

A TRIP THROUGH THE PANAMA CANAL IN 1915.

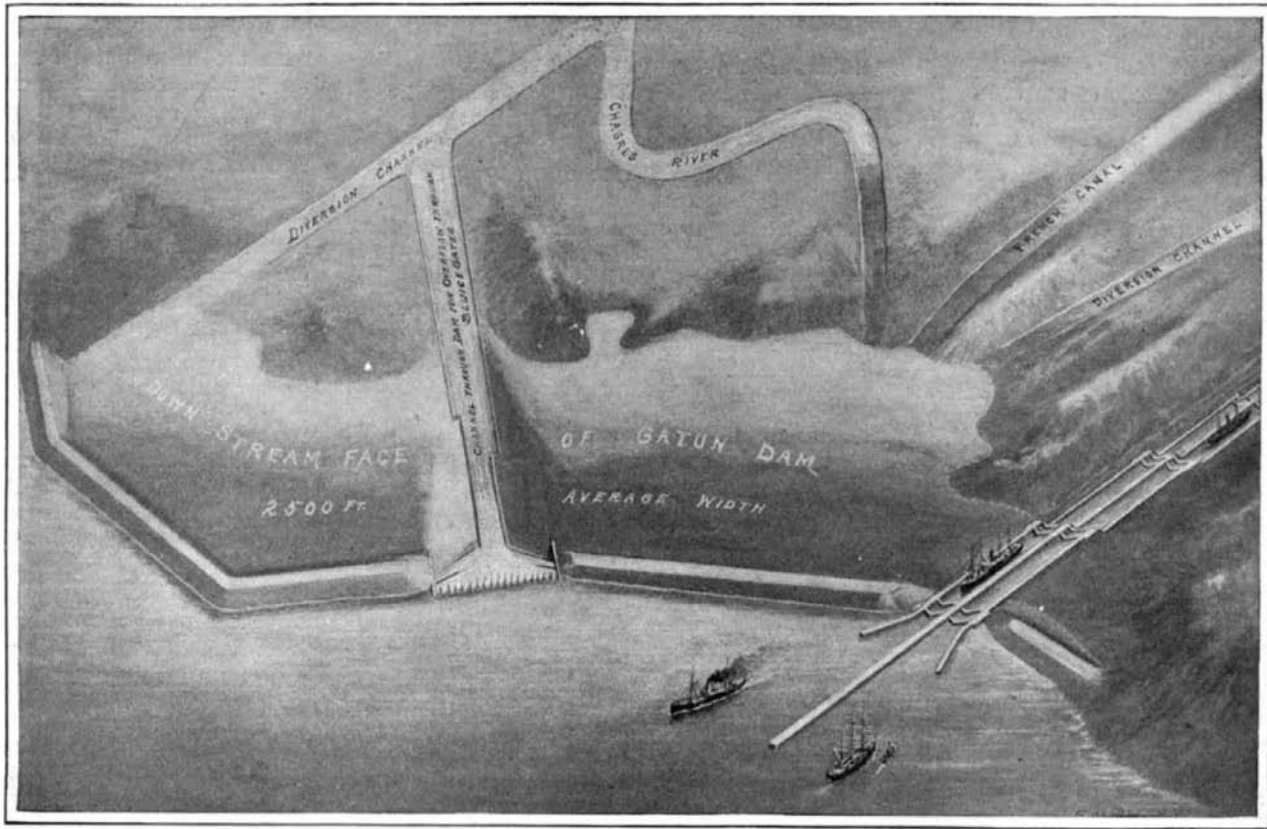
When the Isthmian Canal Commission received the report of the consulting board of thirteen distinguished engineers, appointed by the President to decide which was the best type of canal to build at Panama, it found that, by a vote of eight to five, the Board recommended the construction of a canal at sea level. Because of its distinguished ability, the findings of such a Board should have possessed, it would almost seem, something of a mandatory and final authority. Nevertheless, the Isthmian Canal Commission of six members, four only of which are engineers, felt compelled to decide against the finding of this International Board of thirteen engineers, and recommend a high-level canal with locks. That this momentous decision was given purely on the merits of the case, and was prompted simply by considerations of construction and subsequent operation, goes without saying. It is the purpose of the present issue of the SCIENTIFIC AMERICAN to give a concise description of the canal that is recommended, and present the leading arguments which led the Commission to decide against a canal at sea level and in favor of one with locks and high-level lakes.

THE TERMINUS, LIMON BAY.—By way of gaining a general impression of the lake-and-lock canal as it will appear when completed, let us suppose that the sanguine expectations of the Commission have been realized; that the work has been completed by the year

1915; and that we are approaching the canal from the Atlantic on one of a line of 40,000-ton freight and passenger steamships that are trading between New York and the Orient. Our ship is 700 feet long by 75 feet broad, and draws 35 feet of water. The first indica-

one of its pilots aboard, who at once shapes his course straight for the center of the 1,000-foot entrance.

IN THE SEA-LEVEL CHANNEL.—As we pass through, leaving the terminal lighthouses on either hand, we find ourselves passing between a double line of buoys, and the pilot tells us that these mark the delimitation of a broad channel, 500 feet wide, which has been dredged through the mud and silt of Limon Bay. There is a northwesterly wind blowing, which is kicking up quite a sea on the outside; but we notice that as soon as we have passed in between the breakwaters, we are in quiet water. This is due to the long rock jetty, which extends parallel with our course and about 800 feet to the west of it, and serves to break the force of the sea that is running, and prevent the natural tendency of the waves to set us over toward the easterly side of the channel. We are steering a course due south, and moving along at a comfortable speed of 12 knots an hour. In about twenty minutes time

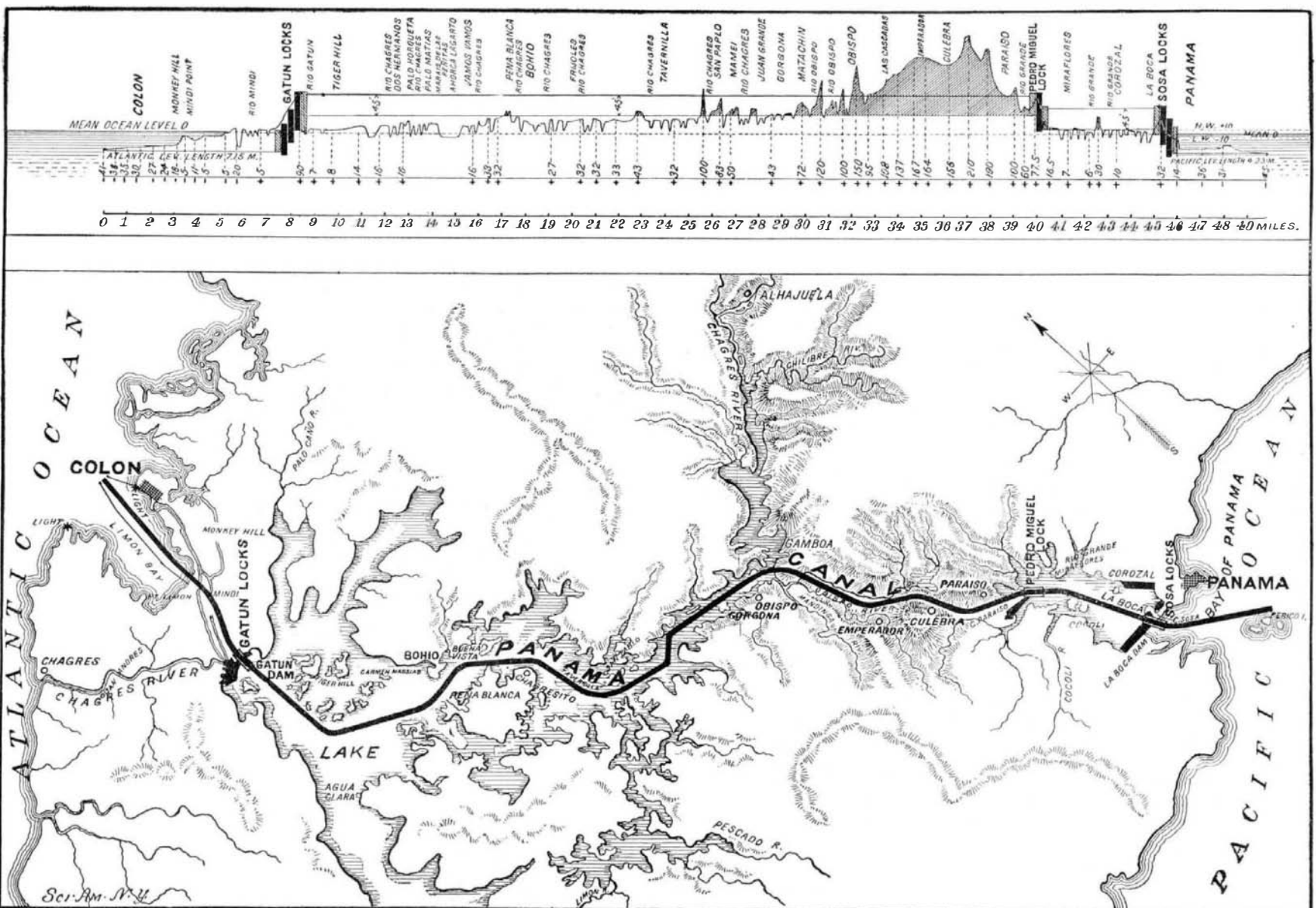


The great earth dam, 9,000 feet long on the crest, 2,500 feet through, and 135 feet high, will create a lake 85 feet deep and 120 square miles in area, in the valley of the Chagres. It will control the Chagres floods and afford twenty miles of deep-water navigation. The surplus water of the Chagres will pass out through the regulating gates shown in the center of the dam. These will be built of massive concrete and masonry.

BIRD'S-EYE VIEW OF THE GATUN DAM AND LOCKS.

tion that we have reached the canal entrance is the sight of two long, low jetties extending seaward, one reaching out for the distance of a mile from the city of Colon, the other extending in a far line across Limon Bay from the low-lying shore, 4½ miles distant. These two jetties, the captain tells us, were built out on converging lines, until they reached deep water at the 40-foot contour line, where they terminate in two lighthouses distant from each other about 1,000 feet. The Panama Canal steam pilotboat now places

we approach the shore line near the mouth of the Minda River, and here the canal proper commences. We steam straight in between the low-lying alluvial shores for a distance of one mile, until the pilot is able to sight the range marks, which tell him that it is time to make a 25-degree turn, and head for the great locks at Gatun dam. To give room for this turn, the canal has been widened out to 800 feet. We head straight for the easterly bank, until, at the command of the pilot, a few turns are given to the wheel, and the



The canal extends from the 40-foot line on the Atlantic to the 40-foot line on the Pacific, a distance of 50 miles. The first 8 miles is a sea-level channel; next is 24 miles of lake navigation at 85 feet above sea level; then 7¼ miles of narrow canal through the Culebra hills; then 5 miles of lake navigation at 55-foot level; and, last, 4¼ miles at sea level.

PROFILE AND MAP OF THE PANAMA LOCK CANAL.

great ship, now running at a reduced speed, swings easily around onto her new course. The pilot explains to us that this method of making the turns by a sharp angle, in a widened channel, is greatly preferable to making the same turn on a long, easy curve, where it would be difficult to keep the helm set at the exact point to guide a large vessel on a true center line between two curving banks.

THE GATUN DAM.—On straightening out on our course, we notice that the country on the port side of the ship is changing in its topographical character, and lifting into what appear to be the foothills of a distant range of mountains. These low foothills appear to stretch directly across our course, and they terminate

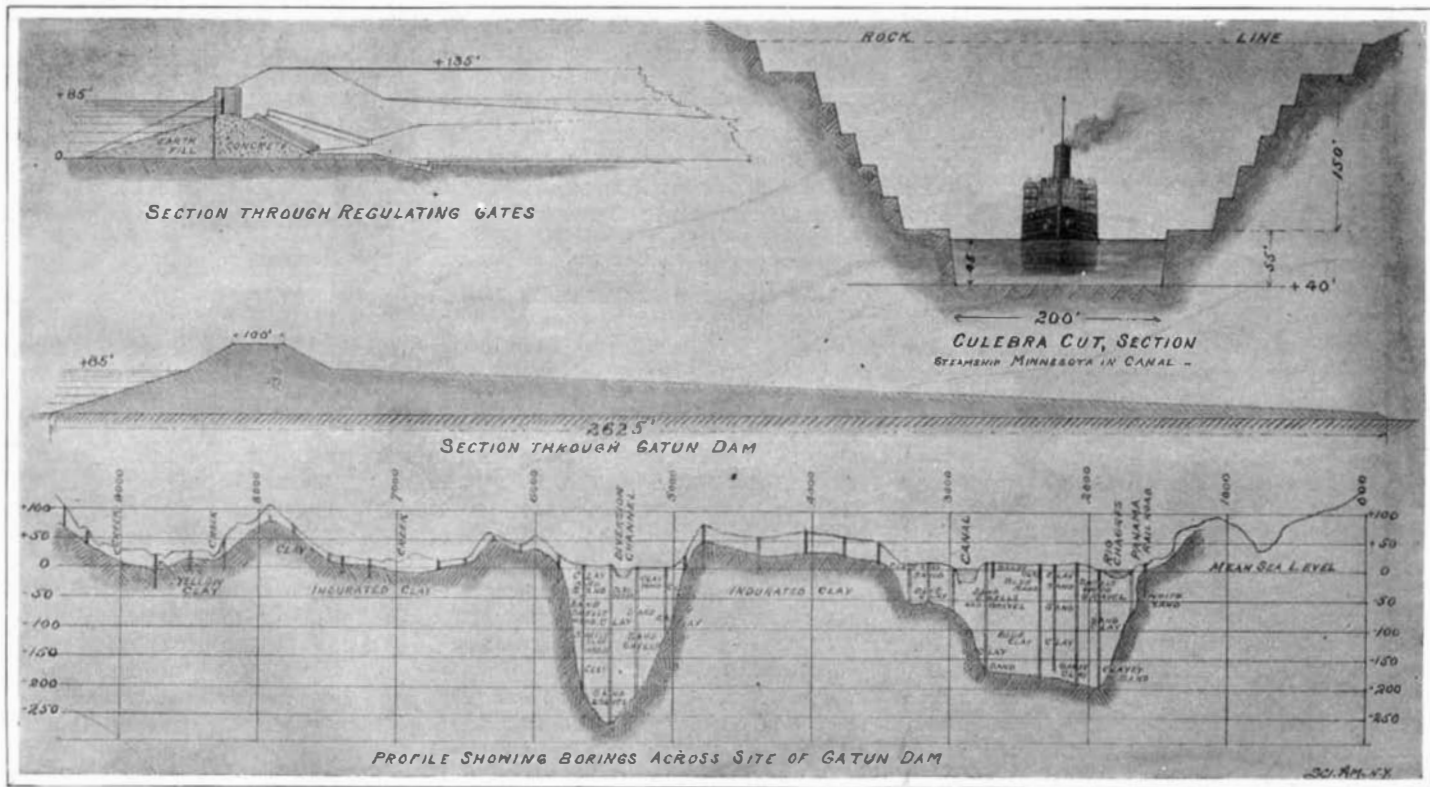
opposite a similar ridge on the opposite side of the valley, through which formerly flowed the far-famed Chagres River. Running straight across the valley between these converging hills, there extends the downstream slope of a vast artificial mound, by which the gap between the hills has been filled in, the valley of the Chagres closed, and the vast interior basin of the Chagres artificial lake formed. This huge dam, on the upstream side, slopes at an easy angle up to its crest 135 feet above the valley, and 50 feet above the surface of the lake, the latter being held at 85 feet above sea level. At the water level the dam is everywhere 375 feet through, measured on a horizontal line, and from its crest it slopes down the valley with a gentle fall of 1 foot in 25, until it meets the natural surface of the ground. Measured on its base on the surface of the ground it is 2,500 feet through, and its cubical contents reach the enormous figure of 21,200,000 cubic yards. Looked at from the downstream side, it has exactly the appearance of the clean-cut parapet and long, sloping glacis of a gigantic modern fortress.

GATUN LOCKS.—The pilot now signals for dead slow speed, and as we make a slight turn to port of a few

degrees, we see before us, a quarter of a mile distant, and standing out white and clear against the sky, the long 3,000-foot stairway of the famous Gatun locks. They consist of six great chambers, each 100 feet wide, 90 feet deep, and 1,000 feet long, arranged side by side

and poverty-stricken villages are gone. We see in their place a broad expanse of water, which stretches on the right hand, past the foothills of Agua Clara to a shore line 15 miles in the distance. To the left the lake extends between the ranges of the mountains in two

long estuaries five and eight miles in length; while directly to the southeast, the pilot informs us that the lake backs up through the old valley of the Chagres for a distance of between thirty and forty miles. It is as fair a picture of lake and mountain scenery as one could wish to look upon, and the pleasing impression was heightened by recollection of the fact that this great inland sea, 120 square miles in extent, is the key to the successful execution of the



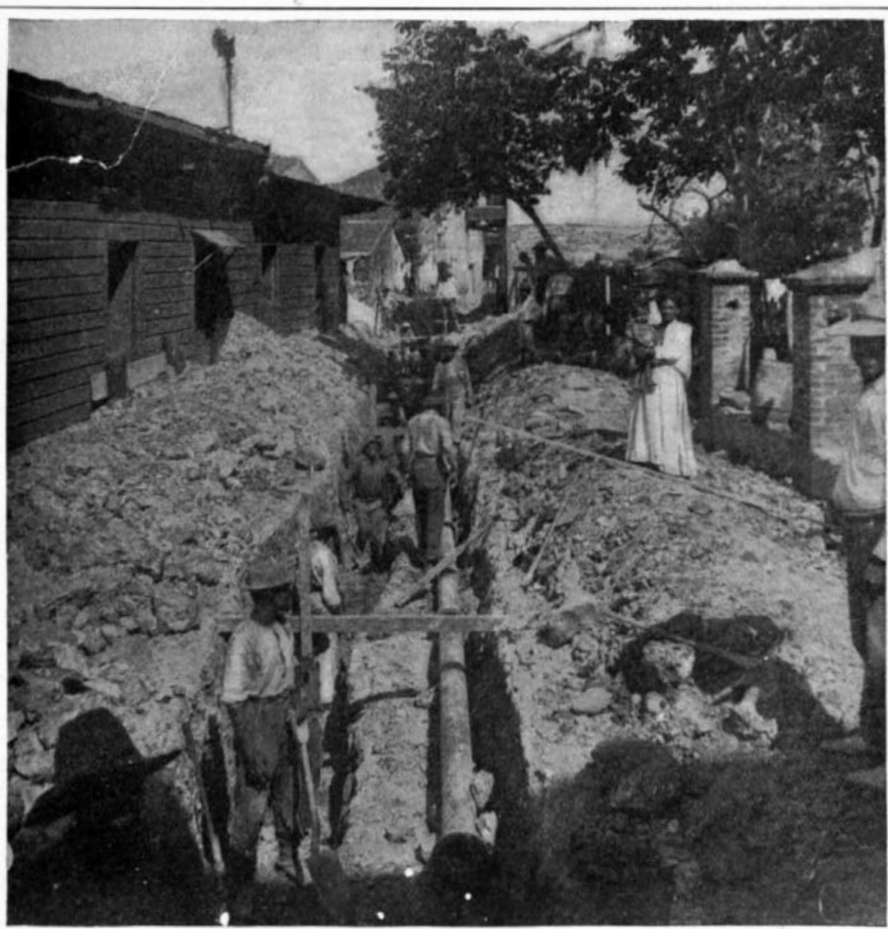
THE FOUNDATIONS, DAM, AND REGULATING WORKS AT GATUN.

in pairs, and rising in three steps, of 28 feet, from the level of the sea to the surface of Gatun Lake, 85 feet above sea level. These locks are the greatest of their kind in the world, and by the time they were completed had cost over \$15,000,000. As we enter the first lock, into which we are warped by means of powerful electric winches, operated, we are told, by hydraulic-electric power from a reservoir located far up the Chagres River, there steams out of the adjoining lock at the same level a famous old freighter, the "Minnesota," the pioneer of a fleet of similar and even larger ships that is now plying between Atlantic and Pacific ports by way of the new canal.

CHAGRES LAKE.—On entering the third lock we catch our first glimpse of the great artificial lake which at once served to solve Panama's greatest problem, the control of the Chagres, and provided twenty miles of broad deep waterway, through which shipping might travel with almost the freedom of ocean navigation. The transformation effected by Gatun Lake is something that can only be appreciated by those who have crossed the Isthmus when the old Panama Railroad was the one means of transit. The marshy swamps

greatest and most useful engineering work of modern times.

As soon as our ship is clear of the last lock, the pilot calls for full speed ahead. With from 70 to 45 feet depth of water, and never less than a clear width of 800 feet of channel, for the next twenty miles we are able to steam with something of the freedom of ocean navigation. For the first four miles our course lies due south, in order to enable us to round a group of islands of which Tiger Hill is the loftiest point. Then another five miles brings us to Bohio, where the hills on either side close in on the Chagres valley until the lake is only about half a mile in width. Here, during the earlier studies of the problem, it was proposed to place the famous Bohio dam, the site having been abandoned because of the impossibility of finding a suitable foundation. After passing Bohio the lake broadens out again, and for the next seven miles to San Pablo it is from two to three miles wide. Here, for the first time, the water of the lake adjacent to the line of the canal begins to have a less depth than that of the canal itself, which, throughout this summit level, is never less than 45 feet. From San Pablo



Laborers Excavating for New Water and Sewer Service. Work Done Under Department of Municipal Engineering of Canal Zone.



Street Cleaning Department at Work on One of the Streets of Panama. This Street Has Been Graded and Covered with Top Dressing of Gravel.

we steam for the next four miles through a channel 45 feet deep and 800 feet wide, to Juan Grande, where the channel reduces in width to 500 feet, at which width it continues for the next $4\frac{3}{4}$ miles to Obispo. By this time the lake has narrowed to an average width of about three-fourths of a mile, and the valley of the Chagres turns from an easterly to a northerly direction, the lake backing up through the valley for a further distance of six or seven miles.

CONTROL OF CHAGRES FLOODS.—At this point is Gamboa, which was selected for the construction of a dam 180 feet high, should it have been determined to build a canal at sea level. At the surface of the water the distance between the abutting hills on either side of the lake is about 1,500 feet, and the depth of the lake through the outlet is about 35 feet. To such a high level has the great dam at Gatun raised the Chagres waters, that the rushing floods of the river have been entirely shorn of their peril. The backing of the lake seven miles up the valley, beyond the point at which the original course of the river intersects the canal, entirely relieves the canal authorities from any anxiety on account of the enormous floods which pour down the valley of the Chagres in the sudden and heavy rain storms. The rushing river spreads out quickly into the ever-widening area of the lake, and long before the gorge at Gamboa is reached, the flood waters have spent their force.

THE GREAT CULEBRA CUT.—Thanks to the height of the Gatun dam, the waters of the lake were raised to such a high level that in the distance we have traveled from Gatun to Obispo the 45 feet of depth in the channel was obtained, we are told, with practically no excavation whatever in the first 17 miles of its length, and with but a very moderate amount of excavation in the next 5 miles. At Obispo, however, the canal swings rather sharply to the right, and we are con-

dredged through the bottom of the lake to a width of 500 feet, and our pilot at once takes advantage of this fact by raising the speed from 5 to 12 knots an hour. At Miraflores we enter again upon unobstructed navigation, the channel broadening out to more than 1,000 feet in bottom width. Still farther increasing our speed, in a quarter of an hour we have crossed the last stretch of the lake, and are confronted by the great dam and double flight of locks at La Boca, on the Bay of Panama.

While we are being warped into the first of the double flight of locks at Sosa we learn that the Rio Grande lake required three separate dams for its formation; one about 3,500 feet long to the west of Sosa Hill, another 1,200 feet long to the east of the hill (these two serving to close the natural outlet of the Rio Grande River) while a third dam, about a mile in length, but of comparatively shallow height, being in fact more in the nature of a dyke, was built across a stretch of lowland about $1\frac{1}{4}$ miles to the northeast of the locks. The main dam adjoining the locks, which is known as La Boca dam, cost over a million and a half dollars, and the same amount was spent on the other two structures, known as the Ancon-Sosa and Ancon-Corozal dams. The Sosa locks cost \$13,000,000. The descent from the Rio Grande lake to Panama Bay is made by two flights, each of 27 feet.

THE PACIFIC TERMINUS.—We are now once more at sea level, and we steam at reduced speed through a dredged channel 300 feet in width until we reach deep water at the 40-foot contour line, at a distance of $4\frac{1}{4}$ miles from the Sosa locks. Here we drop our pilot, and start at full speed on our 5,000-mile trip across the Pacific. From the time when we passed between the inclosing jetties off the city of Colon to the time of entering deep water on the Pacific, a period of 11

15,000 men employed on the work. The houses for the laborers are of wood, and built five feet above the ground. Each contains two or three bunks, with galvanized iron frames and removable wire or canvas bottoms; a stout table, and chairs. They are of a size that provides the 500 cubic feet of space to the man required by sanitary authorities. The camps are built on high ground, and as soon as they are established, drains are dug, sewerage put in, and the vegetation is cut down from a large contiguous area.

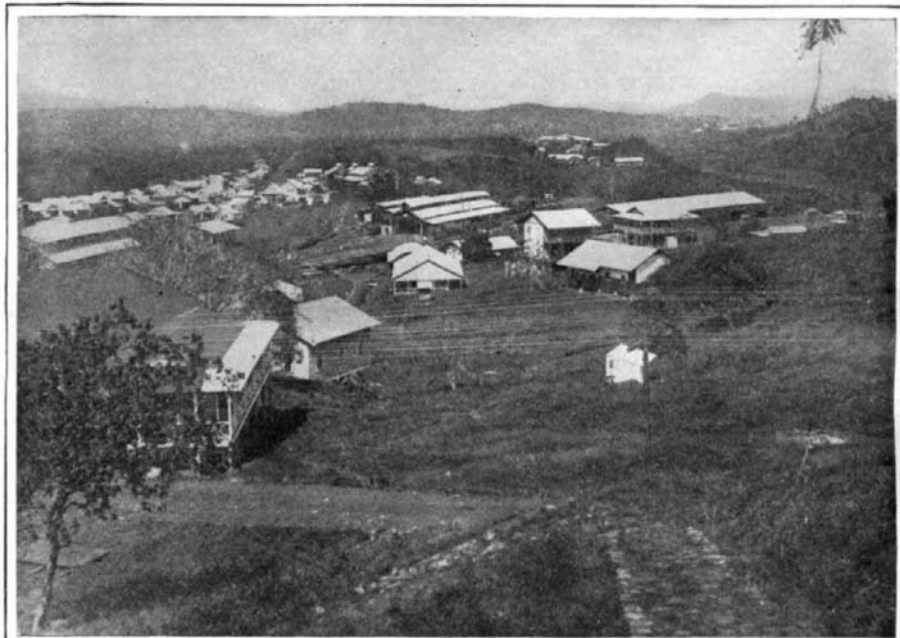
WATER SUPPLY.—An abundant supply of good drinking water is found in the hills that border the canal. Water is piped from reservoirs near the terminal cities of Panama and Colon, and the work of enlarging these, and putting in pipe lines to convey water to the various camps along the line from the nearest natural source of supply, is being vigorously pushed. An analysis, recently made, of the water at Culebra cut showed it to be as pure as the water from Croton reservoir. The laborers are at present being fed by the government at the rate of 30 cents a day; but it is probable that ultimately a contract will be let for the running of the mess-houses for the whole force.

CLEANING THE CITIES.—The system of cleaning up of the cities, which accomplished such wonders for Havana, is being vigorously carried out in the canal zone. Yards are being thoroughly cleaned, sewers put in, cesspools abolished, the garbage is regularly collected, the streets swept, and as fast as possible they are being graded and drainage of surface water established. In Colon the grade of the streets is being raised well above the marsh level, and from one end of the zone to the other, every possible precaution is being taken to render the district cleanly and wholesome.

STAMPING OUT YELLOW FEVER AND MALARIA AT PANAMA.—Thanks to the splendid work of Col. W. C. Gor-



The Main Street of Culebra—a Typical Village on the Route of the Canal.



View of Camp at Empire on the Canal, Showing the Type of Houses Built for the Canal Employees.

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SANITATION OF THE CANAL ZONE.

fronted at once by the Culebra range of mountains through which, like a gigantic railroad cut, we see the canal excavation. For the next mile and a half the canal (we have left the lake channel and are now in the canal proper) is cut with a bottom width of 300 feet to Las Cascadas, where we enter the only stretch of the canal, $4\frac{3}{4}$ miles in length, in which the bottom width is brought down to 200 feet. The walls of the canal immediately abutting on the water are approximately vertical for a height of five feet above the canal surface. Then there is on either side a broad bench, upon the easterly one of which are the tracks of the Panama Railroad. From this bench the sides of the cut are carried up in a series of parallel steps. The distance up the sides of the cut, in the deepest portion, is between 300 and 400 feet. In passing through this section, our speed is reduced to five or six miles an hour, for the reason that if, in the restricted channel, we were to steam any faster, the ship might take a sudden veer and strike the banks before she could be brought on her course again. As we finally emerge from the Culebra hills, we see before us the gates of Pedro Miguel lock, and beyond them we catch our first glimpse of the Pacific Ocean, now only a matter of some seven miles distant. There is but one lock at Pedro Miguel, with a fall of 31 feet, but so vast are its proportions, that it cost the sum of \$7,000,000 to make the huge excavation in the rock bottom and put in the concrete and cut-stone walls and the massive electrically-operated gates.

RIO GRANDE LAKE.—We now find ourselves at the head of another great freshwater lake, formed by damming up the river Rio Grande, which heads in the Culebra Mountains and flows to the Pacific. For the first two miles from the lock to Miraflores the channel is

hours has elapsed, and this in spite of the fact that we met and passed several ships on the way. The meeting of ships, however, occasioned no such delay as it does in the narrow Suez canal at sea level; for the canal superintendent dispatched the ships in such order that they met only in the broader channels or on the broad surface of the freshwater lakes. Throughout the whole of the trip, although we draw 35 feet of water, we have never had less than five feet of water below our keel; for 23 miles out of the whole distance of 49 miles, we have been able to steam at full speed in practically unrestricted navigation; for 12 miles we have steamed at three-quarter speed; and only during our passage through the 200-foot wide section of the canal at Culebra have we been obliged to come down as low as five or six miles per hour.

SANITATION OF THE PANAMA CANAL ZONE.

Towering in importance high above all the many important problems that demand solution if the United States is to build a canal at Panama, is that of sanitation. The 25,000 laborers that will be needed, must be housed, fed, supplied with pure water, and safeguarded by a thorough system of sanitation. Furthermore, the two great scourges of the country, yellow fever and malaria, must be stamped out or kept under control, and measures taken to prevent any outbreak from becoming epidemic.

HOUSING.—The present commission found on the Isthmus a few large hotels for the engineering and clerical force, and 2,100 small houses for the laborers, which had been built by the French. About 1,200 of these houses have already been repaired, a large number of others built, and the hotels have been greatly enlarged. There is to-day accommodation for the

gas, U. S. A., the chief sanitary officer of the canal zone, it has already been proved that yellow fever and malaria, the two prevailing diseases, can be successfully combated and practically stamped out. Yellow fever is conveyed from man to man only by the female *Stegomyia*, who must have previously bitten some human being suffering from yellow fever. Therefore, yellow fever cannot originate in a place where there are no infected *Stegomyia*, until a yellow fever patient has been introduced and has infected the local pest; or until the mosquito, infected at some distant point, has been introduced. Practically, the introduction of a yellow fever patient is the only method by which the locality can be infected.

The immediate object of the sanitary measures is to get rid of all infected *Stegomyia*. This can be accomplished with great certainty by establishing a system whereby the health authorities are certain to be informed of every case of yellow fever; and then fumigating the house in which this case occurred, so as to destroy all the mosquitoes within its borders. The same thing must be done with all contiguous houses. It has been found by experience that this kills all the infected mosquitoes at that particular focus. By doing the same thing at every other focus as yellow fever occurs, all the foci in the community are gradually destroyed, and when the last focus has been got rid of, yellow fever is at an end. A more expeditious method is to systematically fumigate every house in the town.

The *Stegomyia* is a house mosquito, and being cleanly in her habits seeks principally the clean rain-water barrels and water containers, and never travels far from her birthplace. Therefore, as an additional sanitary safeguard, every receptacle for water should be so screened that mosquitoes cannot have access to it.