

THE PROPOSED NICARAGUA CANAL.

Our issue of February 4th contained the first of two illustrated articles which will give a comprehensive description of those two colossal undertakings, the Panama and Nicaragua Canals; the former of which, as our article showed, is surveyed and already two-fifths completed, while the latter is now being surveyed, with a view to determining its feasibility and cost. We take it that it is too late in the day to present arguments to prove that a canal at the isthmus would have great commercial and strategic value—that is universally admitted.

The question is one of site, practicability, and cost. Beyond demanding that the canal as completed shall be the cheapest and best that can be built and shall secure to the United States every advantage to which it is justly entitled of a commercial, strategic and political character, we believe the public is indifferent as to whether the canal is cut through at Panama, Nicaragua or elsewhere.

Probably there is no question involving such an enormous outlay of the public money upon which the people of the United States are so little informed as they are upon the relative standing and merits of the two proposed canals. The present articles are written with a view to giving such an impartial statement of the facts as shall enable the reader to judge for himself of the relative merits and demerits of the rival schemes.

A glance at the map and profile of the proposed route of the Nicaragua Canal is sufficient to explain why it is that from the earliest times it has attracted attention as affording a feasible means of ship communication across the isthmus. The mountain range known as the Cordilleras, which forms the divide between the drainage of the Atlantic and Pacific, separates at a point about 70 miles north of Lake Nicaragua into two branches, one of which extends in a southerly direction between the lake and the Pacific, while the eastern divide runs parallel with and some 18 miles to the east of the lake and then in a southerly direction until it terminates near Greytown on the Atlantic coast. Lying within the V formed by these ranges are Lakes Managua and Nicaragua, and into these lakes, which are connected by the river Tipitapa, there empties the drainage of this basin, which has an area of 12,000 square miles, the area of Nicaragua

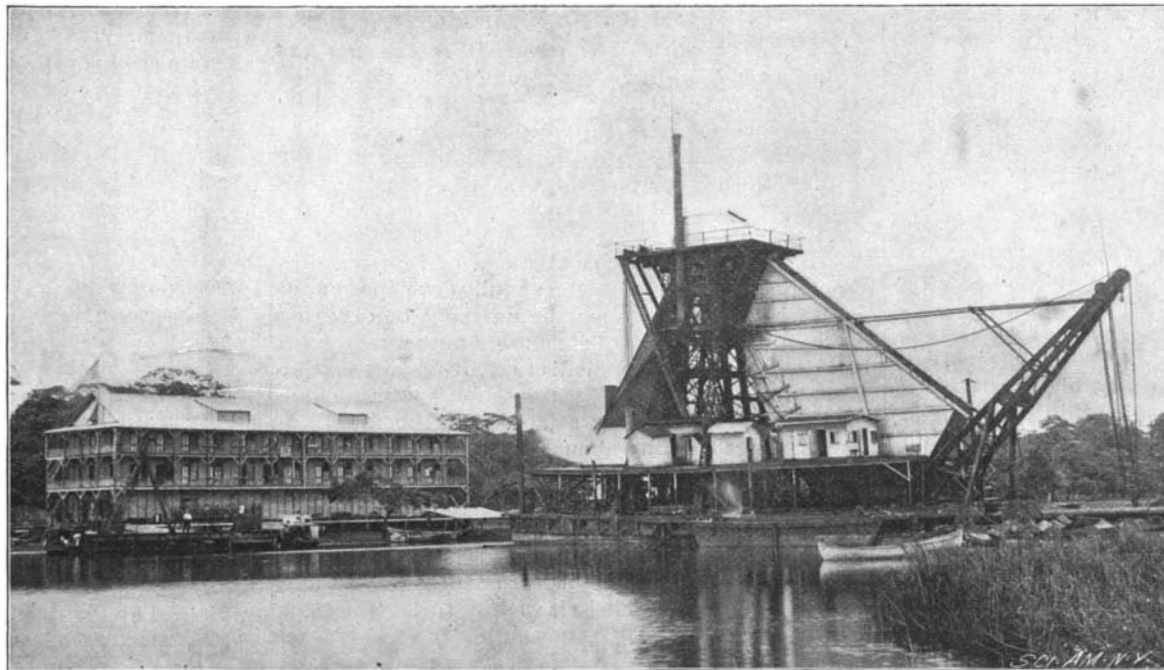
being somewhere between 2,700 and 3,000 square miles.

The lake is 45 miles wide by 110 miles long, and it extends in a general southeasterly direction, its longer axis being parallel with the Pacific Ocean, which at the nearest point is only 11 miles distant. The lake is for the most part deep, and its waters have a mean surface level of 106 feet above sea level. The only outlet for the waters of the lake is by the way of the San Juan, a noble stream of great volume with an average width of 1,500 feet, a minimum discharge estimated at 12,000 cubic feet per second, and a flood discharge which has been estimated by some authorities as 60,000 and

after looking to this object were made as long ago as the close of the eighteenth century.

THE CHILDS SURVEY, 1852.—The first actual survey for a canal was that made in 1850-52 by Col. O. M. Childs, an expert canal and railway engineer of great distinction, for the Transit Company, which had a steamer and stage line across the isthmus as part of a route from New York to California. Steamers ran up the San Juan from Greytown and crossed the lake to its west coast, where they connected with a stage line to the Pacific. The survey was for a waterway with a depth throughout of 17 feet. In the canal portion the bottom width was to be 50 feet, while in the excavated channels in the river and lake the bottom width was to be 150 feet. Locks were to be 250 by 60 by 17 feet. Ships were to pass from the sea level on each side to the summit lake level of 108 feet by 14 locks, each with an 8-foot lift. The lake was to be held at 108 feet elevation by a dam in the Rio Grande valley 9¾ miles west of the lake and another at Castillo Rapids 37¼ miles east of the lake in the San Juan River. The lowest lock on the east side was to be at a point 90 miles from the lake, where the canal was to leave the river and extend across the flat alluvial land to Greytown, where at that time there was a well protected harbor. The total length of the Childs canal was to have been 194 miles, and its cost, including 15 per cent for contingencies, was estimated at \$31,538,319.

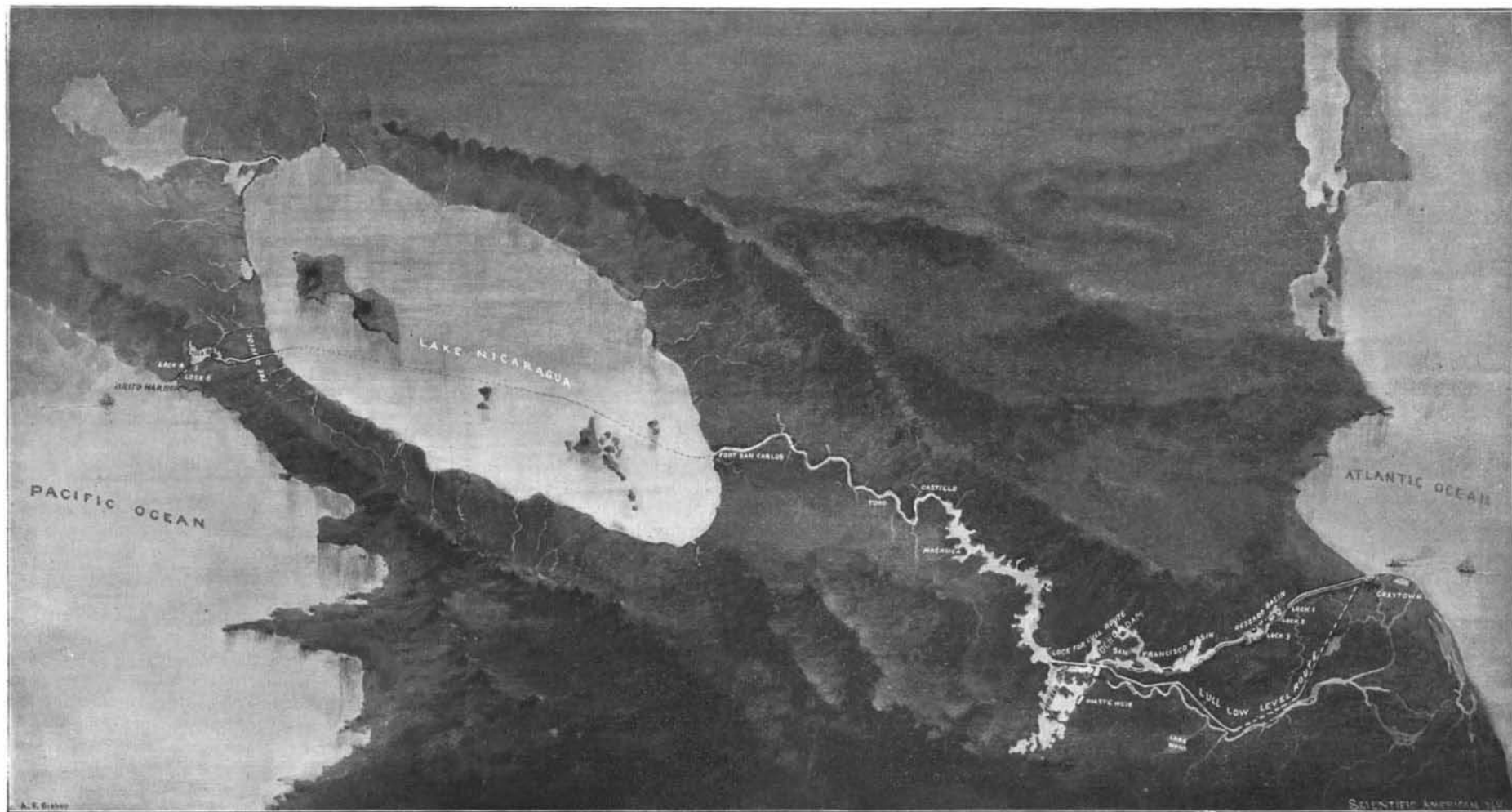
THE LULL SURVEY, 1873.—The United States government sent an expedition to the isthmus in 1872 under Commander Lull, U. S. N., for the purpose of making a resurvey of the Childs route. With Commander Lull was associated Mr. A. G. Menocal, the present engineer of the Maritime Canal Company. The depth of the canal was to be 26 feet and its bottom width 50, 60, and 72 feet, according to locality. In the excavated river channel the bottom width was to be 80 feet and something over 80 feet in the lake channel. Commander Lull proposed several changes. The Pacific terminus was to be the same as that proposed by Childs, namely, Brito. The ascent from the Pacific coast to the lake was to be by way of the Rio Grande Valley, and by means of 11 locks of 10½ feet lift, and the canal was to be cut directly through the western divide to the lake. This portion was to be 16¼ miles long. The route across the lake was to be 56½ miles long. The San Juan was to be navigated



CANAL COMPANY'S STOREHOUSE AND DREDGE AT LA FE, GREYTOWN.

by others as high as 150,000 cubic feet per second, the latter amount being two-thirds the average flow of Niagara itself. The river flows for 120 miles to the Atlantic and is navigable for river steamers, except at some rapids, which in the dry season offer obstruction. On the north side but few streams flow into the San Juan, but the streams that enter it from the south are large and subject to heavy floods which carry down immense volumes of sand from the Costa Rican range some 50 miles distant. The most turbulent tributary is the San Carlos, which flows into the San Juan above Ochoa. The sand and volcanic ash thus brought down are carried by the San Juan and Colorado to the coast, where an extensive delta has accumulated and is steadily encroaching upon the sea.

The navigability of the San Juan and the lake, and the narrow divide separating the lake from the Pacific, have, from very early times, suggested the possibility of opening a ship canal across the isthmus at this point, and surveys of a general and preliminary char-



BIRD'S EYE VIEW OF THE PROPOSED NICARAGUA CANAL.

by placing dams in the river at four places, the uppermost at Castillo, the lowest a mile below the mouth of the San Carlos. This river portion was to be 66½ miles long. At the lowest dam the canal was to leave the river, follow its left bank to the San Juanillo, and then proceed by a straight course to Greytown. The total length of the canal from ocean to ocean was to be 181¼ miles. As Greytown Harbor had been silted up since the Childs survey, an estimate of \$2,500,000 was made for its restoration. The total cost of the project, including 25 per cent for contingencies, was estimated as \$65,722,147.

THE MARITIME CANAL COMPANY'S SURVEY, 1887 to 1890. — The next step was taken in 1885, when Mr. Menocal was directed by the government to make a re-examination of the work, and estimate for the construction of a 28-foot canal. In his report of that year he recommended some very radical changes in the Lull plan and outlined a project which involved some bold engineering measures, especially in the canalization of the San Juan River. The total estimate for the canal was \$60,036,197. Four years later Mr. Menocal returned to the isthmus as chief engineer of a company (the Maritime Canal Company), which had been formed for the purpose of building the canal on the general lines proposed by him in the 1885 report. A large engineering force was put in the field between the years 1887 and 1890, and in the latter year a report was presented

by Mr. Menocal and elaborated in the Chicago Waterways Congress of 1893, setting forth the data and plans upon which it was proposed to build the canal.

It is admitted by the many expert engineers who have criticised the Menocal project that if it were possible to eliminate from it certain elements of danger, it would provide a canal which would be in every way superior to the other alternative plans which have been submitted. Its most striking feature was that it proposed to extend the summit level of 110 feet almost from ocean to ocean. This was to be done by the construction of two great dams, one at La Flor on the Pacific slope of the western divide, at a narrow gorge in the Rio Grande Valley, 3.8 miles from the Pacific, and the other at Ochoa, a point on the San Juan, 3½ miles below the San Carlos River and 64½ miles from the lake. The Ochoa dam would rise 60 feet above the water surface of the San Juan at that point and would cause its waters and those of the San Carlos to back up and flood the two valleys, converting them into lakes which would actually form extensions of the Nicaragua Lake itself. An important feature of the design was the use of the San Carlos Lake as a settling basin for detritus brought down from the mountains. La Flor dam on the Pacific, being placed below the mouth of the Tola, a tributary of the Rio Grande, would similarly flood the Tola Valley, converting it into another lake at the level of and forming part of the big lake.

Nor was this all. With a view to shortening the route and still further extending the summit level, Mr. Menocal proposed to proceed to Greytown, not, as Lull and Childs advised, by way of the marshy lowlands through which the San Juan finds its way to the sea, but by a direct route across the intervening

ridges and valleys, and through the crest of the eastern divide. To do this he proposed to raise embankments across the lower side of the valleys and make cuttings through the intervening ridges, and allow the San Juan waters to flood the basins thus formed, the embankments being built to the same heights as the Ochoa dam and serving to maintain the summit level right through the eastern divide and up to lock number 3 (see profile). The portion between the Ochoa dam and lock 3 would thus consist of two large artificial lakes, known as the San Francisco and Deseado basins, connected by short lengths of canal. Lock 3 is only 13 miles from the Atlantic (Caribbean Sea), so that by this

from the big cut through the eastern divide in as large blocks as possible. The rock, of which the cut would afford an abundant supply, was to be dumped in until it had ceased to sink into the soft bed of the river and a stable structure had been secured. To render it impervious, the excavated clay from the neighborhood was to be dumped upon the upstream face of the dam. A similar method of construction was to be used for the numerous embankments of the San Francisco and other streams crossed by the canal, and for La Flor dam. The most startling proposal of all, however, was that to use the rock-fill dams as weirs over which the surplus waters of the lake and rivers were to discharge.

HARBORS.—All the surveys that have been made for a canal have realized the necessity of creating terminal harbors at each seaboard. On the Pacific the canal terminates at Brito, an indentation of the coast, while at the Atlantic it ends on the shifting sands which have silted up what was once the deep-water harbor of Greytown. At Brito both Childs and Lull estimated that a new harbor would cost about two and one-half million dollars, while the Maritime Company's estimate put it at about one and three-quarters million dollars. It was proposed to create the harbor by running out projecting jetties and dredging out an interior basin. The construction presents no problems that are novel or untried in engineering practice. At Greytown, however, as a study of the accompanying maps will show, the problem



SAN JORGE LANDING ON THE WEST SHORE OF LAKE NICARAGUA. OMETEPE MOUNTAIN, 5,350 FEET, IN THE DISTANCE.

original and daring proposal the summit level would be extended continuously for 154 miles across the isthmus, its eastern terminus being within 13 miles and its western terminus within two miles of the respective oceans. On both sides descent was to be made to sea level by three locks. At the Pacific level the lowest lock would be within a mile of the deep water and on the Atlantic it would be necessary to dredge a canal 9.4 miles in length through the alluvial deposits of the river.

CONSTRUCTION OF DAMS.—Now, to construct a dam 60 to 80 feet high across a great river whose waters in time of flood may be over one-half as great in volume as the flow of Niagara is a stupendous undertaking. Mr. Menocal evidently realized that it was hopeless to divert the river, lay bare its bed, expose the underlying rock, and build up an impervious dam in the ordinary way, for he proposed to make a high, loose-rock fill across the river, dumping in the material excavated

will require careful study, and after the harbor is complete will call for continual dredging and successive additions to the jetty. To understand the conditions we must bear in mind two things: First, that for ten months of the year the trade winds and seas move upon the beach from the northeast; second, that enormous masses of volcanic silt are brought down by the San Juan and deposited, through the Colorado branch, at its mouth, to the eastward of the harbor. The waves, striking this material at an angle with the coast, transport it to the westward to the amount, as estimated by the present Walker Board, of 600,000 cubic yards per year. This remarkable drift is seen in the map of the Peacock survey of 1832, in which the westward travel of the sand is shown from 1832 to 1859. The progress of the sand spit has been accompanied by a shoaling up of the harbor until in 1895 the once capacious harbor with its low water depth of 30 feet has shrunk to a mere lagoon with a maximum depth of 17 feet. To open



VIEW SHOWING SPOIL BANK THROWN UP BY DREDGES AT WORK IN CANAL. RAILROAD RUNS AT BASE OF BANK.

a channel from the canal to deep water the company built a pile and rock jetty 900 feet in length. This was done for the purpose of arresting the westerly drift and enabling them to dredge a channel on its western side. The sand accumulated on the eastern side of the jetty, reached the outer end, flowed past it, and formed the curious tongue which is seen extending past the jetty and almost across the entrance channel. This result shows that while it will be possible to obtain an entrance by extending the jetty far out to deep water, the filling in of the beach behind it at the rate of 600,000 cubic yards per year will be perpetual, and the jetty will require to be extended at recurrent intervals. As there is no tidal scour to rely upon, the channel will have to be maintained by the use of dredges. The company's proposi-

tion was to build an east pier 3,000 feet long and a west pier about 2,000 feet in length, with an entrance 600 feet in width. The entrance channel, 5,000 feet long, was to connect with an artificial basin 237 acres in extent, dredged out in the Greytown Lagoon to a low water depth of 30 feet. The total cost of the whole scheme, including the harbors, was estimated by the company at \$65,084,176.

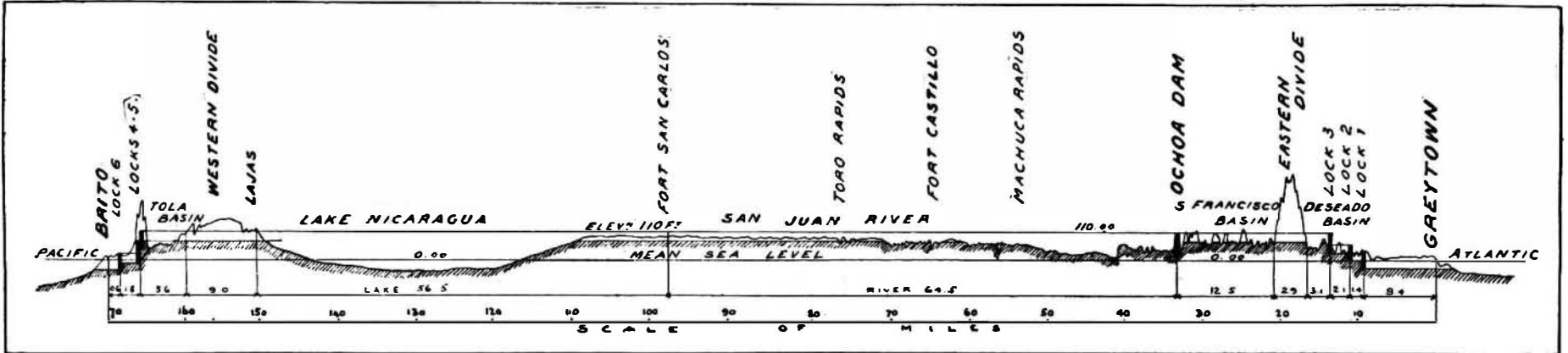
WORK DONE BY THE COMPANY.—A start in construction was made by the company at the Greytown end. Five large dredges commenced cutting through the alluvial deposits through which the first 9 miles of the canal will be cut. Some 4,500 feet of the canal were cut to a depth of 16½ feet and the canal line through the dense tropical growth was cleared for a

indications of an extreme variation in the level of the lake in wet and dry seasons of 15 feet, and that this variation, extending over an area of nearly 3,000 square miles, represented an enormous volume of water, which it might prove extremely difficult to hold at the desired elevation of 110 feet.

The board suggested that a more thorough examination of the locality might disclose alternative routes which would be free from the objections outlined in their report, and they suggested that \$350,000 should be appropriated for a further examination to finish the investigation and prepare final plans and estimates. This recommendation was acted upon, and a new commission consisting of Admiral Walker, Prof. Lewis M. Haupt, and Gen. Hains spent three months in a per-

Ochoa dam by nearly one-half, and the canal will be carried from Ochoa down the left bank of the San Juan to a point at which it will strike off across the divide in the same manner as, but at a lower level than that proposed in the Menocal scheme. This will increase the cuts but reduce the heights of the embankments, thereby avoiding the risky features of the high level route. This route will be in the nature of a compromise between the high level route of the company and the low level route located by Lull.

The security of the Ochoa dam is further assured by the discovery of solid rock everywhere underlying the bed of the river at the proposed site, and a firm clay has been developed along the site of the embankment foundations. The Menocal idea of using the dams as



PROFILE OF THE NICARAGUA CANAL AS PROPOSED BY THE MARITIME CANAL COMPANY.

distance of 32 miles. A single track railroad was built from Greytown, 11 miles into the interior. The jetty above mentioned was built out 900 feet, and a 17-foot channel dredged from the sea to the Greytown Lagoon.

THE LUDLOW COMMISSION.—The operation of the canal company ceased in 1893 for lack of funds. In 1892 the Senate Committee on Foreign Relations introduced a bill providing for the aid of the United States in the construction of the canal by a guarantee of the bonds issued for construction, and in 1895 Congress appointed a commission consisting of three well known engineers, Colonel Ludlow of the army, Civil Engineer M. T. Endicott, of the navy, and Alfred Noble, a civilian in private practice, for the purpose of reporting on the "feasibility and cost of completion" of the company's project. After examining the route on the isthmus and the engineering data collected by the company, the commission reported that while a ship canal project was feasible, they were unable to indorse several important features of the company's plans. They considered that the data upon which the plans were drawn up was neither sufficiently detailed nor spread over a sufficient period of time to enable accurate conclusions to be drawn, either as to permanence of the proposed structures or the

sonal examination of the route and placed in the field a well equipped force of 250 men, including 80 engineers, a geologist, a hydrographer, ten boring outfits, and a very complete set of apparatus for determining rainfall, evaporation, flow of streams, and all the natural phenomena affecting the construction and maintenance of the canal. The expedition landed in December, 1897, and the observations, plans, and estimates are still in progress, and will not be fully completed for some time.

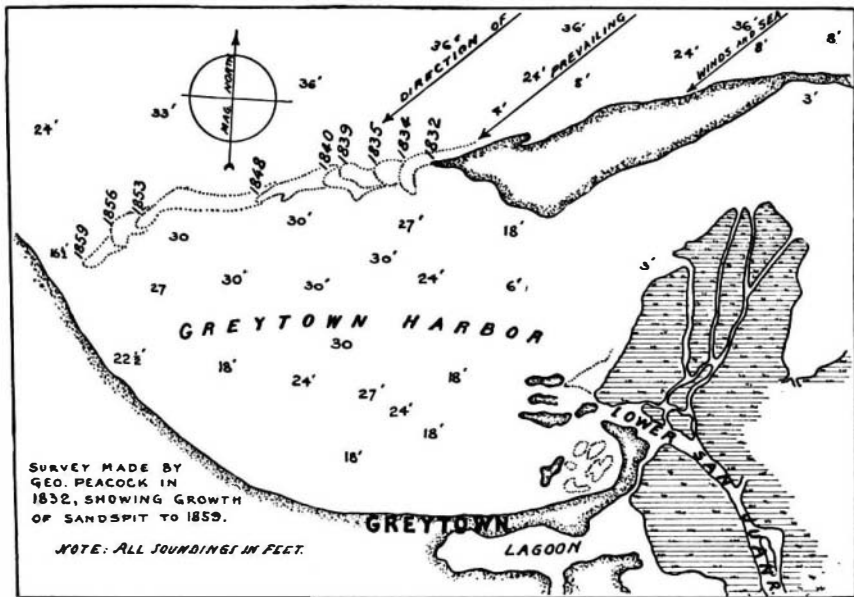
At a preliminary hearing before a select committee of the Senate the members of the commission roughly estimated the cost of construction as follows: Admiral Walker, \$125,000,000; Prof. Haupt, \$90,000,000; and Gen. Hains, \$140,000,000. In a preliminary report, issued at the close of last December, the commission states that of all the routes that have come up for consideration, the two best are the Maritime Canal Company's route, known as the high level route, and the Lull or low level route. The estimated cost is \$124,000,000 for the latter and \$125,000,000 for the former. Gen. Hains, however, who is the oldest and most experienced member of the commission, states in a supplemental note to the report that he thinks the estimate should be raised to about \$150,000,000.

overflow weirs has been abandoned; separate weirs will be provided in every case.

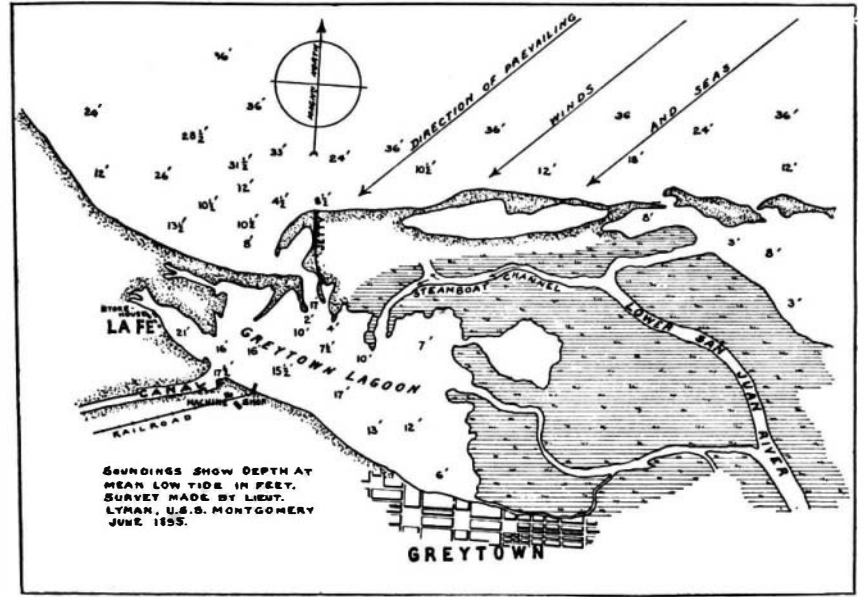
The commission finds that it can regulate the level of the lake within a recorded fluctuation of 2½ feet above and below the normal. On the west side of the lake, La Flor dam and Tola basin are abandoned. The canal will be cut through the divide to the Rio Grande, and it will be carried down to sea level at Brito by means of locks whose number has not been determined. To assist in controlling the lake level and relieving the duty thrown upon the San Juan, it is not unlikely that the canal through the western divide will be given considerably greater width to enable it to assist in carrying off the surplus waters in the seasons of flood.

The least depth throughout of the canal will be 30 feet. All excavated channels will be given extra width both in the river and lake, while the curvature will be eased to render navigation less difficult. All locks will be of a length and depth to accommodate the increasing dimensions of modern steamships.

Finally, the commission is of the opinion that while the rainfall is excessive (22 feet on the eastern section), the material will stand up remarkably well in excavation. Moreover, the climate, on account of the pre-



GREYTOWN HARBOR IN 1832, SHOWING GROWTH OF SAND SPIT TO THE WESTWARD UNDER ACTION OF PREVAILING TRADE WINDS.



SITE OF GREYTOWN HARBOR (NOW A LAGOON) IN 1895. SAN JUAN DELTA HAS EXTENDED OUT TO SAND SPIT AND HARBOR HAS SHOALD TO 16 FEET.

cost of the undertaking as a whole. They considered that the quantities of dredging, excavation, etc., were underestimated, and that the unit prices had been placed too low. They raised the quantities and prices accordingly, and made an estimate of their own which placed the probable cost of completion at \$133,472,893, as against the company's estimate of about \$67,000,000, an increase of 100 per cent.

The features most severely criticised by the commission were the two great rock-fill dams at each end of the summit level, one at La Flor, 2,000 feet long and 90 feet above the bed of the river, the other at Ochoa, 1,900 feet long and 60 feet above the river bed, and the extension of the canal through the San Francisco basin, where it would be necessary to construct 67 clay dams or retaining embankments, one of which is 1¼ miles in length and rises 100 feet above its foundations. It was also stated by the board that they found

All these members of the commission "believe that the construction of a canal across Nicaragua is entirely feasible."

RECOMMENDATIONS OF THE WALKER COMMISSION.—Although some time must elapse before the final report is made public, we are in a position to state what will be the general features of the plan finally recommended by the commission. In the first place, the Ochoa dam will be moved up the river to a point above the San Carlos, with a view to eliminating the torrential floods and the silt of that river, which will be allowed to pass away in the ordinary manner through the San Juan.

No attempt will be made to hold the summit level up to the Ochoa dam; but an intermediate dam and a lock will be placed at one of the upper rapids—probably Machuca—and the level will be lowered 20 or 30 feet at that point. This will reduce the height of the

vailing trade winds, is not unhealthy, and it is not apprehended that it would prove a hindrance to the prosecution of the work. The estimated time for completion is from eight to ten years.

Such is the Nicaragua Canal. A comparison of its natural, commercial and political advantages with those of the Panama Canal will be found on another page.

Naval Engineering at Columbia University.

The Trustees of Columbia University, on February 6, decided to enter the field of naval engineering. William Ledyard Cathcart, Director of Marine Engineering and Designing at the Webb Academy, was appointed chief professor of mechanical engineering. He was recommended for the post by Commodore Melville, Chief of the Bureau of Steam Engineering of the Navy.

SCIENTIFIC AMERICAN

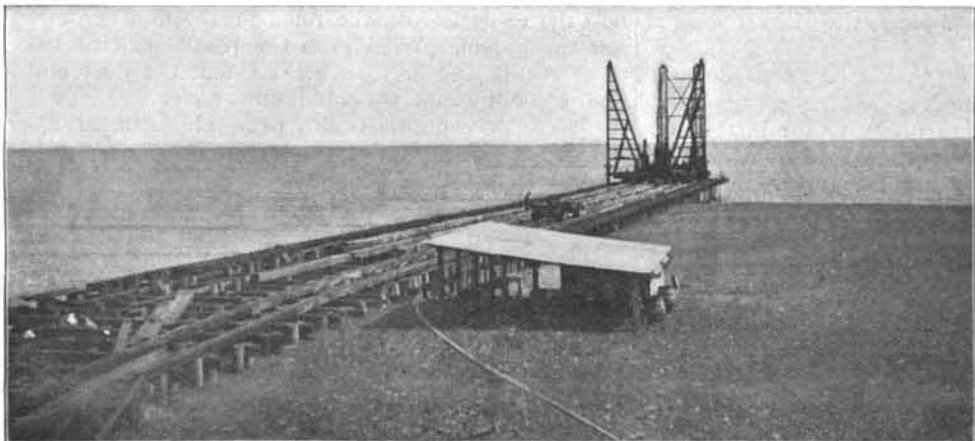
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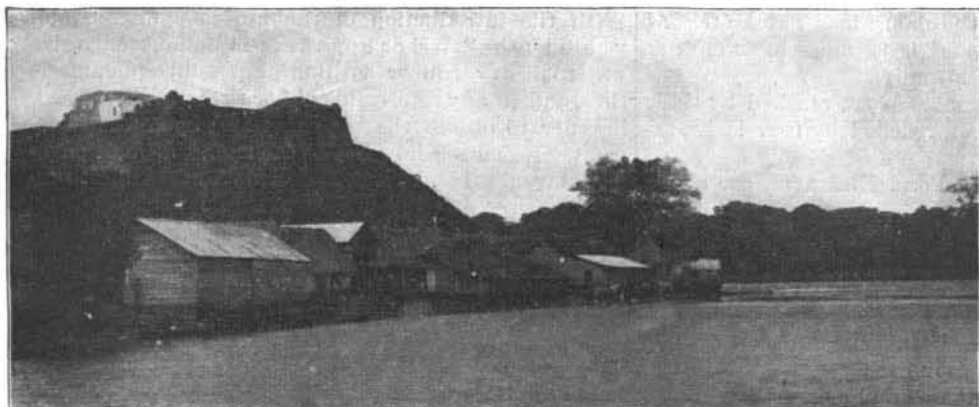
\$3.00 A YEAR.
WEEKLY.



The Jetty at Greytown, Looking Northwest—Shows Accumulation of Drifting Sand Against East Side of Jetty.



Corduroy Foundations for Railroad Fill Across the Swamp.



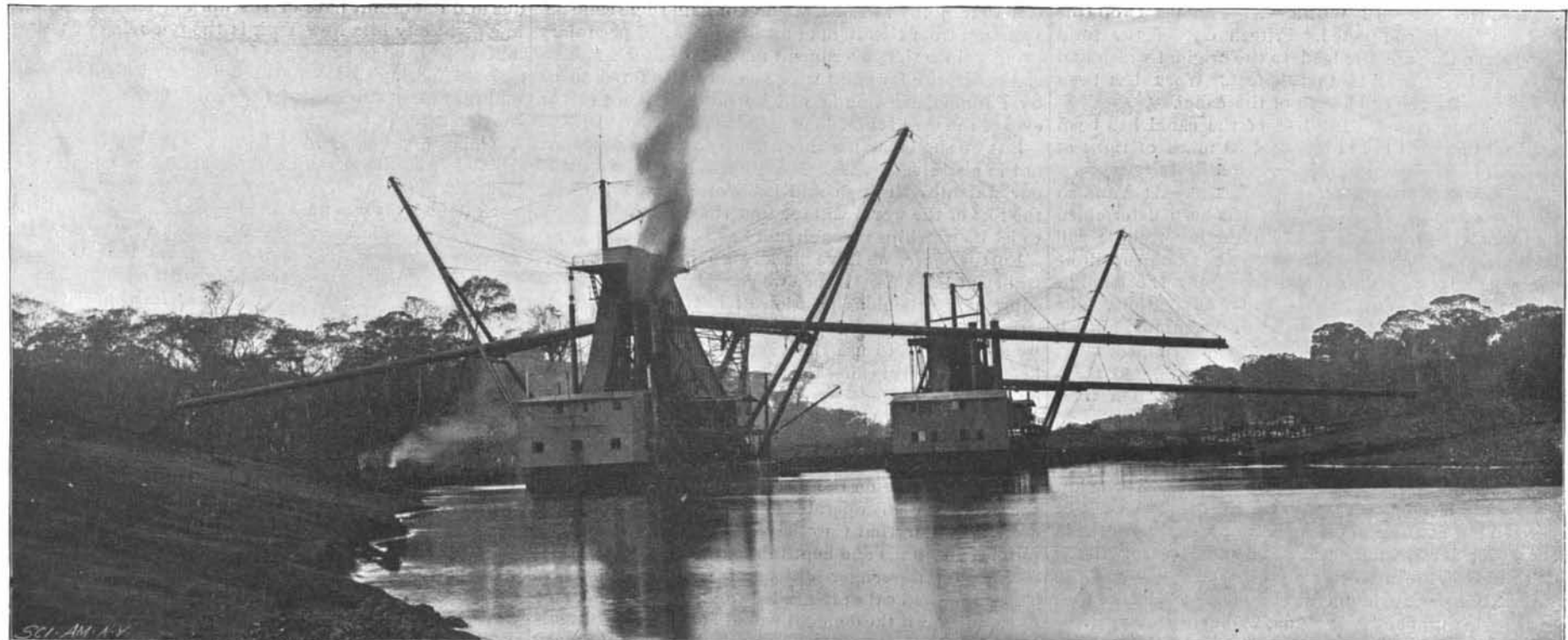
Castillo, Looking up the San Juan—Old Spanish Fort on the Left; Rapids to the Right.



The Market in Granada, Nicaragua.



View on the San Juan River at Mouth of the River San Francisco.



Suction Dredges Cutting the First Mile of the Canal at Greytown.
THE PROPOSED NICARAGUA CANAL.—[See page 104.]