CHAPTER XII

HOW THE Isthmus WAS MADE HEALTHY

THE New French Canal Company lost no time in accepting the $40,000,000, and its representative on the Isthmus formally turned over possession to the United States on May eighth, 1904. At this time, only about six hundred West Indians were working in the Cut, with a few side-excavators and trains of four-wheeled dump-cars, and an impatient call went up from the American people for their government to "make the dirt fly!" But for the next two and a half years, there was very little digging and a great deal of preparation.

Instead of hurrying thousands of laborers to the Isthmus to have them die there, as they did in the fifties and eighties, of fever and insufficient food, we cleaned house before we moved in. Clearings were made in the jungle, swamps were drained, old French houses were repaired and new ones were built. A line of steamers fitted with cold storage brought food from New York, and hotels or mess-houses served it to the men. The French hospitals at Ancon and Colon were enlarged, and the dirty little cities of Panama and Colon were cleaned and made sanitary. But though the filth was gone the fever remained.

In the same way, Havana and Santiago de Cuba, cities which old shipmasters declared they could smell ten miles
SURGEON-GENERAL WILLIAM C. GORGAS.
The Isthmus Made Healthy

to sea in an offshore breeze, had been thoroughly cleaned by our army as soon as the Spaniards evacuated Cuba in 1898, but still our soldiers had kept dying of yellow fever there. Everything that medical science could suggest was done to stop the spread of the disease, but without effect. Thousands sickened and hundreds died, while the doctors stood by, as one of them declared, "in utter perplexity and wonder."

No one knew how yellow fever was spread, though its ravages had been only too well known for two centuries and more. It had killed over thirty-six thousand people in Havana and a hundred and thirty thousand in Spain; it had swept our coast from Massachusetts to Florida, killing one person out of every ten in Philadelphia in 1793, and over forty thousand in New Orleans between then and the end of the nineteenth century. Though other diseases, notably tuberculosis, have caused and still are causing much more direct suffering and loss of life, they were less feared because they lacked the terror of the unknown. When yellow fever broke out in a city, it was as if the very Angel of Death had come, walking invisible and slaying without cause. Then followed wild stampedes, brutally checked by "shotgun quarantines," looting, debauchery, and a wide-spread paralysis of business, causing altogether a loss of life and property impossible to compute.

Two things held yellow fever in check; frost stopped it, and those that recovered from the first attack were immune for the rest of their lives. Several regiments of these "immunes" were raised during the Spanish-American War, but there were not enough of them to garrison,
all Cuba, and the disease soon broke out among the other troops sent there. Among non-immunes, and below the frost-line, what hope was there of stopping the spread of yellow fever? Only that some hero might strip this giant of his invisible coat, and, by showing what path he followed from death-bed to death-bed, enable us to guard and close it. That hero came, and in all our history there is no nobler story than that of his triumphant sacrifice.

It had long been suspected by several doctors that the germs of yellow fever were carried to fresh victims, neither by contact nor in infected clothing, but by certain species of mosquitos. Dr. Carlos Finlay, an old Havana physician, had declared this belief as early as 1883. But no one could say for certain, because yellow fever is a disease that attacks only human beings, and to make the necessary experiments there were required, not mice or guinea-pigs, but living men.

One night in July, 1900, four surgeons of the United States Army Medical Corps met in Havana, where they had been sent as a Yellow-Fever Commission, and decided that the time had come when these experiments must be made. With full knowledge of the fearful nature of the disease, these doctors agreed that before they called for others to volunteer, they would make the first experiments on their own bodies.

But one of the four, Dr. Aristides Agramonte, a Cuban, was an immune and therefore could take no part in the tests; and another, Major Walter Reed, was almost immediately recalled to Washington. The two others, Jesse William Lazear, an American, and James
Carroll, an Englishman, let themselves be bitten by mosquitoes that had sucked the blood of yellow-fever patients. The experiment was but too successful. Both took the disease, Carroll recovered, but Lazear died. "Greater love hath no man than this, that a man lay down his life for his friends."

A tablet, erected to the memory of Lazear, in Johns Hopkins Hospital at Baltimore, bears this inscription, written by President Eliot of Harvard University:

"With more than the courage and the devotion of the soldier, he risked and lost his life to show how a fearful pestilence is communicated and how its ravages may be prevented."

Volunteers were called for, that further experiments might be made, and General Leonard Wood, then military governor of Cuba, offered to pay each a reward of $200. When this was explained to the first men who came forward, two young soldiers from Ohio, John R. Kissinger and John J. Moran, both refused to accept it, declaring that they had volunteered "solely in the interest of humanity and the cause of science." Major Reed, to whom this declaration was made, rose to his feet, raised his hand to his forehead as if in the presence of his superior officer and said to these humble enlisted men, "Gentlemen, I salute you." When Major Reed told of this incident, not long afterwards, he declared, "In my opinion, this exhibition of moral courage has never been surpassed in the annals of the army of the United States."

Thanks to the skill of Major Reed, none of the thirteen men who followed the splendid example of Carroll and
Lazear lost their lives; though some permitted themselves to be bitten by infected mosquitoes and so took the fever, while their comrades entered a little room as dark and airless as the Black Hole of Calcutta, and slept there for three weeks, between blankets taken from the beds where yellow-fever patients had died. These last suffered nothing worse than discomfort, and it was conclusively proved that yellow fever is carried by the bite of a single species of mosquito; the Stegomyia fasciata, and by nothing else. This discovery, which has been truly said to be worth more than the entire cost of the Spanish War, gave the doctors something tangible to fight. Reed and Carroll drew up a complete program for protecting patients and killing off the mosquitoes, and by putting it vigorously into effect, freed Cuba from yellow fever within a year.

Among Major Reed’s assistants in Havana was Dr. William C. Gorgas, who was made chief sanitary officer of the Canal Zone shortly after the Americans came to Panama. Here he was confronted with a problem almost exactly like that which he had already seen solved in Cuba. All that was required was the intelligent and vigorous application of the principles discovered by the sacrifice of Lazear and elaborated by Carroll and Reed. Unfortunately, Dr. Gorgas was badly handicapped at the start by the failure of the United States Government to supply him with the force and funds necessary to do this.

The natural result was an outbreak of yellow fever, in Panama, in the spring and summer of 1905. Thirty-five of the American employees died, and hundreds more
fled north as fast as they could find deck-room on the crowded ships. There they filled the newspapers with panic-stricken interviews and doleful prophecies that the Canal would never be built, and fervidly quoted this well-known stanza from the works of Gilbert, the poet of Colon.

Beyond the Chagres River,
'T is said (the story's old)
Are paths that lead to mountains
Of purest virgin gold;
But 't is my firm conviction,
Whate'er the tales they tell,
That beyond the Chagres River,
All paths lead straight to Hell!

"There are three diseases in Panama," declared Mr. John L. Stevens, who became chief engineer at this time. "They are yellow fever, malaria, and cold feet; and the greatest of these is cold feet."

But now Dr. Gorgas was given his long-delayed medical supplies, his water-pipes, porch-screens, and plenty of money. Thousands of men were taken from the excavating force to swell the sanitary-squad. Best of all, the new governor of the Canal Zone—to whom the head of the Department of Sanitation was then subordinate—was Mr. Charles E. Magoon, who helped Dr. Gorgas with the greatest good-will and energy.

The first thing was to establish a rigid quarantine at both ports, to prevent new cases being brought in from other countries by sea. Every ship that came from a yellow-fever port was thoroughly fumigated to kill any infected mosquitos that might be on board, and all the
passengers were kept in a screened house, where no local mosquitos could get at them, until long after the time required for the development and discovery of any possible fever-case among them. Without sick people to bite, the mosquitos could get no germs to carry, and, contrariwise, without the Stegomyia mosquito, the germs could not be carried from one person to another. Dr. Gorgas and his little army attacked the enemy from both directions at once.

The two great strongholds of the disease were the cities of Panama and Colon. Here the sanitary control which we had obtained by treaty-right was greatly helped by the fortunate fact that the first President of the Republic of Panama was Dr. Manuel Amador Guerrero, a well-trained physician and an authority on tropical diseases. At his suggestion, native doctors were appointed sanitary inspectors, and they did their work far more tactfully and with less friction than American inspectors could possibly have done, among a Spanish-speaking population, virtually all of whom were immune to yellow fever and had no idea of sanitation. They submitted with the greatest good-nature to having their houses entered and searched for yellow-fever patients, and during the worst of the epidemic, every house in Panama City was visited every day. As soon as a new case was discovered, the sick man was carried to the hospital in a screened ambulance, and his house and those of his neighbors were tightly sealed up with strips of paper and fumigated with sulphur, after which the dead mosquitoes were carefully swept up and burned. Then detective work would begin in two different directions: watching
DR. JUAN GUITERAS
DR. JOHN R. ROSS, U.S.N.
DR. JESSE W. LAZEAR, U.S.V.
DR. JAMES CARROLL, U.S.V.
DR. CARLOS FINLAY
MAJOR WALTER REED, U.S.A
JACK R. KISSINGER
for new cases caused by mosquitos that might have bitten this man; and tracing back the source of his infec-
tion to some earlier and perhaps hitherto undiscovered case.

This would have been a well-nigh impossible task if the yellow-fever mosquito had been as strong on the wing as the more harmless species we know so well at home, most of whom can fly for miles with a favorable breeze. Fortunately, the Stegomyia is a feeble creature, usually living in or about houses, and rarely flying more than a hundred yards from its birthplace in some stagnant pool. The favorite breeding-places of these insects in Panama City were the rain-water barrels and cisterns, which were first screened and afterwards destroyed when the new waterworks were finished.

The old waterworks consisted of two or three large Spanish wells, that received most of the drainage from the graveyard, and a few carts, from which the man who owned the graveyard used to peddle this water through the streets, for five cents a gallon. It was much better for his business than for the people who drank it. The Americans stopped this, and piped in good water from a reservoir made by damming the Rio Grande. There was a great celebration on the Fourth of July, 1905., when the water was turned on in the Cathedral Plaza. The President, and the Governor, and all the other dignitaries, both Panamanian and American, attended a solemn high Mass in the cathedral, and at the elevation of the Host and the stroke of noon, the water was sent spurting into the air outside, and the Panamanian Republican Band struck up what it thought was the American national
Panama Past and Present

It was a popular tune of the period, called "Mr. Dooley"!

Sewers were laid at the same time as the water-pipes, and the big clumsy cobblestones were ground up in portable rock-crushers to make a concrete bed for the smooth new pavements of vitrified brick. Formerly, garbage of all sorts was thrown out into the streets to rot there or be eaten by the hundreds of vultures that were the only street-cleaning department. But now the streets are swept every night by gangs of negroes, employed by the Panamanian Government, under American supervision.

In sanitation as in politics, we found Panama a city of the Middle Ages. Our doctors discovered a few wretched lunatics chained to the damp walls of the seventeenth-century dungeons, hewn out of the rock beneath the sea-wall; and lepers, who lived on the beach outside the city wall, and dared not come too near, lest people call out, "Unclean! Unclean!" and stone them, exactly as they did in Old Testament times. Though these un-
fortunates had no claim on our charity, our government at once built a modern insane asylum, first at Miraflores, and later at the Ancon hospital, and moved the lepers to a very beautiful little settlement called Palo Seco. There they are so well cared for that one man, whom our army doctors cured of a slight case of the disease, begged to be allowed to stay in that place for the rest of his life, and was made a hospital orderly there.

Driven out of the two cities, the harried Stegomyia found no refuge in the Canal Zone. There Dr. Gorgas's men cut down hundreds of acres of sheltering brush and high grass, dug miles of drainage ditches and covered all undrained pools and swamps with heavy oil that killed the mosquito larvae whenever they came to the surface to breathe. Holes were blown in old French dump-cars to keep them from holding water. To throw an empty tin can where it might become a breeding-place for mosquitoes was made a finable offense.

The epidemic of 1905 came to an end in September and the panic stopped with it. The last case of yellow fever on the Isthmus was in November, 1906. To-day, the Stegomyia mosquito is virtually extinct there, and so long as it is kept down and all foreign cases of the disease kept out, there will never be any more danger of an epidemic of yellow fever at Panama than at the North Pole. There is still a certain amount of "Chagres fever," which is nothing more or less than malaria. For the Anopheles mosquito, that carries the germ of this disease—a fact discovered by Dr. Ronald Ross of the British Army, in India in 1898—is a much stronger and harder insect than the Stegomyia, and it is almost im-
possible to destroy it completely, especially round the smaller construction camps in the jungle. But there is much less malaria in Panama than in most parts of the United States.

One of the greatest and least-known triumphs of Dr. Gorgas and his organization was keeping the Isthmus free from the bubonic plague, at a time when this terrible disease, the "Black Death" that swept through Europe in the fourteenth century, was raging in the other Pacific ports both north and south of Panama. There it was confined to the three original cases brought in by sea, all of which proved fatal. This disease is carried, not by mosquitos, but by fleas, that travel on the backs of rats. A reward of ten cents was promptly offered for every rat tail brought in, and the rat is now a very scarce animal in Panama.

Dr. Gorgas was promoted to the rank of colonel in the United States Army Medical Corps, and made a member of the Isthmian Canal Commission in 1907. Though he has turned Panama from a pest-hole into a health resort, there is still no lack of work there for him and for those who will come after him, for only by constant vigilance and costly sanitation can large bodies of Northern white men be kept healthy in the tropics. Moreover, if yellow fever or any other dangerous disease were ever again allowed to break out there, after Panama has become one of the great highways of the world, the Canal might easily prove as great a curse to humanity as it promises to be a blessing, for then ships would carry the sickness all too swiftly to all parts of the earth.

1 He was appointed Surgeon-General of the United States Army, January 16, 1914.
Few physicians have ever had laid upon them a heavier burden or a more sacred trust than that of the chief sanitary officer of the Canal Zone, and all the world knows how well General Gorgas has discharged it. His name will go down in history as that of the man who freed the Isthmus from its most terrible enemy.

But General Gorgas would be the last man to deny that if it had not been for the work of his old chief and associates in Cuba in 1900-01, neither he nor any other man would have known how to fight yellow fever on the Isthmus in 1905. And if ever a fitting monument is raised, either in Panama or in the United States, to celebrate the building of the Canal and the victory of mankind over yellow fever, there should be graven high upon it the names of Reed and Carroll and Lazear.
CHAPTER XIII

HOW WE ARE BUILDING THE CANAL

To give a complete history of the building of the Canal, from the arrival of the first American steam-shovel to the final merging of the construction into the operating force, would take a library of little books like this. The best I can hope for is to give the reader some slight idea of what we might have seen, had we crossed the Isthmus together, in the days of the canal-builders. Let us imagine that we are taking such a trip.

As we steam into Limon Bay, after a two-thousand-mile voyage from New York, you will notice the long breakwater that is being built out from Toro Point, to make this a safe harbor, and also to keep storms and tides from washing the mud back into the four miles of canal that run under the sea to deep water. Down this channel comes something that looks like a very fat ocean steamer, and when it reaches the end it rises several feet in the water, turns round, and waddles back again. This is the sea-going dredge Caribbean, busy sucking up the bottom into its insides, and carrying it away. This craft is painted white, with a buff super-

1 The greater part of this chapter originally appeared in St. Nicholas, in February, 1912, and no better time could have been chosen for a trip to Panama, either in the flesh or in print. Then the great work, though so near completion that it was possible to see in it the finished design, was still being pushed with undiminished vigor.
How We Are Building the Canal

structure, as our warships used to be, and when it first came to the Isthmus, the quarantine officer put on his best suit of white duck, and went out to take breakfast on board the "battleship." Many other smaller dredges are dipping up rock into barges or pumping mud through long pipes to the land, all the way to the shore, and up the four miles of sea-level canal to where the Gatun Locks loom in the distance. All this you can see as we cross the bay to the ugly town of Colon, and its pretty suburb of Cristobal, which last is in the American Canal Zone, and the place where the steamers dock.

Now that you have seen what these dredges can do, you will ask me why we do not dig the rest of the Canal that way, instead of bothering with locks and dams, and I can give you the answer in five words: because of the Chagres River. This troublesome stream, as you can see by the map on page 4, comes down from the San Blas hills, strikes the line of the Canal at a place called "Bas Obispo," and zigzags across it to Gatun. And though we can dredge a channel up to Gatun, or scoop out the Gaillard Cut, which is an artificial cañon nine miles long through the hills between Bas Obispo and Pedro Miguel, on the Pacific side of the divide, we could not dig below the bed of the Chagres without having a lot of waterfalls pouring into the Canal, washing down the banks and silting up the channel. And as the Chagres is a sizable river that has been known to rise more than twenty-five feet in a night — for the rainfall at Panama is very severe — you can see that it is no easy problem to control it. But we have solved that problem by means of the Gatun Dam.
At Gatun, the valley of the Chagres is only about a mile and a quarter wide, and by closing the gap between the hills on either side with an artificial hill — for that is what the Gatun Dam really is — we accomplish two things: first, by backing up the river behind the dam, we form a deep lake that will float our ships up against the side of the hills at Bas Obispo, and make so much less digging in the Gaillard Cut; and, second, a flood that would cause a rise of twenty-five feet in the river would not cause one of a quarter of an inch in the big lake, that will have an area of nearly two hundred square miles.

In building the dam that is to hold back all this water, two trestles were driven across the valley, and from them were dumped many train-loads of hard rock from the Gaillard Cut, to form what the engineers call the "toes" of the dam. To fill the space between them, dredges pump in muddy water that filters away between the cracks of the toes, leaving the sediment it carried to settle and form a solid core of hard-packed clay, over a quarter of a mile thick. When the dam is finished, the side toward the lake will be thoroughly riprapped with stone to prevent washing by the waves, and so gentle will be the slope that you could ride over it on a bicycle without rising on the pedals.

To keep the water from running over the top of the dam, the engineers have cut a new channel for the Chagres through a natural hill of rock that stands in the center of the valley, and this, lined with concrete and fitted with regulating works, is what they call the "spillway." When the dam is finished, the spillway will be
FINISHED SECTION OF GAILLARD CUT, AT BAS OBISPO.

The water in the drainage ditch is four feet below the level of the completed canal.
Gatun Dam, Spillway and Locks.

From Official Handbook.
closed, and then the tremendously heavy rainfall — from ten to fifteen feet a year — will fill the lake in less than a twelvemonth. All the surplus water will run off through the spillway, and as it runs it will pass through turbines and turn dynamos to generate electricity for operating the machinery of the Gatun Locks that will lift ships over the dam.

These locks are in pairs, like the two tracks of a railroad, so that ships can go up and down at the same time; three pairs, like a double stairway, of great concrete tanks each big enough for a ship a thousand feet long, a hundred and ten feet wide, and forty-two feet deep to float in it like a toy boat in a bath-tub. You can get some idea of their size when you remember that the Titanic was only eight hundred and fifty-two feet long. Or, to put it another way: every one of these six locks (and there are six more on the Pacific side) contains more concrete than there is stone in the biggest pyramid in Egypt.¹ The American people have been able to do more in half a dozen years than the Pharaohs in a century, for our machinery has given us the power of many myriads of slaves.

And wonderful machinery it is at Gatun, both human and mechanical. It is not easy for a visitor, standing on one of the lock walls — which, as you can see from the diagram, is as high as a six-story house — and looking down into the swarming, clanging lock-pits, to see any system, but if he look closely, he can trace its main

¹ In the construction of the locks, it is estimated that there will be used approximately four million, two hundred thousand cubic yards of concrete, requiring about the same number of barrels of cement. — Official Handbook of the Panama Canal.
GATUN LOCKS.
Steel form for casting a section of the square centre wall.
outlines. Up the straight four-mile channel from Limon Bay come many barges, towed either by sturdy sea-going tugs or an outlandish-looking, stern-wheel steamer called the *Exotic*. Some of these barges are laden with Portland cement from the United States, others with sand from the beaches of Nombre de Dios, or crushed stone from the quarries of Porto Bello. (For both of these old Spanish ports are now alive again, helping in the building of the Canal, and every now and then one of our dredges strikes the hull of a sunken galleon, or brings up cannon-balls or pieces-of-eight.)

1 See Appendix.
these barges are snatched up by giant unloader-crane
s and put into storehouses, out of which, like chicks from
a brooder, run intelligent little electric cars that need no
motormen, but climb of themselves up into the top story
of the dusty mixing-house. Here, eight huge rotary
mixers churn the three elements, cement, sand, and stone,
into concrete, and drop it wetly into great skips or
buckets, two of which sit on each car of a somewhat
larger-sized system of electric trains, whose tracks run
along one side of the lock-pits. Presently those skips
rise in the air and go sailing across the lock-pit in the
grip of a carrier traveling on a steel cable stretched be-
tween two of the tall skeleton towers that stand on either
side of the lock-site. When the skip is squarely above
the one of the high steel molds it is to help fill, it is tilted
up, and there is so much more concrete in place.

When the last cubic yard has been set, the gates hung,
and the water turned in, a ship coming from the Atlantic
will stop in the forebay or vestibule of the lowest right-
hand locks, and make fast to electric towing-locomotives
running along the top of the lock-walls. No vessel will
be allowed to enter a lock under her own power, for fear
of her ramming a gate and letting the water out, as a
steamer did a few years ago in the "Soo" Locks, be-
tween Lake Huron and Lake Superior. Every possible
precaution has been taken to prevent such an accident at
Gatun. Any ship that tried to steam into one of the
locks there, for any reason whatsoever, would first have
to carry away a heavy steel chain, that will always be
raised from the bottom as a vessel approaches, and never
lowered until she has come to a full stop. Then the
PEDRO MIGUEL LOCKS.
Arches for carrying the touring locomotive tracks from level to level.
runaway ship would crash, not into the gates that hold back the water, but a pair of massive "Guard gates," placed below the others for this very purpose.

"The lock gates will be steel structures seven feet thick, sixty-five feet long, and from forty-seven to eighty-two high. They will weigh from three hundred to six hundred tons each. Ninety-two leaves will be required for the entire Canal, the total weighing fifty-seven thousand tons. Intermediate gates will be used in the locks, in order to save water and time, if desired, in locking small vessels through, the gates being so placed as to divide the locks into chambers six hundred and four hundred feet long, respectively. Ninety-five per
cent. of the vessels navigating the high seas are less than six hundred feet long." ¹

You will notice that each leaf of a pair of these gates is sixty-five feet long, instead of fifty-five or half the width of a lock. When they are closed, they form a blunt wedge pointing upstream, and the pressure of the water only keeps them tighter shut. Finally, if all the gates were swept away, there would still remain the "emergency dam" at the head of each flight of locks, ready to be swung round and dropped into position like a portcullis.

Once a ship is inside, the lower gates will be closed behind her by machinery hidden in the square center-pier, valves will be opened, and water from the lake will rush down the conduits in the walls and flow quietly in from below, until it has reached the level of the lock above. Then the upper gates will open, and the electric locomotives,—there will be four of them to handle every big ship, one at each corner,—will go clicking and scrambling up the cog-tracks carried on broad, graceful arches

¹ Official Handbook.
from level to level, and then pull the ship through after them. In like manner will she pass through the two upper locks, and out on the wide waters of Gatun Lake, eighty-five feet above the level of the sea.

The average time of filling and emptying a lock will be about fifteen minutes, without opening the valves so suddenly as to create disturbing currents in the locks or approaches. The time required to pass a vessel through all the locks is estimated at three hours; one hour and a half in the three locks at Gatun, and about the same time in the three locks on the Pacific side. The time of passage of a vessel through the entire canal (about fifty miles from deep water in one ocean to deep water in the other; forty from beach to beach), is estimated as ranging from ten to twelve hours, according to the size of the ship, and the rate of speed at which it can travel.”

The time spent by a ship in the locks at Panama will be more than made up by the much greater ease and speed with which she will be able to navigate the rest of the Canal there, as compared with that at Suez, where steamers must crawl at a snail’s pace, or the wash from their propellors will bring down the sandy banks; and two large liners cannot meet and pass without one of them having to stop and tie up to the shore. At no place on the Panama Canal will this be necessary, for even at its narrowest part—the nine miles through the Gaillard Cut—the channel will be three hundred feet wide at the bottom, giving plenty of elbow-room for the largest ships, and lined with concrete where it is not hewn out of solid rock. The under-water and sea-level sections

1 Official Handbook.
at either entrance will be five hundred feet wide, and through the greater part of the Gatun Lake, a ship will steam at full speed down a magnificent channel one thousand feet broad, with no more danger of washing the banks than if she were in the middle of the lower Amazon.

To help night navigation, there will be long rows of acetylene buoys, so ingeniously made that the difference of a few degrees of heat regularly caused on the Isthmus by the rising and setting of the sun, will serve to turn their light off and on, by expanding and contracting a little copper rod. This device, invented by one of the American canal employees, has been thoroughly tested, and found to work perfectly. Everywhere trim little concrete lighthouses, looking strange enough in the jungle, are being built, or, rather, cast in one piece, on wooded hilltops that will soon be islands.

Already the yellow water is rapidly backing up, as the dam and the spillway gates are being raised. You can mark the spread of the lake by the gray of the dying, drowned-out trees against the green of the living jungle. Only in the channel and the anchorage basin has Gatun Lake been cleared of timber, and the greater part of it will be a mass of stumps and snags. The centuries-old trade-route down the Chagres has been wiped out, and more than a dozen little towns and villages, Ahorca Lagarto, Frijoles, San Pablo, Matachin,¹ have been moved to new sites on higher ground. It was not easy to make the natives believe that these places that had been inhabited for hundreds of years would soon be un-

¹ See Appendix.
der forty feet of water. Some thought the Americans were prophesying a second deluge. “Ah, no, Señores,” protested one old Spaniard, “the good God destroyed the world that way once, but He will never do so again.”

The Panama Railroad, too, has been relocated for its entire length, except for two miles or so out of Panama City, and a little over four miles between Colon and Gatun. Both the former station and the old village at Gatun (which is the place where Morgan’s bucanneers and the Forty-niners, and all the other travelers up-river spent the first night) are now buried under the huge mass of the Gatun Dam. The former line of the Panama Railroad through the lake-bed, though double-tracked and modernized only a few years ago, has been completely abandoned. The new, permanent, single-track road swings to the east at Gatun, and runs on high ground round the shore of the lake to a bridge across the Chagres at Gamboa, a little above Bas Obispo. It was originally planned that the railroad should run from here through the Gaillard Cut on a “berm” or shelf, ten feet above the surface of the water, but the many slides caused this to be abandoned, and the line was built through the hills on the eastern side of the Cut. At Miraflores it runs through the only tunnel on the Isthmus. Because of the very heavy cuts and fills, the relocation of the Panama Railroad has cost $9,000,000, or $1,000,000 more than building the original road, although the new line is about a mile shorter. It is very solidly built, with steel bridges, concrete culverts, steel telegraph poles, made of lengths of old French rails bolted together and set up on end, and embankments
filled with several million cubic yards of rock from the Cut.

Only a little rock was taken out of the Gaillard Cut by the French, most of their digging being what the engineers call "soft-ground work." But the deeper part of the great nine-mile trench, which they left for the Americans to dig, is almost entirely a "hard-rock job." From Bas Obispo to Pedro Miguel (which every American on the Isthmus calls "Peter Magill") it must be hewn and blasted out of solid stone. Row above row of steam or compressed-air drills are boring deep holes in the terraces beneath them, and gangs of men are kept busy filling these holes with dynamite. As much as twenty-six tons were used in one blast, when an entire hillside was blown to pieces, and twice every day, when the men have left the Cut for lunch or to go home, hundreds of reports go rattling off like a bombardment.

Then they move up the great steam-shovels to dig out the shattered rock with their sharp-toothed steel "dippers" that can pick up five cubic yards or eight tons, at a time. Think how bulky a ton of coal looks in the cellar, and then imagine eight times that much being lifted in the air, swung across a railroad track, and dropped on a flat-car, as easily as a grocer's clerk would scoop up a pound of sugar and pour it into a paper bag. Boulders too large to handle conveniently are broken up with "dobey shots," small charges of dynamite stuck into crevices, and tamped down with adobe clay. So skillful are the steam-shovel men (all Americans), that they will make one of their huge machines pick up a little pebble rolling down the side of the Cut as easily as
you could with your hand; and every one of them is racing the others, and trying to beat the last man’s record for a day’s excavation. The present record was made on March twenty-second, 1910, when four thousand, eight hundred and twenty-three cubic yards of rock, or eight thousand, three hundred and ninety-five tons were excavated in eight hours by one machine. There are one hundred of these steam-shovels on the Isthmus, and more than fifty of them in the Gaillard Cut, and to see them all puffing and rooting together, more like a herd of living monsters than a collection of machinery, is one of the most wonderful spectacles in the world.

Sometimes steam-shovels will be caught and buried by a “slide,” an avalanche of rock or a river of mud brought down by some weakness in the banks. Wrecking trains and powerful railroad-cranes are always kept ready to go to their rescue. The worst place is across the Cut from the town of Culebra, where forty-seven acres of hillside are crawling down like a glacier. This is the famous Cucaracha Slide, that began to trouble the French as long ago as 1884; and though two million cubic yards of it have been dug away, there is half as much more to come. Altogether, this slide and the twenty others will have brought twenty million cubic yards of extra material to be taken out of the Cut, by the time the Canal is finished. But our engineers have learned how to stop them, by cutting away the weight at the top of each slide, and that, and the pressure of the water in the finished canal, should keep the banks at rest.

To carry away the rock and earth dug out by the steam-shovels, there is an elaborate railroad system of
several hundred miles of track, so ingeniously arranged that the loaded trains travel down-grade and only empty cars have to be hauled up hill. Much rock is used on the Gatun Dam, and also on the breakwaters at either end of the Canal, but most of the material excavated from the Cut is disposed of by filling up swamps and valleys. Every dirt-train (they would call it that on the Isthmus even if it carried nothing but lumps of rock as big as grand pianos), travels an average distance of ten miles to the dumps and has the right of way over passenger trains, specials, and even mail trains. Only for the President of the United States has the line ever been cleared.

At the dumping-ground, each dirt-train is run out on a trestle, and unloaded in one of two ways. If it is composed of steel dump-cars, they are tipped up either by hand or compressed air. Most of the trains, however, are of big wooden flat-cars, raised on one side, and connected by steel flaps or "aprons," so that a heavy steel wedge, like a snow-plow, can be drawn from one end of the train to the other by a windlass and cable, thus clearing all the cars in a jiffy. (It is great fun to ride on the big wedge when they are "plowing-off.") When the dirt begins to rise above the edge of the trestle, a locomotive pushes up a machine called the "spreader," that smooths it out into a level embankment, and then another machine, the "track-shifter," picks up the ties and rails bodily, and swings them over to the edge of the new ground. Each of these machines does the work of hundreds of laborers.

Two large machine shops, now at Gorgona and Em-
LIDGERWOOD FLATS BEING UNLOADED
Balboa Dumps, low tide, March, 1908.

A SPREADER
Balboa Dumps, low tide, March, 1908.
How We Are Building the Canal

pire, but soon to be moved to Balboa, at the Pacific end of the Canal, are kept busy assembling new machinery brought down from the United States, and repairing the worn parts of the steam-shovels, the hundreds of locomotives and thousands of cars. At Mount Hope, near Colon, is a shipyard for the tugs and dredges of the Atlantic division, and a huge general storage yard and warehouse for everything from a ten-ton casting for a lock-gate to a box of thumb-tacks for fastening a blueprint of that gate to a drawing-board. Every necessary article is there and in its proper place; and the same is
true of the tool-box of the smallest switch-engine. From the top to the bottom there is neither skimping nor waste, but an efficiency like that of a Japanese army in the field.

At Pedro Miguel a ship from the Atlantic will begin the descent on the other side of the divide. The locks on the Pacific side are exactly like those at Gatun, except that instead of having all three pairs together, there is one pair here and two at Miraflores, with a little lake between. From Miraflores, the Canal is being dredged out at sea-level to its Pacific terminus at Balboa, where there will be great docks and warehouses and shipyards on land that has been made by filling in tidal marshes with dirt from the Gaillard Cut. As on the Atlantic side, the Canal will run four miles out under the sea to deep water; and to protect it from storms, a breakwater is being built from the shore to Naos Island, in the Bay of Panama. It is both strange and appropriate that the Panama Canal should have one of its entrances at this island, whose name, the Spanish word for "ship," reminds us that three hundred and fifty years ago it was the port of the city of Old Panama.