he would then play a violin, a zither, or a harmonica to set in motion the harmonic vibrations upon which he depended for obtaining his remarkable manifestations. The first exhibition room has many auger holes, which have been indicated by our artist. These holes were, of course, hidden by the oilcloth which covered the floor, and one of the holes was covered with a piece of tin with a hole cut out of it the same size as the auger hole, as shown in the diagram at *D*. It is surmised that these holes, and specially the last one to which we have referred, permitted the "etheric flow" of compressed air from the receiver in the cellar to the apparatus on exhibition to be controlled by a spring valve operated by the foot. Other holes seemed to have been located under the apparatus and doubtless aided in the experiments.

The upper floor of the main exhibition room was torn away during the investigation, and showed that tubing of the same kind as the alleged "wires" of Keely's lever machine passed under the joists, through the brick partition, under the threshold of the door at the point, *A*, connecting the two exhibition rooms. This is in a way the most remarkable of the find, as it was so carefully hidden in the brickwork, which had been removed and reset. The tubing ran through the brick partition under the steps, where it apparently descended into the room below, but this end was broken off. At the point, *B*, another piece of tubing was found running out into the front room from the rear room below. Those who assisted at the investigation were Prof. A. W. Goodspeed, Prof. Carl Hering, Dr. M. G. Miller, Mr. Moore and Mr. Sellers, and the investigations were so thorough and the results obtained were so satisfactory that it is to be hoped that, once for all, the Keely motor may be considered to be exposed, though we have no doubt that, like the scotched snake, the tail may still continue to wiggle.

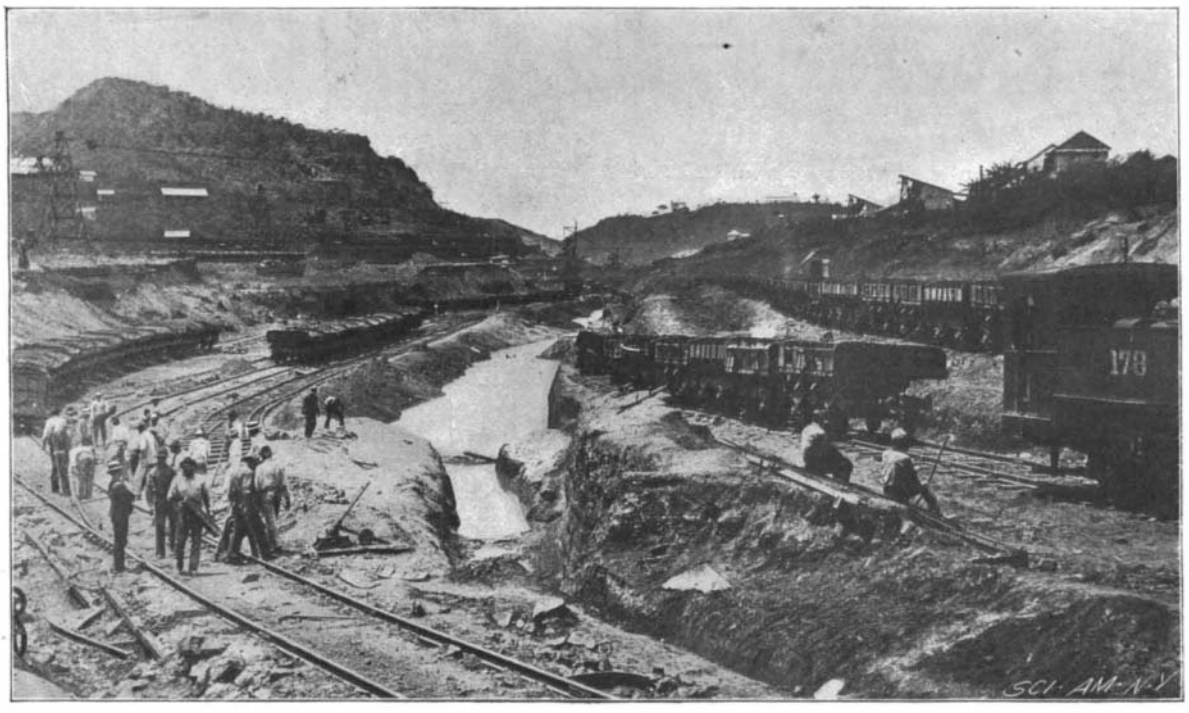
THE NEW PANAMA CANAL.

There is a broad difference between the Panama Canal as it actually is and the Panama Canal as it exists in the public mind. It would be difficult to find another great undertaking about whose present status there is so much general ignorance or positive misinformation as there is concerning the artificial waterway with which Ferdinand de Lesseps attempted to join the waters of the Atlantic and Pacific Oceans. It is a matter of history how the distinguished Frenchman, emboldened by his success in cutting the Suez Canal, undertook to open a great sea-level cutting through the mountains of the Panama Isthmus and failed—the physical difficulties of the project, assisted by gross corruption on the part of the promoters, serving to bankrupt the company when only a fragment of the sea-level scheme had been completed. The odium of that ill-considered and worse executed project still attaches in the public mind to the Panama Canal as such, and it is only the small minority, who have followed the subsequent course of events on the isthmus and are familiar with the heroic and successful attempts that have been made to bring order out of chaos, who are alive to the fact that the new Panama Canal project is on a sound engineering and financial footing and is within a calculable distance of completion.

The present article is written for the purpose of putting the public in possession of the facts regarding the present status and future prospects of this undertaking. In view of the fact that one canal at the isthmus will be amply sufficient to accommodate the traffic, the question of the completion or abandonment of the Panama scheme becomes of supreme importance in considering the advisability of building a canal on the Nicaragua route, for the construction of two practically contiguous canals would mean the bankruptcy of both.

HISTORICAL.—In 1879 an international congress met in Paris, and, after investigating various routes, recommended the building of a sea-level canal from Colon, on the Atlantic, to Panama, on the Pacific. Many of the best informed members of the congress, it should be said, considered that a sea-level scheme presented too many difficulties and advocated a canal with locks; but the influence of M. de Lesseps prevailed and the sea-level route was adopted. The calculated time for completion was set at twelve years, and the cost, including interest on capital, at $240,000,000.

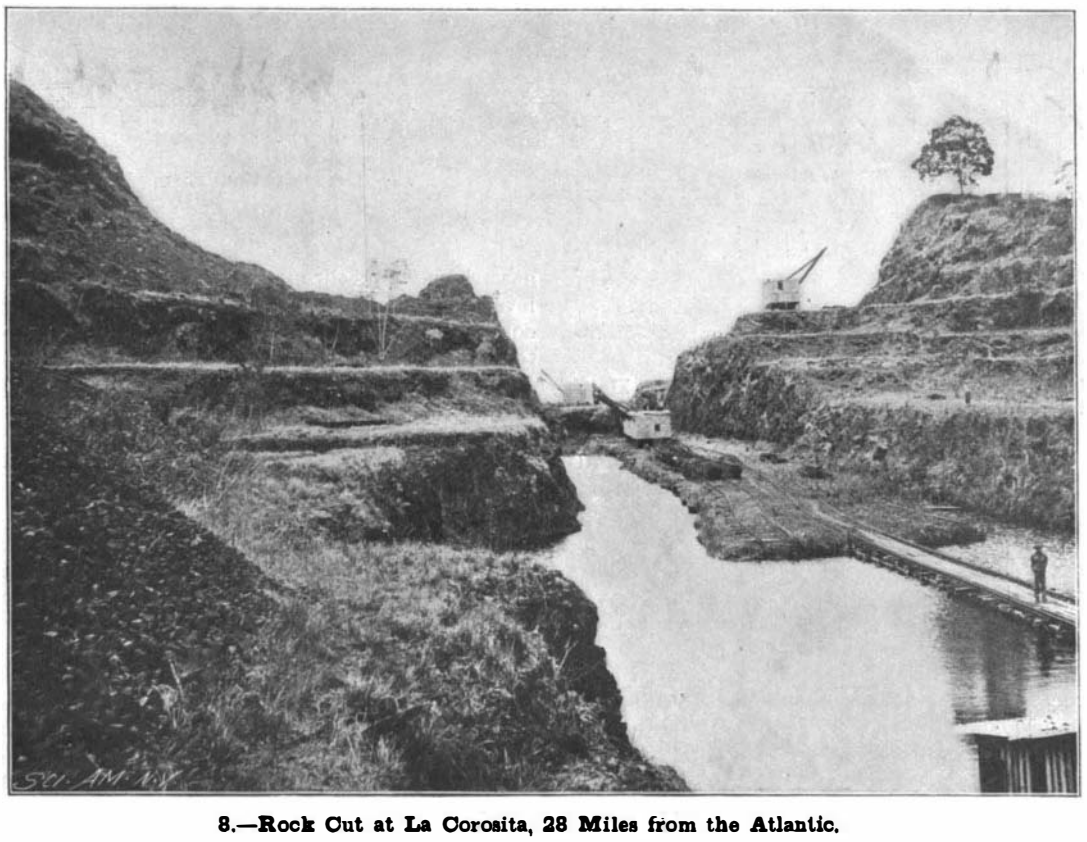
6.—French Excavators at Work in the Emperador Cut.



7.—The Work at Outlet of Culebra Cut on Pacific Slope.

Now, when it is stated that the route of the proposed canal followed for over twenty-five miles a river which in the rainy season is subjected to enormous freshets, and that in passing through the Cordillera mountains an excavation 8 miles in length and varying from 100 to 325 feet in depth had to be made, it is evident that the first duty of De Lesseps was to secure the results of careful gagings of the rainfall, and to make elaborate borings along the route of the canal to ascertain the nature of the material to be excavated. Neither of these precautions was taken, or if taken, were so incompletely carried out as to leave the engineering features of the scheme very much in the air.

Work was begun in 1881. A large amount of the capital of the company was swallowed up in purchasing and placing along the line the necessary plant, in constructing shelter for 15,000 laborers, and building the necessary workshops and hospitals. The first opening up of the surface soil induced an appalling amount of sickness, and the enormous floods of the Chagres River proved altogether beyond the control of the engineers. Moreover, the upper layers of material in the great Culebra cut proved to be of a treacher-



8.—Rock Cut at La Corosita, 28 Miles from the Atlantic.

THE NEW PANAMA CANAL.—PRESENT CONDITION OF THE WORK.

ous character, and the side slopes caved into the excavation faster than the material could be taken out. The hopelessness of the task of building a sea-level canal was by this time apparent, and the company decided to adopt a new plan involving the construction of locks. The decision came too late. The credit of the company was not equal to the raising of further capital, and, in 1889, a receiver was appointed. At this date a sum of $156,400 000 had been expended upon the isthmus, of which about $88,600,000 had been put into excavation and embankment. The commission which examined the company's affairs states: "The enormous amount of material at hand ready to be utilized, the great number of works established, lands received, labor actually expended, experience gained, supplies laid in, preliminaries mapped out, including the right of way, are worth to the new company at least $90,000,000." The receiver obtained at this time a further extension of time from the Colombian government, carrying the date to 1904; and a later concession of six years extends the date of completion to the year 1910.

THE NEW PANAMA CANAL.—In October, 1894, a new company was formed for the purpose of completing the canal. It was organized with a cash capital of $13,000,000, and, with a view to giving it a commanding position in the financial world, the stock was purchased by several of the leading financial institutions in France, the whole $13,000,000 being actually paid in. The new company was officially recognized and its titles, etc., duly confirmed by the Colombian government.

On coming into possession, the new owners very properly determined that their first duty was to make that complete study of the engineering features of the scheme, to the lack of which the failure of the old company was largely due. They also determined to begin work on a considerable scale with a view to determining exactly what quality of material would be encountered in completing the excavations and building the various dams and locks. To this end a staff of one hundred and fifty engineers was placed in the field and a force of several thousand men was put upon the work at the more important points, including the great Culebra cut through the divide.

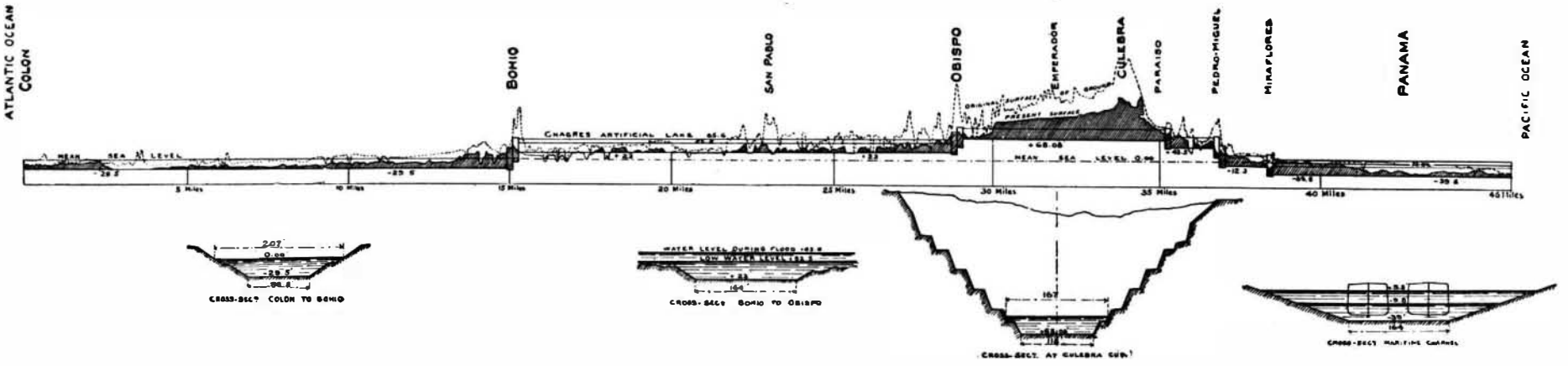
CULEBRA CUT.—The experience of the De Lesseps engineers and the opinion of casual visitors to the Culebra cut had agreed in indicating that the caving in of the loose material would prevent this great ditch from being successfully excavated. The new company accordingly concentrated a large force at this point and at Emperador for the purpose of ascertaining the nature of the underlying material of the mountain. A tunnel 1,100 feet in length was driven along the axis of the canal and a dozen test pits 6 feet in diameter were sunk at various points through the cut down to the proposed level of the bottom of the canal, and the shafts were connected by short tunnels. In short, the mass of material to be excavated was so thoroughly honeycombed in the regions where the worst caving had occurred as to leave no doubt as to its actual composition. Altogether, in the past four years there has been taken out of the Culebra and Emperador cuts 3,924,000 cubic yards of material, and the cost of this survey by excavation has been over $4,000,000. It was costly, but absolutely necessary to an exact estimate of the feasibility and expense of completing the canal. The evidence thus acquired proves that the "Culebra sliding mountain" does not exist, the excavation having passed through the upper layer of loose material and reached an argillaceous schist, below which, to the proposed bed of the canal, is solid rock. At Emperador the material is less firm, but perfectly capable of control when provided with proper drainage—a precaution wholly neglected in the happy-go-lucky methods of the De Lesseps regime.

THE CONTROL OF THE RIVER CHAGRES.—Another problem to be solved by the new company was that of the control of the turbulent Chagres River. By reference to the map (Fig. 9), it will be seen that the route of the canal, immediately after passing through the divide at Culebra, follows the course of the Obispo River, a tributary of the Chagres. At Obispo the canal enters the valley through which the latter river flows, and it follows this valley from mile 29 to mile 5, a distance of 24 miles. Now during the rainy season the Chagres is liable to enormous floods, which were such as to render the canal construction on the original lines a physical impossibility.

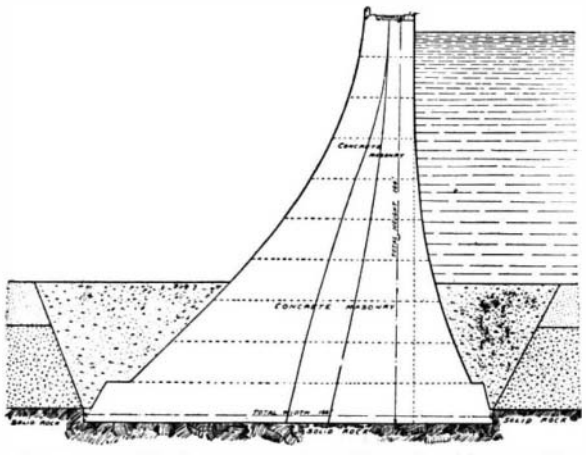
The new company decided at the outset to abandon De Lesseps' extravagant idea of a sea level canal and substitute a system of locks. This decision opened up the question of a sufficient supply of water to compensate for losses and supply the summit level. The floods of the Chagres evidently afforded an abundant supply, and the problem then took the form of an investigation of the amount of the Chagres River discharge and the possibility of storing it in suitable reservoirs, which should at once serve to feed the summit level and to hold back the rush of the Chagres waters in times of flood. With the question of the Chagres control was associated that of the most desirable elevation for the summit level and the number and location of the various locks.

This investigation was intrusted to 150 engineers, who, with their corps of assistants, have been occupied for four years in exhaustive surveys, the total cost of which has amounted to $1,200,000. This included, in addition to superintendence of the work at Culebra, extensive borings at the sites of the proposed dams and locks, sufficient to determine the exact nature of the whole site covered by their foundations; gagings of the river; the complete cross-sectioning of the basins of the proposed storage and control reservoirs, together with every kind of research that is necessary to the determination of the feasibility and cost of an engineering work of this magnitude. The investigation has been carried out to the smallest details, the drawing of every culvert, bridge, etc., being worked out with such elaboration that, on receipt of orders to go ahead with the work, these plans could be sent to the shops and the material ordered. We have had the pleasure of inspect

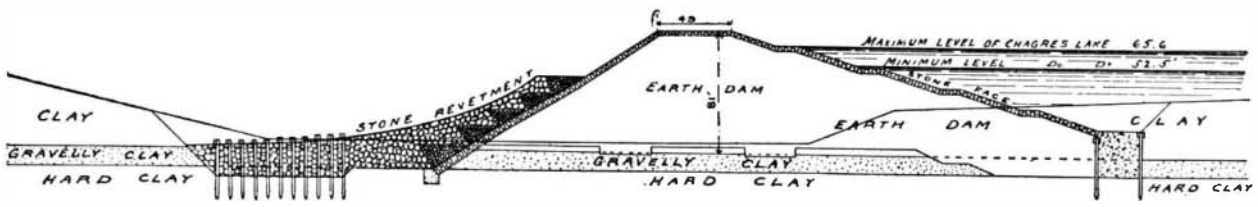
9.—General Plan of the New Panama Canal.



10.—Profile and Cross-Sections of the New Panama Canal.



11.—Cross-Section Through Alhajuela Dam. Height, 164 feet. Base, 166 feet. Length of Crest, 936·7 feet.



12.—Cross-Section Through Bohio Dam. Height, 75½ feet. Length of Crest, 1,286 feet.

THE NEW PANAMA CANAL.

ing the engineering data, and we are free to admit that the plans, profiles, maps, shop drawings, records, etc., are as complete as the most fastidious could ask for.

The new company has evidently laid the lesson of the first failure to heart; but, in order to give further weight to the findings of the engineers, it asked for the appointment of a Technical Commission composed of eminent engineers of different nationalities, whose experience in similar work gave them special qualifications for passing upon the new surveys and plans. The International Commission included such men as Brig.-Gen. H. L. Abbot, Corps of Engineers, U. S. A.; Mr. Fulscher, formerly Engineering Director of the Kiel Canal; Mr. Koch, engineering member of the same canal; Mr. W. Henry Hunter, Chief Engineer of the Manchester Canal Company; Mr. A. Fteley, Chief Engineer Aqueduct Commissioners, New York City; Mr. C. Skalkowski, formerly Director of Mines, Russia; and four of the former General Inspectors of Roads and Bridges, France.

This commission, organized in 1896, through some of its members has made personal inspection of the canal on the Isthmus and in addition to having at its disposal the local records of rainfall and floods for the last 15 years, for two years has made its own elaborate records of rainfall and of the flow and floods of the Chagres, and has held over 100 sessions. It presented a unanimous report on December 2, 1898, which, considering the standing and experience of the members, is perhaps the most representative and authoritative document of the kind ever drawn up.

The report fully indorses the plans and estimates of cost of the new canal.

THE NEW PANAMA CANAL.—The International Commission find that the work on the canal is at present two-fifths completed, that the cost to complete the work under the new plans will be $87,000,000. If 20 per cent be added for contingencies, the total cost is $102,400,000, and the time for completion, not allowing for improvements in methods of working and plant, is from eight to ten years.

The canal is forty-six miles in length. The map (Fig. 9) shows its location, and the profile (Fig. 10) shows by a dotted line the amount of excavation that has been done and by a full line and shaded portions, the excavation remaining to be done. The engineers drew up three designs for a canal with locks. In the first the summit level was to be 96¾ feet; in the second, 68·08 feet; and in the third, 32¾ feet above the sea level. The technical commission recommends the second, which is the one shown in the map and profile.

As the determination of the levels and number of locks is dependent upon the means taken to control and utilize the Chagres River, it will be well to explain that this control is secured by constructing two large dams, one at Alhajuela, in the upper Chagres, about nine and one-third miles above the canal (see map), and the other at Bohio, at the end of the sea level length of the canal on the Atlantic side. The Bohio dam will be thrown across the Chagres valley at a point about half a mile to the left of the canal at Obispo. It will be of earth, upon a bed of compact clay. The general features are shown in the cross-section, Fig. 12. The crest is 1,286 feet long, and the extreme height above the bed of the river is 75½ feet, and above the foundation 93½ feet. This dam will create a vast artificial lake, which will extend thirteen and a half miles to Obispo. Its lowest level will be 52·5 feet and its highest level, when the river is in flood, 65·5 feet. The channel of the canal will lie in the bed of this lake, which will not only take care of a large part of the flood waters, but will greatly reduce the amount of excavation necessary for the canal. The other dam, at Alhajuela, will be built everywhere upon solid rock, and will consist of concrete masonry. Its crest, 936·75 feet long, will be 134·5 feet above the river bed, and 164 feet above the lowest foundation.

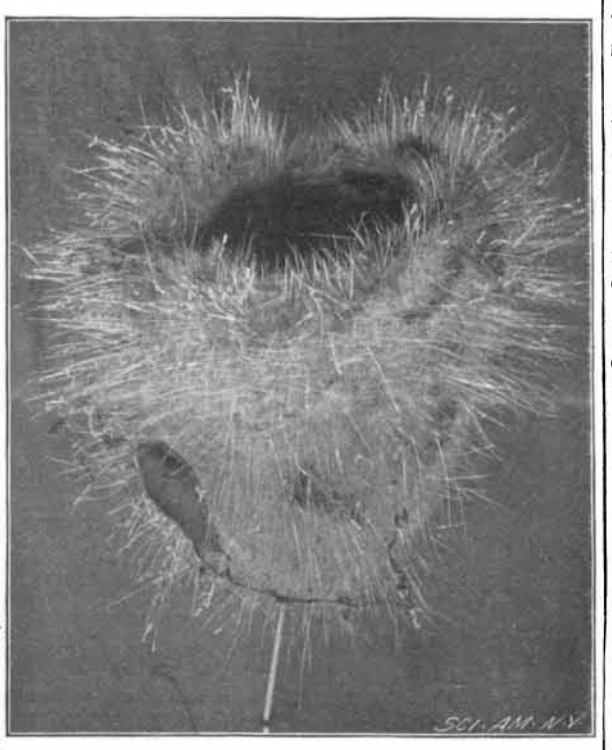
This dam will be connected with the summit level by a feeder with a capacity of 6,605 gallons per second. The dam will also furnish energy for the electric lighting of the canal and the electric operation of the locks, etc.

The storage capacity of the two artificial lakes thus formed will be 66 billion gallons, which provides a wide margin of safety, as shown by careful records, over any possible flood discharges of the river. The records of the flow of the upper Chagres have demonstrated that the surplus quantity of water impounded during the rainy season by the Alhajuela dam will be many times as great as will be necessary to supply the summit level during the dry season.

Commencing at Colon on the Atlantic, the first section of the canal, 15 miles in length, is tidal up to the two double locks at Bohio, by which vessels will pass into the Chagres River lake. These locks are of masonry and will be built upon rock foundations, as will all the locks of the canal. The deep cut shown in Fig. 3 is the site of the Bohio locks. The Obispo dam will be half a mile to the left of the locks in the bend of the Chagres River, which river is seen in the foreground of this same illustration. The working length of the locks will be 738·22 feet, the width of one of the twin locks being 82·02 feet and of the other 59·05 feet. Of this sea level stretch of the canal, the first 11·8 miles are navigable, the depth varying from 16·4 feet to 29·5 feet, the finished depth. It has been excavated to the original width (see Fig. 5), and not much dredging will be necessary to complete it for the whole 15 miles to Bohio. After passing the locks the canal channel extends for about 13½ miles along the bed of the lake to Obispo, where two double locks (built like all the other locks of the company upon a rock foundation) will admit vessels to the summit level 5 miles in length, where the bottom of the canal is 68·08 feet above mean sea level. On the Pacific slope admission is gained at Paraiso by one double lock to a level 7,963 feet in length, and at Pedro-Miguel two double locks lead down to a level 7,930 feet long, from which at Miraflores one double lock will admit vessels to the tide level of the Pacific. This portion of the canal is 7½ miles in length. The depth of water in the locks will be 29·5 feet and will not exceed 32·8 feet.

It should be noted that the slopes of the canal, particularly in the Culebra cut, are to be reveted with stone, and that the curvature of the canal is easy throughout, the smallest radius being 8,200 feet and the prevailing radius 9,843 feet.

THE QUESTION OF HEALTH.—The Technical Commission examined carefully into the question of mortality and concluded that the climatic dangers have been exaggerated. It is true that, during the first years of operation, owing to carelessness as to sanitation, the employment of races not used to hard labor in the tropics, and the fact that surface ground full of fever germs was being opened, the loss of life was serious. Of late years, however, owing to the employment of negroes from the British Antilles who are used to the climatic conditions, and as a result of the fact that the excavation is in the deeper rock formations, the amount of sickness is not abnormal.



GLASS SPONGE FROM SANTA CATALINA ISLAND, CAL.

RELATIONS OF THE NEW TO THE OLD CANAL COMPANY.—In conclusion, answering the inevitable question as to the relation of the new company to the financial burdens of the old company, we can say briefly that the old bondholders have no control over the new company, the receiver turning the property over to the latter upon the condition that the old bondholders were to have an interest in the profits (after the payment of operating expenses, depreciation, interest on construction bonds and dividend on new capital) to the extent of 60 per cent.

GLASS SPONGES.

BY PROF. CHARLES FREDERICK HOLDER.

It is not generally known that the beautiful animals known as glass sponges are found within the borders of the United States, yet one species at least is common, though rarely taken, off the coast of the Southern Californian islands, especially on the so-called grouper banks of Santa Catalina, where fishing is carried on in water five hundred or six hundred feet deep.

It was here that the attractive specimen shown in the accompanying illustration was found, being brought up on a fish hook. The sponge was a species of Holtenia, probably Holtenia Carpenteria, about twelve inches in height and nearly six in diameter; the long glass-like roots had been torn off when it was brought up. In appearance the sponge was a veritable porcupine; long needle-like spicules standing out all over it, the longest three inches in length, needles so sharp and brittle that it was difficult to hold or touch the sponge, and at a glance it resembled some odd or fanciful cactus.

The sponge was vase shaped, and would hold three pints of fluid, bulging out in the center, with an opening at the top sufficiently large to admit the closed hand. The long spicules reaching out from it presented a splendid appearance when held up to the sun, and resembled glossy hairs, gleaming and scintillating wherever the sun flashed along their surfaces. Many of the spicules were overgrown with an attractive coralline, so that they appeared branched like the limbs of a tree. In these mimic branches hung pendent many miniature pink-hued star fishes and shrimps, while fastened to them, coiled and interlaced, were the barrow-like egg cases of a skate. These are shown in the illustration.

That these sponges are fairly common in deep water offshore is evident by the small specimens often brought up and the pieces found on the outer islands, especially San Nicolas; but never before has so large and perfect a specimen been seen.

The glass sponges are so called because their skeleton, or the spicules, resemble glass, being formed of silica instead of lime, and closely resembling spun glass.

The most beautiful of the group is the Venus flower basket, or Euplectella aspergillum, which represents a vase of spun glass of the most beautiful description. When the first specimen was found it was sold at a fabulous price, and its true nature was not suspected. But finally a specimen was taken by a naturalist, who made the interesting discovery that the delicate and fragile glass-like vase, that seemed to be the work of some cunning East Indian, was nothing more nor less than the skeleton of a sponge whose spicules were silicious. In the water and alive the sponge is not an attractive object, being of a gray color and half buried in the mud, anchored by long glass-like streamers. But once dead and relieved of its covering, it becomes one of the most resplendent objects of the sea—a fairy vase, that might well have been modeled by the sea gods as a gift to Venus.

This sponge has the spicules so arranged that they present the appearance of squares. It is closed at the top and sides, hollow in the interior, and is occasionally the prison of small crustaceans, which enter the interstices when very young and unable to escape become prisoners for life, and in the skeleton may be seen with their claws protruding through the opening, creating much wonder among the uninitiated as to how they obtained ingress into the glassy prison.

Another interesting glass sponge is Hyalonema, which resembles a glass rope. The sponge itself is a small cup, perched upon a long series of glass-like stems, which is buried in the mud. This was for a long time sold as the skeleton of the little coral polyps which are parasites on its stems.

AN INSECT BREEDING IN CRUDE PETROLEUM.

BY L. O. HOWARD.

In view of the extensive use of petroleum products for insecticidal purposes, the title of this article would seem paradoxical. That such a case should be found seems, in fact, more remarkable than the breeding of the cigarette beetle, Lasioderma serricorne, in pyrethrum powder, recorded by the writer in the Proceedings of the Entomological Society of Washington, volume i., page 37.

At the meeting of the Boston Society of Natural History, January 22, 1879 (Proc. B. S. N. H., volume xx., page 134) Dr. Hagen read a letter from a Mr. Dean to Henry Edwards, of Santa Cruz County, Cal., describing a small alkaline lake in the southeastern corner of Santa Cruz County, of 20 to 30 acres area, into which copious petroleum springs continually poured their contents, which, drying, formed masses of asphaltum overlying the soil and running down to the lake. The petroleum had forced passages through the asphaltum, forming little pools of about the consistence of molasses. Mr. Dean sent with the letter a number of flies of the genus Ephydra, which he had found sitting upon the petroleum and piled up upon one another in vast numbers just like flies upon molasses, those underneath dying and becoming embedded in the petroleum and being succeeded by others, which, in turn, were pressed down into the liquid tar by those above. On approaching they would rise in a cloud about 2 feet above the petroleum, and, on being unmolested, would return and settle upon it. The dead flies were said to rise several inches deep above the liquid petroleum. Mr. Dean further stated that the flies appear to breed upon the water plants covering the surface of the lake, which are left incrusted with the salt and covered with the empty shells of the insects.

This is the only published note with which the writer is familiar which approaches in any way or is related to the case which he is about to describe. There seems no doubt, however, that in this case the insect was a true Ephydra, possibly E. californica of Packard, which breeds upon water plants in the alkaline lakes of the far Western States.

On May 20 of the past year the writer received a letter from Mr. C. G. Kellogg, Secretary of the Board of Horticultural Commissioners for Los Angeles County, of Los Angeles, Cal., transmitting in alcohol some small maggots, the natural habitat of which he wrote was "in the old pools of crude petroleum oil that is

SCIENTIFIC AMERICAN

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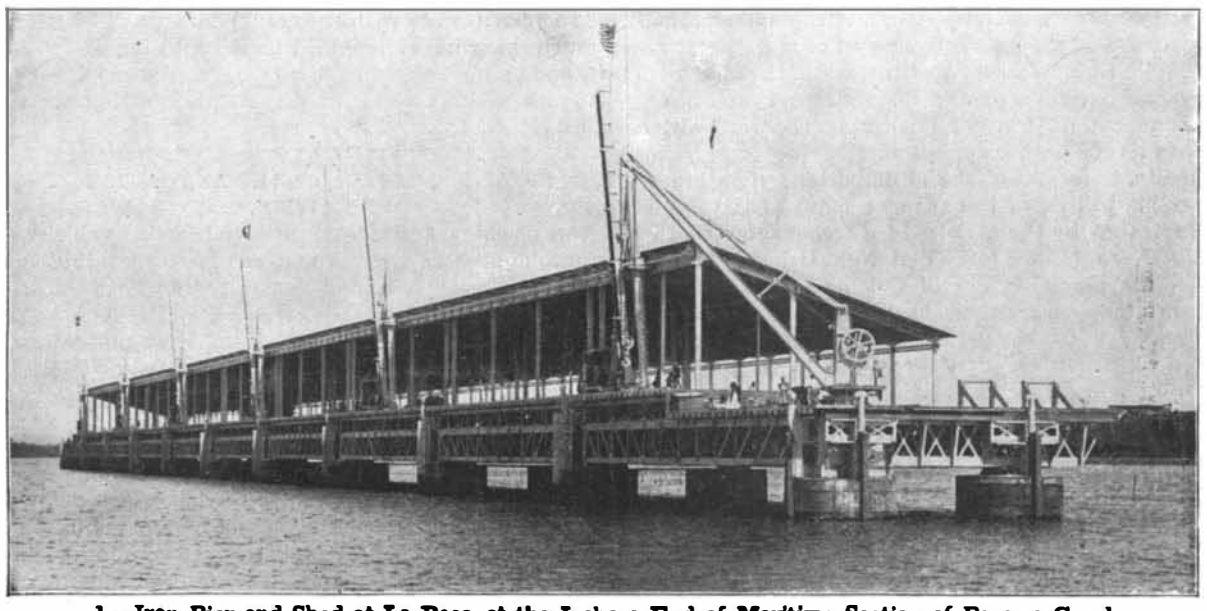
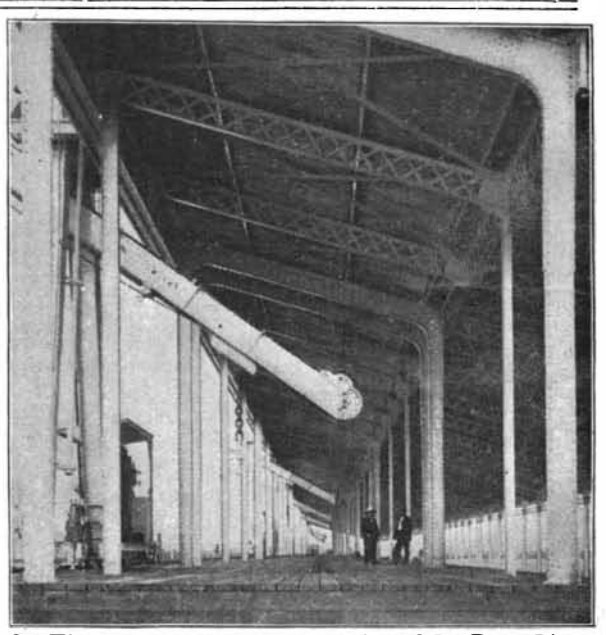
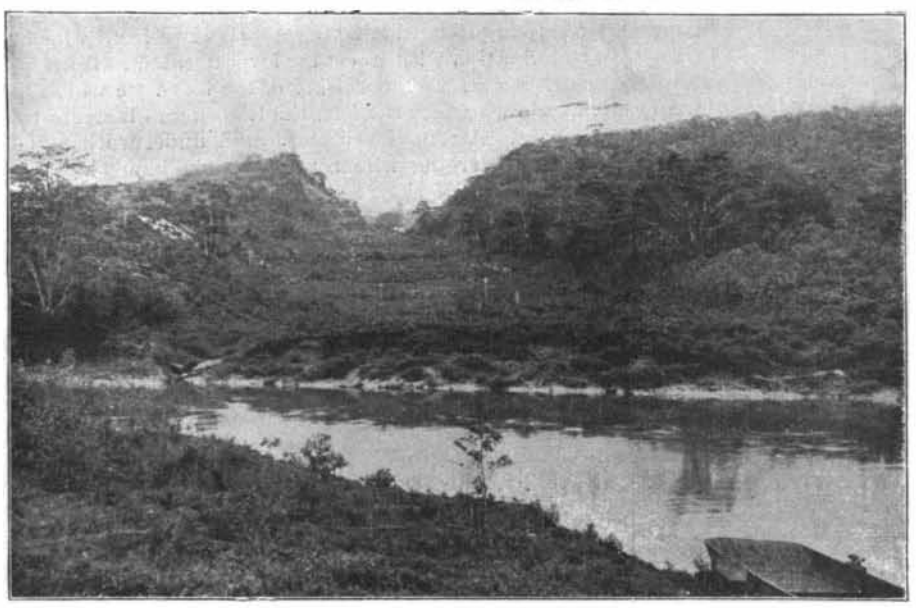


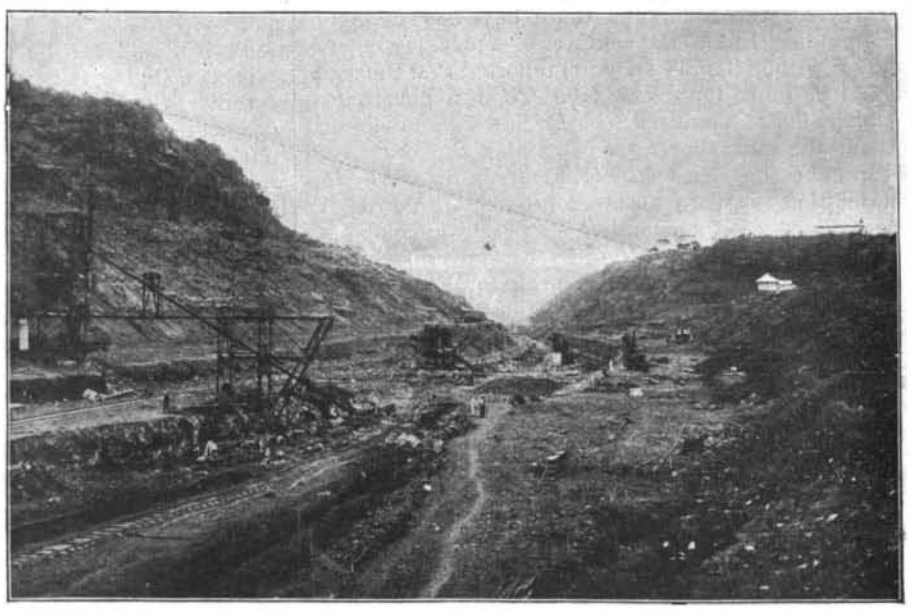
1.—Iron Pier and Shed at La Boca, at the Inshore End of Maritime Section of Panama Canal on the Pacific.



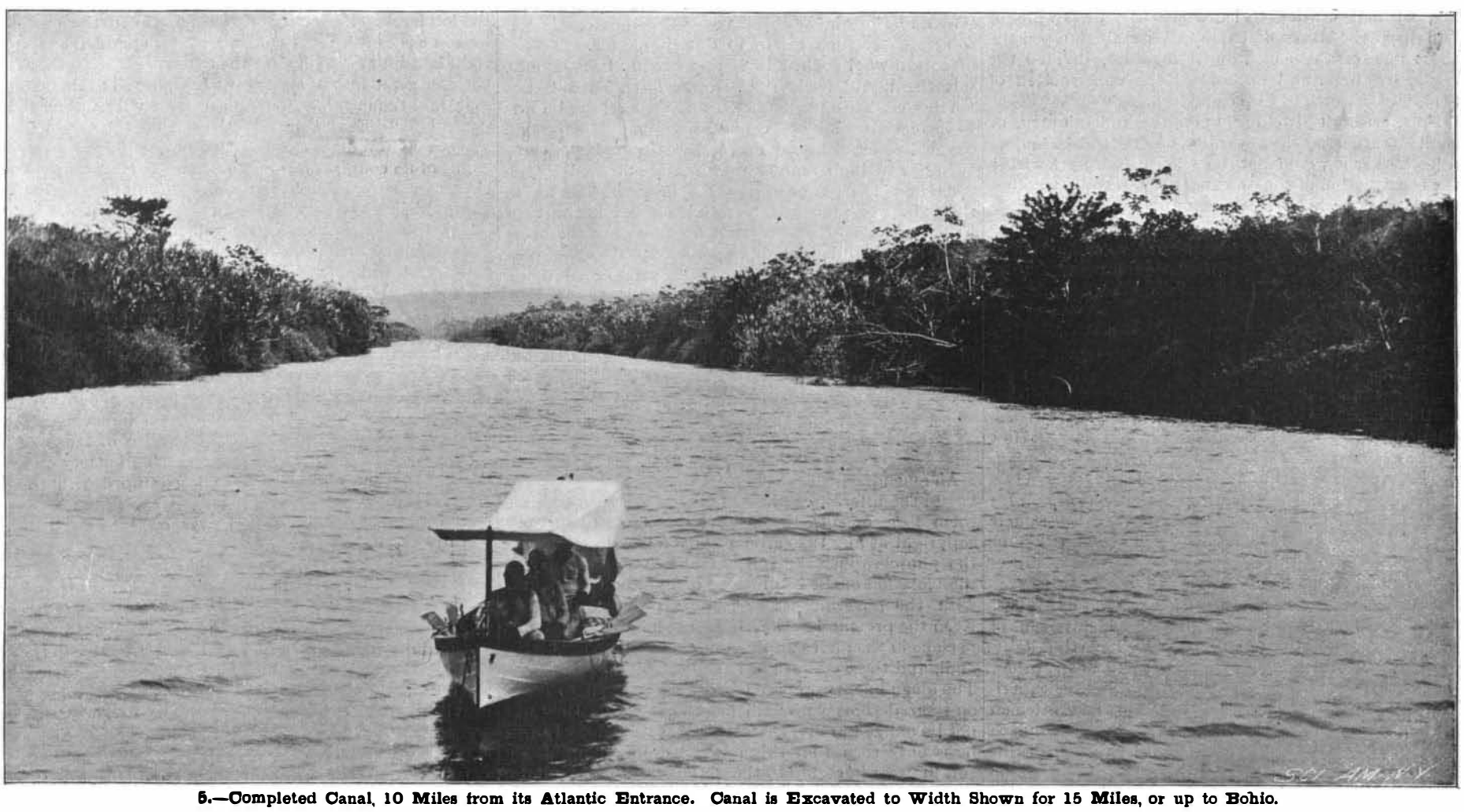
2.—View Looking Through Interior of La Boca Pier Shed. Length, 991½ Feet.



3.—Bohio—Site of Locks and Dam. Chagres River in the Foreground. Locks will be Built in the Rock Cut Beyond the River.



4.—Great Culebra Cut, 34 Miles from Atlantic. Dotted Line Shows Original Surface of Mountain.



5.—Completed Canal, 10 Miles from its Atlantic Entrance. Canal is Excavated to Width Shown for 15 Miles, or up to Bohio.

THE NEW PANAMA CANAL—PRESENT CONDITION OF THE WORK.—[See page 73.]