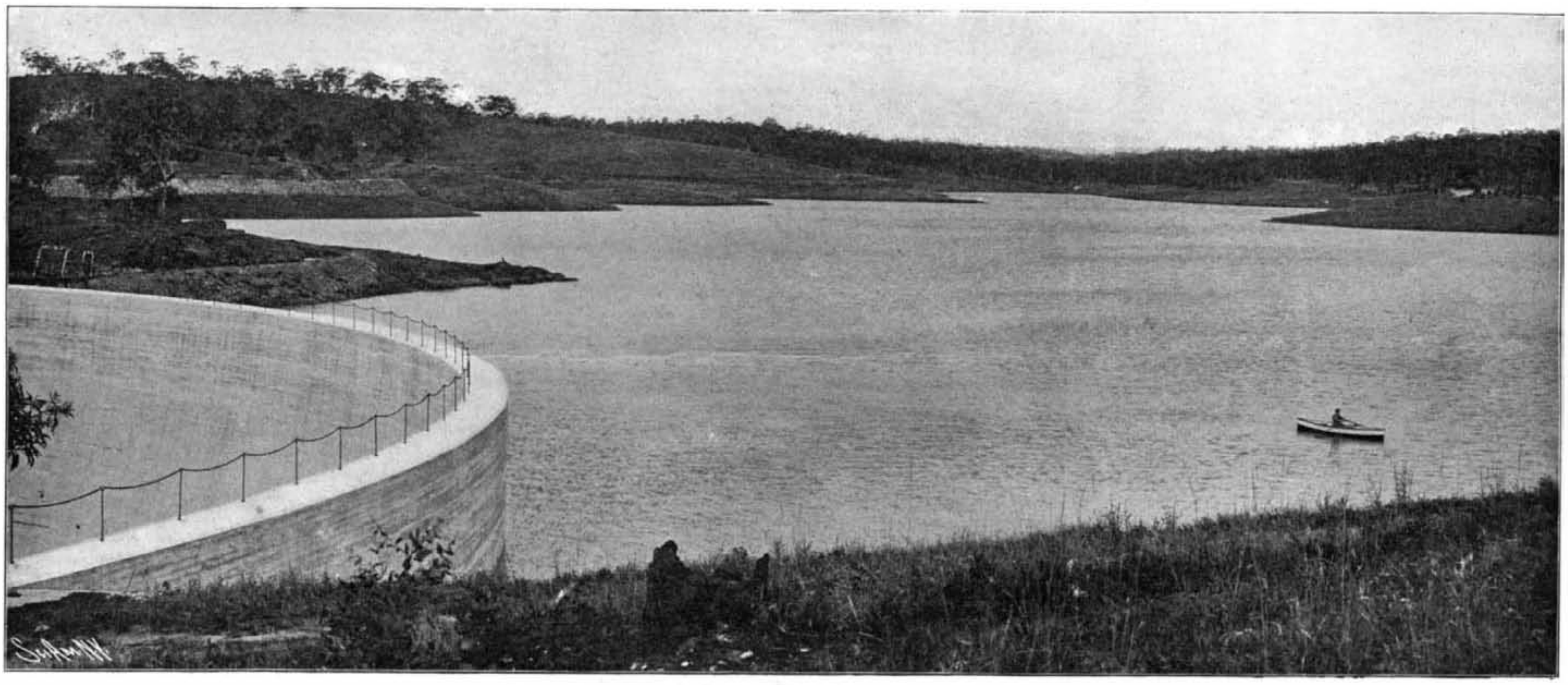
The site of the dam was selected at a point at which one of the banks presented a nearly perpendicular cliff 98 feet high, and at which the opposite bank, of an easy slope, formed a sort of spur, that projected into the bed of the river.

The dam is constructed entirely of concrete without any facing of dressed stone or rubble. Nevertheless, blocks of undressed gneiss were placed in the concrete, with intervals between them of at least six inches. At about 14¾ feet from the top of the dam, such blocks ceased to be employed because of the slight thickness of the dam at this part, and rows of curved rails, connected by fish plates, were imbedded in the concrete. A total weight of 40 tons of rails was worked into the dam in this manner. The dam is of the curved type, presenting its convex face to the water. The vertical section of the dam is triangular. The upstream facing is vertical and the downstream inclined. The height is 95 feet above the old level of the river. The thickness is but 36 feet at the base of the foundation in the thickest part, and 4.5 at the top. It was possible to make the dam of such slight thickness owing to the curved form that was given it in the plan and which gives to the structure all the resisting qualities of the arch. In plan, the curve of the upstream face is struck on a radius of 200 feet, over an angle of 135 deg. 20 min. and through an arc of 470 feet. The cost of the work ($849,400) is relatively very low, and, thanks to the reduction in thickness and the arched form, it is very much less than that of a dam having a profile sufficiently thick to resist the thrust of the water by its mass alone. The cost of such a dam was at first estimated at $1,145,800.

After the work was completed, the total cubical contents of the dam was estimated by precise methods, and was found to be exactly equal to that deduced from the weight of the materials that entered into the construction.

Since the dam was put in service, an observation made during six days, in which the temperature varied by 31 deg., has shown that, with such variation, the pitch increases by 0.8 of an inch, corresponding to a 1½-inch elongation of the arc. During the construction the temperature varied from —2 deg. to +55 deg. During the time of frosts, the masonry was covered with straw matting and fire was kindled that produced much smoke at the top of the masonry, doubtless to prevent the loss of heat by radiation. In this way the newly-laid concrete was very efficiently protected against the cold. The intention was to fill the reservoir in measure as the construction proceeded; but the irregular risings of the water of the river did not permit of this.

The concrete employed in the work was always mixed with the greatest care and in small quantities at a time. The mixture was made by weight and automatically. Before the composition of the concrete for one part or another of the dam was decided upon, experiments were always made in order to make sure of the impermeability of the material to the pressure that it had to support. The sand and broken stones were carefully washed, and, as for the cement, that was well aerated previous to being employed. The concrete was mixed in quantities of 28 cubic feet at a time, and immediately deposited in layers upon the work, the beds being arranged in such a way that the surfaces of separation corresponding to each deposit, and forming of joints, as it were, of this sort of bond, never presented any continuity either in a vertical or a horizontal direction.



View Along the Crest Showing Curved Form of the Dam.

THE CURVED CONCRETE DAM AT BAROSSA, SOUTH AUSTRALIA.

◆

## THE NEW BLACKWELL'S ISLAND BRIDGE.

In common with the other large bridges spanning the East River, the Blackwell's Island Bridge has had to pass through a period of preliminary investigation and futile financiering before it was finally taken hold of by the city, its plans definitely determined upon, and construction actually begun. The first franchise for a bridge at that point was granted to a private citizen in 1884, but fourteen years passed away before the final plans as drawn up by the Bridge Commissioner were adopted. The crossing extends from Manhattan Island on the blocks bounded by Avenues A and B, and by 59th and 60th Streets, and extends across the two channels of the East River and over Blackwell's Island to the Long Island shore.

As originally planned, the structure was to consist of a cantilever bridge of five spans on four piers, one pier on the Manhattan shore, two intermediate piers on the shores of Blackwell's Island, and the fourth pier on the Long Island shore. Ground was broken in September, 1901, but the work was carried along with such indifferent speed that by January, 1902, only $42,000 had been expended. At that time the plans of the superstructure were revised by the Bridge Commissioner and drawn up on the following dimensions: First, starting from the Manhattan side, there is a shore span of the main cantilever, 469 feet 6 inches in length; then the main river span 1,182 feet in length; next is the span across Blackwell's Island, 630 feet in length; then follow the span over the easterly channel, 984 feet long, and the Long Island shore span, 459 feet long.

From the above dimensions it will be seen that the Blackwell's Island Bridge will include one of the longest cantilevers in existence, the well-known Forth Bridge being the most notable of this type of structure, with two main cantilever spans, each 1,710 feet in length. The superstructure consists of two lines of trusses spaced 60 feet from center to center. The top chord is built up of nickel-steel eye-bars which vary in depth from 12 inches to 8 inches, according to the stresses that have to be provided for in any given section of the bridge. The bottom chord will be of the regular box construction of the kind that is now universally used for compression members in long-span bridges of this type. The floor system will be supported upon massive transverse floor beams, which will be carried out for a distance of 13 feet beyond the main trusses to provide a roadway for two lines of trolley cars, one on each side of the bridge, these extensions forming cantilever or bracket supports for such roadways. Between the floor beams, running in longitudinal lines throughout the whole length of the bridge, will be worked in a series of parallel plate-steel stringers, fifteen in all, and above these stringers will be placed a continuous steel buckle-plate floor. On the main floor of the bridge provision will be made for four trolley tracks, two on the inside of, and immediately adjoining, the trusses for the use of the overhead trolley cars, and two, as above mentioned, on the outside of the trusses for the use of the underground trolley cars. Between the overhead trolley tracks between the main trusses will be a broad roadway for vehicles having a clear width of 36 feet. This arrangement of the vehicle roadway is something new in New York bridges, where hitherto they have been separate, and placed on opposite sides of the axis of the bridge. The new method will have the advantage of providing a very broad and impressive thoroughfare, that will add greatly to the sense of spaciousness and dignity in this structure. At a height of 15 feet above the main floor of the bridge will be a second floor or deck, supported on transverse floor beams, which will be attached to the vertical posts of the bridge at each panel-point, the connection being stiffened by knees worked in below the point of attachment. On this upper deck provision will be made for two foot walks, each 11 feet wide and placed immediately next to the main trusses, and between them will be two tracks for the use of the cars of the elevated railways. Each tower will consist of a pair of massive legs of a general box section, each leg being battered to give greater lateral stability against wind pressure. The two legs of the tower will be heavily sway-braced, and at the top of the towers they will be connected by a deep latticed truss, and by an arch designed to harmonize from an architectural point of view with the general construction of the whole bridge.

Considerable interest attaches to the eye-bars, inasmuch as they are of the same type as the much-debated eye-bars designed by the late Bridge Commissioner for the new Manhattan Bridge. They are to have an ultimate strength, annealed, of 90,000 pounds to the square inch, an elastic limit of 54,000 pounds to the square inch, and an elongation of 13 per cent in 8 inches with 35 per cent reduction of area. The great toughness of the material is shown by the severe tests to which it will be subjected. Thus an annealed test piece 4 inches wide or more must be bent cold through 180 degrees, around a pin whose diameter is twice the thickness of the test piece; while the unannealed specimen must bend through 180 degrees, around a pin whose diameter is three times the thickness of the test piece; and this must be done without any fracture appearing in the metal.

This fine structure, in addition to carrying the load due to its own weight, will have to support a live load of 6,300 pounds per foot run of the bridge, this being considered as the ordinary traffic; and it must also carry 12,500 pounds as congested traffic. The floor beams, moreover, will be dimensioned to meet the stresses of unusually heavy concentrated loads. The loading assumed for the foot walks is a maximum of 100 pounds per square foot.

The accompanying illustrations show the character of the masonry piers. These are of a simple and massive design, well suited to the character of a bridge of these monumental proportions. They are faced with dressed granite, and will harmonize well with the finished steelwork of the trusses.