As one travels along the Pacific end of the canal he is reminded of the words of Isaiah:

"Every valley shall be exalted, and every mountain and hill shall be made low; and the uneven shall be made level, and the rough places a plain."

Hundreds of acres of low, marshy land have been filled up, either with mud from the suction dredges and the hydraulic excavators, or with spoil from Culebra Cut. Much of this made land will be valuable for tropical agriculture, while other parts will never serve any purpose other than to keep down the marshes. But they afforded a dumping ground for material taken out of the canal prism, and added something to the improvement of health and living conditions on the Isthmus.

Probably the most interesting process of excavation in the sea-level channels was that of the sea-going suction dredges. These dredges took out material more cheaply than any other kind of excavating machinery used on the Isthmus. Two of them were put to work in 1908, about the time the operations reached full-blast and have been kept in commission ever since. While it cost as much as $70,000 a year to keep each one in commission, they were able to maintain an annual average of about 5,000,000 cubic yards of material excavated at a cost per yard of 5 cents and even less. With steam shovels it ranged from 10 to 20 times as much per yard. These big dredges were built with great bins in their holds and equipped
with powerful 20-inch centrifugal pumps. When at work they steamed up and down the channel, sucking up the mud, and carrying it out to sea.

Another interesting dredge used was the big ladder dredge Corozal. It is a great floating dock, as it were, with a huge endless chain carrying 52 immense, 35-cubic-foot buckets. On the center line amidships there is a large opening down to the water. The big elevator framework carrying the endless chain goes down through this and into the water at a considerable angle. The buckets pass around this, and as they round the end of it their great steel lips dig down into the material until filled, then they come up at the rate of three every five seconds and deposit their burden in a huge hopper which conveys it to the barge at the side of the dredge. The dredge is anchored fast at a given place, and keeps on attacking the material beneath it until the desired level is reached. This dredge, with the sea-going suction dredges, will be retained as the permanent dredging fleet. The stationary suction dredges at the two ends of the canal were used to pump up the soft material and to force it out through long pipe lines into the swamps or into the hydraulic cores of the earth dams.

Several old French ladder dredges were rescued from the jungle and put into commission at the beginning of the work, and they held out faithfully to the end, dividing honors with the newer equipment in hastening the day when the oceans might go inland to Gatun and Miraflores. While they looked like toys beside such giant excavators as the Corozal, they probably showed more
THE Corozal AND ITS METHOD OF ATTACK
efficiency than any other class of excavators of their period of construction. They were attended by large self-propelling scows built by the French. When these were filled they steamed out to sea and dumped their burden and then steamed back again for another load. Some of the dredges were attended by ordinary barges which were towed out to sea by tugs and dumped.

Another interesting machine used on the Pacific end of the canal was the Lobnitz rock breaker. This consists of a sort of pile driver mounted on a large barge. Instead of a pile driving weight there is a big battering ram made of round steel, pointed at one end. It is lifted up perhaps 10 feet and allowed to drop suddenly. As some of these rams weigh as much as 25 tons their striking force may be imagined. When the ram struck the rock the top would shake back and forth like a bamboo pole, in spite of the fact that it was made of the best steel and more than 15 inches in diameter. Sooner or later the rams would break off at the water line, this being due to the fact that the constant flexion at that point set the molecules in the steel and took away all its elasticity.

It was found desirable to excavate a part of the sea-level channel before the water was let into it. To accomplish this a big dam, or dike, was built across the channel several miles inland, and steam shovels were used behind this dike. As the work neared completion, however, it was found advisable to let the water come further inland, so that the dredges could extend the field of their activities. To do this another dike was thrown across the channel about a mile north of the first one,
and water was admitted to the section of the big ditch between these two dikes. The engineers were afraid to cut a small ditch in the top of the first dike, and allow the water to eat the dam away as it flowed in, for fear that it would rush in so rapidly it would destroy the second dike. Therefore they filled the basin between the two dikes by siphon and by pumping, a process which required the drawing in of billions of gallons of water. This was accomplished in due time, however, and then 16 tons of dynamite was placed in the no longer useful dike. An electric spark did the rest.

The distinguishing features of the ends of the canal are the big breakwaters at Toro Point, at the Atlantic end, and Naos Island, at the Pacific end. The former extends from the shore out into the sea for a distance of 2 miles and has a large lighthouse at the seaward end. It was built by dumping stone from the shore out into the sea, this process being followed by driving piles into the dumped stone and building a railroad on the crest, over which the stone was hauled for its further extension. The top of the breakwater is covered with huge stones weighing from 8 to 20 tons each, these to make sure that it will stand against the pounding of the waves. Two minor breakwaters were also built at the Atlantic end to protect the terminal basin.

The big dike at Naos Island in the Pacific is more than 17,000 feet long and transforms the island into the cape of a small peninsula. There was a threefold purpose in its construction — to cut out the cross currents that brought thousands
of yards of sand and silt into the canal channel, to afford a dumping place for a large quantity of the spoil from Culebra Cut, and to make a connection with the mainland for the fortifications on Naos, Flamenco, and Perico Islands. In building it the engineers were under the necessity of first building a trestle on which the spoil trains could be backed and dumped. The piles had to be driven in soft, blue mud, and as the rock was dumped, it sank down and down until, at places, ten times as much stone was required as would have been necessary if the ocean bottom had been firm. In addition to this thousands of trainloads of material were dumped in the landward end of the dike, some 20,000,000 cubic yards of material being thus disposed of.

The last part of the canal work to be completed will be the terminal facilities at the ends of the big waterway. At the time this book went to press they were something more than a year from completion, but the indications were that they would be finished within the time limit originally set for the completion of the canal itself. These terminal facilities consist of dry docks, wharfage space, storehouses, and everything else necessary to perform any service that might ordinarily be required for passing ships, whether they be those of commerce or of war. The main coaling station is to be established at the Atlantic end. The storehouses, the laundry, the bakery, and the other equipment of the Isthmian Canal Commission and the Panama Railroad also will be made a part of the permanent terminal plant on that side of the Isthmus.
A large dry dock is being built at the Pacific end having the same usable dimensions as the canal locks, capable of accommodating any vessel that can pass through the canal. The principal machine shops will also be erected there, and a coaling plant of half the capacity of the one at the Atlantic end will be provided. A little to the east of the Pacific terminal works will be stationed the capital of the Canal Zone, where the administrative offices, the governor's residence, and two new towns will be built. The administration building, which is to be a three-story structure of concrete, hollow tile, and structural steel, is to occupy an eminence on the side of Ancon Hill, which will afford a splendid view of the Pacific fortifications, the entrance to the canal channel, a part of the port works, and of the canal itself from the great continental divide to the Pacific.

There one may sit and see ships coming into the canal, tying up at the docks, sailing up the big ditch, and passing through the locks at Miraflores and Pedro Miguel. Near by will be the permanent home of the marines who will be stationed on the Isthmus, their barracks and grounds occupying the broad plateau on the side of Ancon Hill made by taking out the millions of cubic yards of stone required for the concrete works on the Pacific side of the Isthmus. Two permanent towns will be built at Balboa, one for the Americans and the other for the common laborers. The American town will be built under the capitol hill on a broad plain that was made by pumping hydraulic material into a swamp and by dumping spoil from Culebra Cut.
When the terminal plant at Balboa is completed it will represent probably the most extensive and adequate port works in the New World. In addition to the main dry dock it will have a second one which will be smaller, but which will be large enough to accommodate a majority of the ships that will pass through the canal. The existing dry dock at the Atlantic end will be continued in service.

It is certain that none of these port works will ever fail by reason of insecure foundations. Whenever unusual loads were to be carried great piers of reinforced concrete were sent down to solid rock, often a distance of 60 feet below the surface. They consisted of a hollow shell of reinforced concrete which was allowed to sink to hardpan of its own accord or under heavy weight. These shells were built in sections 6 feet high. The bottom section was 10 feet in diameter, and the lower end was equipped with a sharp steel shoe. As the section cut down into the earth of its own weight and that above it, laborers on the inside removed the material under the shoe and as they did so it sank further down. The sections above were only 8 feet in diameter, and did not quite fill up the hole made by the bottom of the section, thus overcoming all skin friction, and permitting the full weight of the series of sections to fall on the lower one. A jet of water was forced around the sinking pier all the time it was going down, and this made its progress the more easy. At times the weight of the superimposed sections was sufficient to force the pier down through the soft mud, while at other times the material became so
heavy that even a 25-ton weight on top of the pier scarcely moved it. At one place a stratum of material was struck about 25 feet below the surface which yielded sulphuretted hydrogen gas. This affected the laborers' eyes, and some of them had to go to the hospital for treatment. The work of digging out the material was continued until the lower section reached bed rock, where it was anchored. The sections themselves were tied together with heavy iron rods. After they were firmly in place the interior was filled up with concrete, itself reinforced, so that the foundations became, in reality, a series of huge concrete piles, 8 feet in diameter, anchored to bed rock.

The coaling plants at the two terminals will be the crowning features of the terminal facilities. With an immense storage capacity, and with every possible facility for the rapid handling of coal, both in shipping and unshipping it, no other canal in the world will be so well equipped. The coal storage basin at the Atlantic end will hold nearly 300,000 tons. This basin will be built of reinforced concrete, and will permit the flooding of the coal pile so that one-half of it will be stored under water for war purposes. It is said that deterioration in coal is not as great in subaqueous storage, and at the same time the pile is less subject to fire. The plant will be able to discharge a thousand tons of coal an hour and to load 2,000 tons an hour. Ships will not go alongside the wharves to be coaled, but will lie out in the ship basin and be coaled from barges with reloader outfits. Special efforts have been made to provide for the quick loading of colliers in case of war. The coal
handling plant at the Pacific entrance will have a normal capacity of 135,000 tons and will be able to handle half as much coal in a given time as the one at the Atlantic end.

There will be big supply depots where ships can get any kind of stores they need from a few buckets of white lead to an anchor or a hawser; a laundry in which a ship’s wash can be accepted at the hour it begins its transit of the canal, for delivery by railroad at the other end before it is ready to resume its ocean journey; an ice plant which will replenish the cold storage compartments of ships lacking such facilities. In short, it is proposed to attempt to do everything that may be done to make more attractive the bid of the canal for its share of business.
CHAPTER VIII

THE PANAMA RAILROAD

WHEN the United States acquired the properties of the new French Canal Company, it found itself in the possession of a railroad for which it had allowed the canal company $7,000,000. This road, in the high tide of its history, had proved a bonanza for its stockholders, and during the 43 years between 1855 and 1898 it showed net profits five times as great as the original cost of its construction.

When the United States took over the road, someone described it as being merely "two streaks of rust and a right of way." While the Panama road, as acquired by the United States in its purchase of the assets of the new French Canal Company, might have been all that this phrase implies, it was none the less as great a bargain as was ever bought by any Government, and probably the greatest bargain ever sold in the shape of a railroad. It was not the rolling stock that was valuable, nor yet the road itself; the real value was to be found in the possibilities of the concession. Not only was this road destined to render to the United States a service in the building of the Panama Canal, worth to Uncle Sam a great many times more than its cost, but it was also destined to yield a net profit from its commercial
operations which in 10 years would amount to double the price paid for it. Since the Americans took it over it has been yielding net returns ranging from a million and a quarter to a million and three-quarters dollars a year. In these 10 years it has brought an aggregate profit of some $15,000,000 into the coffers of the United States.

While $7,000,000 may have been a high price, judged from the standpoint of the physical value of the road, it was a very reasonable one, indeed, as compared with the price paid for it by the new French Canal Company. This company, which sold it to the United States for $7,000,000, paid the Panama Railroad Company $18,000,000 for it 23 years before. When the French Canal Company decided to undertake the building of the canal, it found that the Panama Railroad Company held concessions that were absolutely necessary to the construction of the canal. The Colombian Government had granted the company the concession to complete the road in 1849, and had agreed that no other interoceanic communication should be opened without the consent of the railroad. This gave to the railroad company the whip hand in trading with the canal company and it was able to name its own price.

When the United States wanted to buy the rights and properties of the new French Canal Company the shoe was on the other foot. There was only one buyer — the United States; and it could choose between the Panama and Nicaragua routes. If the United States did not buy the property its principal value would have been what it was worth as an uncertain prospect that at
some future time a second Isthmian canal might be built. That is why the United States was able to buy from the French for $7,000,000 property that they had bought for $13,000,000.

After the United States acquired possession of the railroad, one change after another took place — now in the location, now in the rolling stock, now in directorate, and again in location — until almost all that remained of the original road was its name. It is now built almost every foot of the distance on a new location, and the permanent Panama Railroad is a thoroughly modern, well-ballasted, heavy-galeted, block-signal operated line of railway, built along the east bank of the Panama Canal from the Atlantic to the Pacific. Nearly half of the old right of way lies on the bottom of Lake Gatun, while the new line skirts that artificial body of water along its eastern shore, at places crossing its outlying arms over big bridges and heavy trestles. The construction of this new line was attended with much difficulty and probably no other road in the world has such a great percentage of fills and embankments in proportion to its length. One embankment, a mile and a quarter long and 82 feet high, required upward of 2,500,000 yards of material for its construction. The road is built about 10 feet above the water’s edge, and more than 12,000,000 cubic yards of material was required to make the fills necessary to carry the road bed at this elevation.

When the United States took over the French property it was decided that the canal work and the railroad operations should be maintained as distinct activities. It was agreed that the Canal
Commission should have the right to haul its
dirt trains over the Panama Railroad, and in
compensation therefor the commission undertook
to build a new road to take the place of the old
line, which was in the way of the completion of
the canal.

The work of relocating the road was undertaken
early in the construction of the canal in order that
it might be completed by the time the old road
had to be abandoned. It was built at a cost of
approximately $9,000,000, or close to $170,000
a mile. It is interesting to note that the cost of
this thoroughly modern railroad was only about a
million dollars more than the cost of the first
Panama road which has been built with rather less
than usual attention to grades, and with small rails
and light bridges. The relocated Panama Rail-
road was turned over to the railroad company in
1912.

How good a bargain the United States secured
when it acquired the Panama Railroad is shown
by the fact that during the 10 years of canal work
the net earnings of the railroad company have
reimbursed the United States for the cost of the
old road and the construction of the new one, to
say nothing of the invaluable aid rendered in the
building of the canal.

The relations existing between the Isthmian
Canal Commission and the Panama Railroad
Company during the years of the construction of
the canal were somewhat peculiar. The Panama
Railroad Company is as much the property of the
United States as the canal itself, yet the books of
the two organizations were kept as carefully sep-
arate and distinct as though they were under entirely different ownership. The Panama Railroad Company, being a chartered corporation, under the terms of its ownership could engage in commercial business with all of the facility of a private corporation. Money received by the Isthmian Canal Commission from outside sources had to be covered into the treasury and reappropriated for distinct and special purposes. On the other hand, the railroad company could use its money over and over again without turning it back into the treasury. This advantage of operation was a useful one in conducting the road itself, and also in the construction of the canal.

There was another reason which led the canal authorities to advocate the maintenance of the two organizations as separate entities. This had to do with the concession rights. Under the terms of the concession of the railroad company the property was to revert to the Republic of Colombia in 1967, or at any earlier date should the company cease to exist as such. While most authorities agree that with the secession of Panama and the setting up of the new Government all of Colombia’s rights in the railroad company passed with the territory, and while the treaty between the United States and the Republic of Panama expressly provides that the United States shall have “absolute title—free from every present or reversionary interest or claim” in the railroad, the Republic of Colombia contends that it possesses some rights with reference to the railroad and, not desiring to complicate matters, the canal authorities thought it best to live up to the letter
of the treaty, in spite of Panama’s express grant of title free from reversionary interest or claim.

While it was deemed desirable to have the Panama Railroad operated as a separate organization, it was equally important that it should be operated in a way that its interests always would be subordinate to those of the canal. It was decided that the best way to accomplish this was to make the chairman and chief engineer of the Canal Commission the president of the railroad company, and the members of the commission its directors. The stock of the company is held in the name of the Secretary of War, with the exception of a few shares held by the directors to entitle them to membership on the board. There are also a few directors chosen from other parts of the Government service, but their activities are purely perfunctory.

In addition to the railroad, the Panama Railroad Company also operates a steamship line between New York and Colon. This line was acquired with other properties of the new French Canal Company as a part of the Panama Railroad’s holdings. There were only a few years during the construction period when this steamship line did not show a loss. But the advantages of having a steamship line for carrying the supplies of the canal were so great, because of the special facilities that could be provided, that the loss was more than compensated by them. During the year 1912 the cost of operating this steamship line was $305,000 greater than the revenues derived from its operation. But, at the same time there was a return of net earnings by the Panama Railroad
of over $2,000,000, at least a part of which was made possible by the operation of the steamship line. Even after deducting the losses sustained in the operation of the steamship company there was a net profit of more than $1,700,000, which, for a railroad of less than 50 miles in length, is no small item.

As a matter of fact, Government ownership of railways as applied at Panama is remarkably successful from the standpoint of the Government, and partially so to the patrons of the railroad. Probably no railroad in the United States could show net earnings per mile of line anywhere comparable with those of the Panama Railroad.

The rates for passengers and baggage across the Isthmus were rather high for first-class passengers, the fare for the 48-mile trip being $2.40, or 5 cents a mile. The second-class rate was only half as much. On the handling of freight the railroad had to divide the through rate with the steamship companies of the Atlantic and the Pacific, but, while the rates were high, judged by American standards, and the percentages of profits very large, the service maintained was so superior to that encountered on the privately owned railroads of the Tropics that no one ever seriously complained of the charges.

One of the most important services rendered by the Panama Railroad Company in the construction of the canal was in connection with the commissary. It had more to do with the maintenance of a reasonable standard of living cost on the Isthmus than anything else.

When the canal was nearing completion it be-