CHAPTER VI

CULEBRA CUT

CULEBRA CUT! Here the barrier of the continental divide resisted to the utmost the attacks of the canal army; here disturbed and outraged Nature conspired with gross mountain mass to make the defense stronger and stronger; here was the mountain that must be moved. Here came the French, jauntily confident, to dig a narrow channel that would let their ships go through. The mountain was the victor. And then here came the Americans, confident but not jaunty. They weighed that mass, laid out the lines of a wider ditch, arranged complicated transportation systems to take away the half hundred million cubic yards of earth and rocks that they had measured. Nature came to the aid of the beleaguered mountain. The volcanic rocks were piled helter-skelter and when the ditch deepened the softer strata underneath refused to bear the burden and the slides, slowly and like glaciers, crept out into the ditch, burying shovels and sweeping aside the railway tracks. Even the bottom of the canal bulged up under the added stress of the heavier strata above.

Grim, now, but still confident, the attackers fought on. The mountain was defeated.

Now stretches a man-made canyon across the

backbone of the continent; now lies a channel for ships through the barrier; now is found what Columbus sought in vain — the gate through the west to the east. Men call it Culebra Cut.

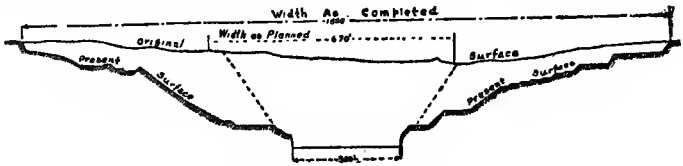
Nine miles long, its average depth is 120 feet. At places its sides tower nearly 500 feet above its channel bottom, which is nowhere narrower than 300 feet.

It is the greatest single trophy of the triumph of man over the terrestrial arrangement of his world. Compared to it, the scooping out of the sand levels of Suez seems but child's play — the tunnels of Hoosac and Simplon but the sport of boys. It is majestic. It is awful. It is the Canal.

When estimates for digging the canal were made, it was calculated that 53,000,000 cubic yards of material would have to be removed from the cut, and that under the most favorable conditions it would require eight and a half years to complete the work. But at that time no one had the remotest idea of the actual difficulties that would beset the canal builders; no one dreamed of the avalanches of material that would slide into the cut.

One can in no way get a better idea of the meaning of the slides and breaks in Culebra Cut than to refer to the accompanying figure. There it will be seen that whereas it was originally planned that the top width of the cut at one point should be 670 feet, it has grown wider, because of slides and breaks, to as much as 1,800 feet at one place. In all, some 25,000,000 cubic yards of material which should have remained outside the canal

prism slipped into it and had to be removed by the steam shovels.



THE EFFECT OF SLIDES

No less than 26 slides and breaks were encountered in the construction of Culebra Cut, their total area being 225 acres. The largest covered 75, and another 47 acres. When the slides, which were more like earthen glaciers than avalanches, began to flow into the big ditch, sometimes steam shovels were buried, sometimes railroad tracks were caught beneath the débris, and sometimes even the bottom of the cut itself began to bulge and disarrange the entire transportation system, at the same time interfering with the compressed air and water supplies. But with all these trials and tribulations, the army that was trying to conquer the eternal hills that had refused passage to the ships of the world for so many centuries, kept up its courage and renewed its attack. The result is that ships sail through Culebra and that engineers everywhere have new records of efficiency to inspire them.

These efficiency records are told in the cost-keeping reports based upon one of the most careful and thorough cost-accounting systems ever devised. This system was instituted for the purpose of keeping a check upon all expenditures

by reducing everything to a unit basis and then comparing the cost of doing the same thing at different places. For instance, if it were found that it cost more to excavate a cubic yard of material at one place than at another, under identical conditions, this fact was brought to the attention of the men responsible and an intimation given that there seemed to be room for taking up a little lost motion. The lost motion usually was recovered or else someone had to be satisfied that conditions were not identical after all.

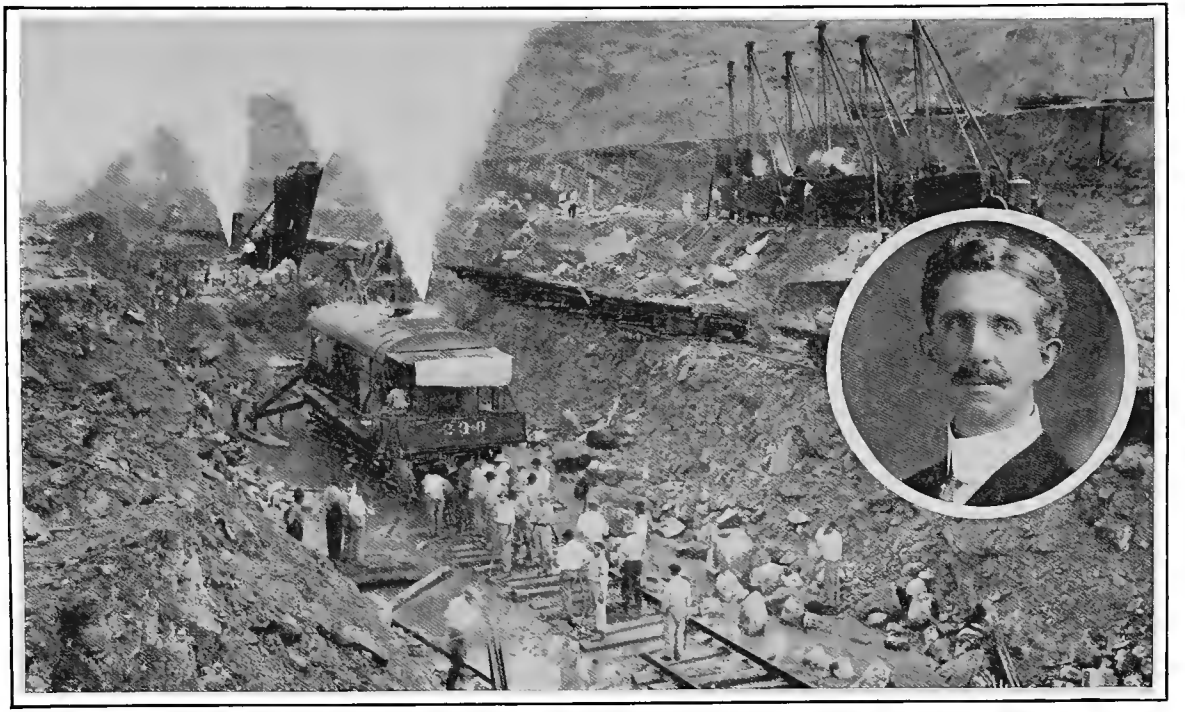
In no other part of the canal work do these cost-keeping reports tell such a graphic story as in Culebra Cut. In spite of the fact that as the cut became deeper it became narrower, and the slides and breaks became more troublesome, to say nothing of the extra effort required to get the excavated material out of the cut, every unit cost was forced down notch by notch and year by year until the bottom in costs was reached only a little before the actual bottom of the cut was exposed to view.

For instance, in 1908 it cost $11\frac{1}{2}$ cents a yard to load material with steam shovels, while in 1912 it cost less than 7 cents. In 1908 it cost more than 14 cents a yard for drilling and blasting; in 1912 it cost less than 12 cents. In 1908 it cost $18.54 to haul away a hundred yards of spoil; in 1912 it required only $13.31 to perform the same operation, although the average distance it had to be hauled had increased 50 per cent. In 1908 it cost more than 13 cents a yard to dump the material as compared with less than 5 cents in 1912. The whole operation of excavating and removing

the material, including overhead charges and depreciation, fell from $1.03 a cubic yard in 1908 to less than 55 cents a yard in 1912. And that is why 232,000,000 cubic yards of material were removed for less than it was estimated 135,000,000 cubic yards would cost.

To remove the 105,000,000 cubic yards of earth from the backbone of the Americas required about 6,000,000 pounds of high-grade dynamite each year to break up the material, so that it might be successfully attacked by the steam shovels. To prepare the holes for placing the explosives required the services of 150 well drills, 230 tripod rock drills, and a large corps of hand drillers. Altogether they drilled nearly a thousand miles of holes annually. During every working day in the year about 600 holes were fired. They had an average depth of about 19 feet. In addition to this a hundred toe holes were fired each day, and as many more "dobe" blasts placed on top of large boulders to break them up into loadable sizes. So carefully was the dynamite handled that during a period of three years, in which time some 19,000,000 pounds were exploded in Culebra Cut, only eight men were killed.

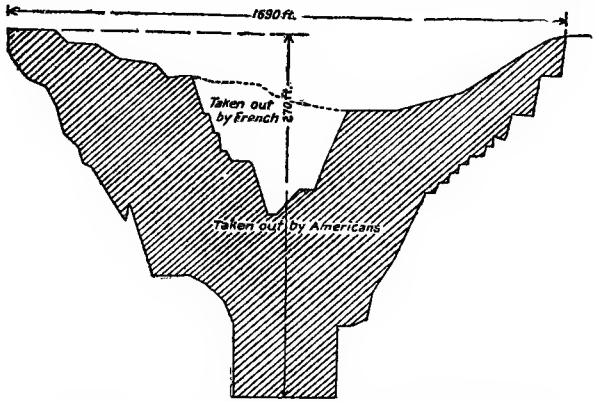
The transportation of the spoil from Culebra Cut was a tremendous job. A large percentage of it was hauled out in Lidgerwood flat cars. Twenty-one cars made up the average Lidgerwood train. It required about 140 locomotives to take care of the spoil, and the average day saw nearly 3,700 cars loaded and hauled out of the cut. In a single year 1,116,286 carloads of material were hauled out. There were 75 trains in constant



STEAM SHOVELS MEETING AT BOTTOM OF CULEBRA CUT

L. K. ROURKE

operation, one for each $2\frac{1}{2}$ miles of track in the Central Division, which was approximately 32 miles long. A huge steam shovel, taking up 5



AVERAGE SHAPE AND DIMENSIONS OF CULEBRA CUT

yards of material at a mouthful, would load one of these trains in less than an hour with some 400 yards of material. Then the powerful locomotive attached to it, assisted by a helper engine, would pull the train out of the cut, and then, unassisted, would haul it to the dumping ground some 12 miles or more away.

Arriving near the scene of the dump, another engine, having in front of it a huge horizontal steam windlass mounted on a flat car, was hooked on the rear end of the train. Then the locomotive which had brought the train to the dump was uncoupled and moved away, and in its stead there was attached an empty flat car, on which there was a huge plow. A long wire cable was stretched from the big windlass at the other end of the train

and attached to this plow. As the drum of the windlass began to turn it gradually drew the plow forward over the 21 cars, plowing the material off as it went forward. The cars were equipped with a high sideboard on one side and had none at all on the other. A flat surface over which the plow could pass from car to car was made by hinging a heavy piece of sheet steel to the front end of each car and allowing it to cover the break between that car and the next, thus affording a practically continuous car floor over 800 feet long. The operation of unloading 400 yards of material with this plow seldom required more than 10 minutes.

After the plow had finished its work it left a long string of spoil on one side of the track which must be cleared away. So another plow, pushed by an engine, attacked the spoil and forced it down the embankment. This process of unloading and spreading the material was kept up until the embankment became wide enough to permit the track to be shifted over. Here another especially designed machine, the track shifter, was brought into play. It was a sort of derrick mounted on a flat car, and with it the track shifters were able to pick up a piece of track and lift it over to the desired position. With this machine a score of men could do the work that without it would have required a gang of 600 men.

In addition to the Lidgerwood dirt trains there were a large number of trains made up of steel dump cars which were dumped by compressed air, and still other trains made up of small hand-dumped cars, and each class found its own peculiar uses.

As has been said, the problem of digging the big ditch has been one of the transportation of the spoil, and this has involved numerous difficulties. In Culebra Cut no little difficulty was experienced in keeping open enough tracks to afford the necessary room for dirt trains. Slides came down and forced track after track out of alignment, burying some of them beyond the hope of usable recovery; often the very bottom of the cut itself heaved up under the stress of the heavy weight of faulty strata on the sides of the mountain; and sometimes the slides and breaks threatened entirely to shut up one end of the cut.

In hauling away the spoil one improvement after another was made in the interest of efficiency. It was found at first that the capacity of a big Lidgerwood flat car was only about 16 cubic yards, and that with a sideboard on only one side of the car, the load did not center well on the car, thus placing an undue strain on the wheels on one side. The transportation department, therefore, extended the bed of the car further out over the wheels on the open side, and this served a triple purpose — it permitted the steam shovels to load the cars so that the load rested in the center, increased the capacity of each car by about 3 yards, and permitted the unloader plow to throw the spoil further from the track, thus adding to the efficiency of the dumping apparatus.

Frequent breaks in the trains were caused by worn couplers. These accidents were almost entirely overcome by equipping each train with a sort of "bridle" which prevented the separation of the cars in the event of the parting of a defective

coupler. In the operation of the unloader plows it was found that the big cables frequently broke when a plow would strike an obstruction on the car, and this caused no end of annoyance and frequent delays. Then someone thought of putting between the cable and the plow a link whose breaking point was lower than that of the cable. After that when a plow struck an obstruction the cable did not part — the link simply gave way, and another was always at hand. On the big spreaders no less than 51 improvements were made, each the answer of the engineers to some challenge from the stubborn material with which they had to contend.

The major portion of the material excavated from the canal had to be hauled out and dumped where it was of no further use. From the Central Division alone, which includes Culebra Cut, upward of a hundred million cubic yards of material was hauled away and dumped as useless. At Tabernilla one dump contained nearly 17,000,000 cubic yards. A great deal of spoil, however, was used to excellent advantage. Wherever there was swampy ground contiguous to the permanent settlements it was covered over with material from the cut and brought up above the water level. Many hundreds of acres were thus converted from malaria-breeding grounds into high and dry lands.

During the last stages of the work in Culebra Cut it was found that some of the slides were so bad that they were breaking back of the crest of the hills that border the cut. Therefore it was found to be feasible to attack the problem by

sluicing the material down the side of the hills into the valley beyond. To this end a big hydraulic plant which had been used on the Pacific end of the canal was brought up and installed beyond the east bank of the cut. A reservoir of water was impounded and tremendous pumps installed. They pumped a stream of water 40 inches in diameter. This was gradually tapered down to a number of 4-inch nozzles, and out of these spouted streams of water with a pressure of 80 pounds to the square inch. These streams ate away the dirt at a rapid rate.

The slides did not hold up the completion of the canal a minute, at least to the point of usability. The day that the lock gates were ready there was water enough in the canal to carry the entire American navy from ocean to ocean. That day the big dredges from the Atlantic and the Pacific were brought into the cut, and with them putting the finishing touches on the slides at the bottom, and the hydraulic excavators attacking them at the top, the problem of the slides was solved.

Viewing Culebra Cut in retrospect, it proved an immensely less difficult task than some prophesied, and a much more serious one than others predicted. There were those who opposed the building of the Panama Canal because of the belief that Culebra Cut could not be dug, that Culebra Mountain was an effective barrier to human ambition. Also, there were those who asserted that Gold Hill and Contractor's Hill were in danger of sliding into the big ditch and that they were mountains which neither the faith nor the pocketbooks of the Americans could remove. Others

saw the handwriting of Failure on the wall in the heaving up of the bottom of the cut, interpreting this as a movement from the very depths of the earth. Still others saw it in the smoke that issued from fissures in the cut, which spoke to them of volcanoes being unearthed and told them that the Babel of American ambitions must totter to the ground. They did not know that these were only little splotches of decomposing metals suddenly exposed to the air, any more than their fellow pessimists knew that the heaving up of the bottom of the cut was due to the pressure of the earth on the adjacent banks.

To-day Culebra Mountain bows its lofty head to the genius of the American engineer and to the courage of the canal army. Through its vitals there runs a great artificial canyon nearly 9 miles long, 300 feet wide at its bottom, in places as much as a half mile wide at its top and nearly 500 feet deep at the deepest point. Out of it there was taken 105,000,000 cubic yards of material, and at places it cost as much as $15,000,000 a mile to make the excavations. Through it now extends a great ribbon of water broad enough to permit the largest vessels afloat to pass one another under their own power, and deep enough to carry a ship with a draft beyond anything in the minds of naval constructors to-day. With towering hills lining it on either side, with banks that are precipitous here and farflung there, with great and deep recesses at one place and another telling of the gigantic breaks and slides with which the men who built it had to contend, going through Culebra Cut gives to the human heart a thrill

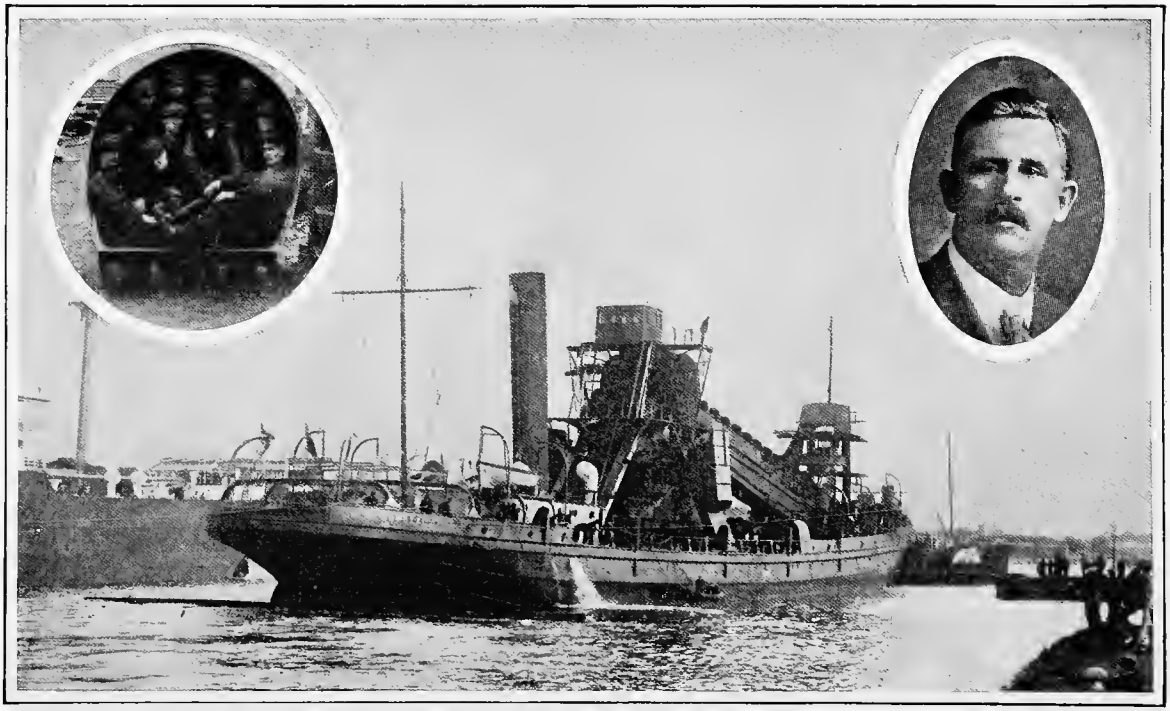
such as the sight of no other work of the human hand can give. Its magnitude, its awe-inspiring aspect as one navigates the channel between the two great hills which stand like sentinels above it, and the memory of the thousands of tons of dynamite, the hundreds of millions of money and the vast investment of brain and brawn required in its digging, all conspire to make the wonder greater. It is the mightiest deed the hand of man has done.

CHAPTER VII

ENDS OF THE CANAL

WHILE the completed Panama Canal does not wed the two oceans, or permit their waters to mingle in Gatun Lake, it does bring them a little closer together. On the Atlantic side a sea-level channel has been dug from deep water due south to Gatun, a distance of 7 miles. On the Pacific side a similar channel has been dug from deep water in a northwesterly direction to Miraflores, a distance of 8 miles. It follows that 15 of the 50 miles of the canal will be filled with salt water. The remaining 35 miles will be filled with fresh water supplied by the Chagres and the lesser rivers of Panama. The task of digging these sea-level sections was a considerable one and almost every method of ditch digging that human ingenuity has been able to devise was employed. Steam shovels, dipper dredges, ladder dredges, stationary suction dredges, and sea-going suction dredges, all contributed their share toward bringing the waters of the Atlantic to Gatun and those of the Pacific to Miraflores. In addition to these methods, on the Pacific side use was made of the hydraulic process of excavating soft material, washing it loose with powerful streams of water and pumping it out with giant pumps.

THE DISASTROUS EFFECTS OF SLIDES IN CULEBRA CUT



U. S. LADDER DREDGE "COROZAL" AND ONE OF HER MUD BUCKETS

W. G. COMBER

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."

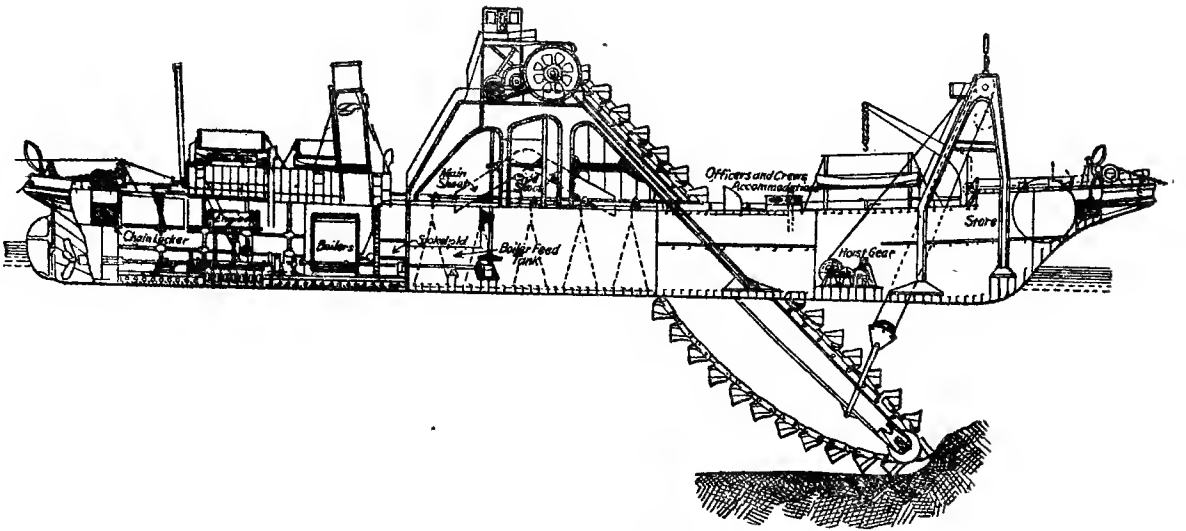
Hundreds of acres of low, marshy land have been filled up, either with mud from the suction dredges and the hydraulic excavators, or with spoil from Culebra Cut. Much of this made land will be valuable for tropical agriculture, while other parts will never serve any purpose other than to keep down the 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. Wherever 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 $18,000,000.

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-railed, 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 Railroad 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 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-

came advisable to determine what rôle the Panama Railroad should play after the permanent organization went into effect. Should it be continued as a separate entity distinct from the canal but controlled by the canal authorities? Or should it be merged into the Canal Government and operated purely as an auxiliary of the canal with no separate existence? This matter was carefully weighed by the canal authorities and the Government at Washington, and it was finally decided that the best plan would be to operate them as separate entities, but to have all the work done by single organization. Another question that arose was whether the Panama Railroad Steamship Line should be operated as a Government line after the completion of the canal. Recalling the fact that the line never had been a profitable one, and that there was no further reason why it should be continued in operation with an annual deficit, the recommendation was made by the chairman and the chief engineer that the ships should be disposed of and the line discontinued.

As the tide of tourist travel set toward Panama, the serious problem of taking care of thousands of visitors confronted the canal authorities. There were times when every available facility for taking care of lodgers was called into requisition, and still hundreds of American tourists had to find quarters in cheap, vermin-infested native hotels at Colon. Believing that the situation demanded a modern hotel at the Atlantic side of the Isthmus, and having in mind the success of the Government in the construction and maintenance of the Tivoli Hotel at the Pacific side, it was decided by the

Secretary of War that the Panama Railroad Company should build a new hotel at Colon, to be operated by that company for the Government. The result was the beautiful Washington Hotel, in whose architecture one finds the world's best example of northern standards of hotel construction adapted to tropical needs.

Built of concrete and cement blocks, it is constructed in a modified Spanish Mission style that makes it cool and comfortable at all times. Its public rooms, from the main lobby to the dining-rooms, from the ladies' parlor to the telephone and cable rooms, from the barber shop to the billiard room, are large, airy, and most attractively furnished. Its ball room, opening on three sides to the breezes borne in from the Caribbean is a delight to the disciples of Terpsichore, while its open-air swimming pool, said to be the largest hotel swimming pool in the world, affords ideal facilities for those who otherwise would sigh for the surf. Persons who have visited every leading hotel in the New World, from the Rio Grande southward to the Strait of Magellan, say that it is without a superior in all that region and, perhaps, without an equal except for one in Buenos Aires.

Here one may find accommodations to suit his taste and largely to meet the necessities of his pocketbook. The best rooms with bath cost $5 a day for one, or $6 for two. Table d'hote meals are served at $1 each, while those who prefer it may secure club breakfasts and a la carte service. Anyone who has visited the Hotel Washington, situated as it is on Colon Beach, where the breakers sweep in from the Caribbean Sea, feels

that Uncle Sam is no less successful as a hotel keeper than as a builder of canals.

The Panama Railroad, under the American régime, has always looked well after the comfort of its patrons. The coaches are of the standard American type, and enough of them are run on every train to make it certain that no patron need stand for lack of a seat. The most popular trains carry from 8 to 12 cars. These trains are run on convenient schedules, permitting a person to go and come from any point on the road in any forenoon or afternoon. All coaches are supplied with hygienic drinking cups, and in every way the Panama Railroad shows that Uncle Sam is solicitous for the welfare of his patrons.

All the rolling stock on the Isthmus is built on a 5-foot gauge, this having been the gauge of the original Panama Railroad. As the rolling stock of the Canal Commission had to run over the lines of the Panama Railroad, it also was built on the gauge. When this rolling stock is disposed of it will be necessary to readjust the gauge to meet the ordinary American standard which is $2\frac{1}{2}$ inches narrower. It has been estimated that the engine axles can be shortened for $750 per locomotive and those of cars at prices ranging from $27 to $31 per car.

The first attempt to build the Panama Railroad was made in 1847, when a French company secured a charter from the Government of Colombia for a building of a road across the Isthmus. This company was unable to finance the project and the concession lapsed.

In 1849 William H. Aspinwall, John L. Stevens,

and Henry Chauncey, New York capitalists, undertook the construction of the road. The terms of the concession provided that the road would be purchased by the Government at the expiration of 20 years after its completion for $5,000,000. The loss of life in the construction of this road, serious as it was, has been monumentally exaggerated. It is an oft-repeated statement that a man died for every tie laid on the road. This would mean that there were 150,000 deaths in its construction. As a matter of fact, the total number of persons employed during the six years the line was being built did not exceed 6,000. But among these the death rate was very high. Several thousand Chinese were brought over and they died almost like flies. Malaria and yellow fever were the great scourges they had to encounter, although smallpox and other diseases carried away hundreds.

The road was completed in January, 1855. Before the last rail was laid more than $2,000,000 had been taken in for hauling passengers as far as the road extended. The way in which the original 50-cent per mile rate across the Isthmus was established is interesting. The chief engineer encountered much trouble from people who wanted to use the road as far inland as it went from Colon, so he suggested that a 50-cent rate be established, thinking to make it prohibitory. But the people who wanted to cross the Isthmus were willing to pay even 50 cents a mile. Hence for years after the completion of the road the passenger rate continued at $25 for the one-way trip across the Isthmus.

The railroad proved to be such an unexpectedly good investment that the Republic of Colombia began to establish its claim to acquire ownership of the road at the expiration of the 2-year term, which would take place in 1875. It was necessary therefore, that the railroad company should take steps to save the railroad from a forced sale with $5,000,000 as the consideration. Representatives were dispatched to Bogota with instructions to get an extension of the concession under the most favorable terms possible. As it was realized that the Republic of Colombia held the whip hand in the negotiations, the railroad company understood that if it wished to escape selling its great revenue producing road for $5,000,000 it would have to meet any terms Colombia might dictate. The result of this mission was an agreement by the railroad that in consideration of an extension of the concession for a term of 99 years it would pay to the Colombian Government $1,000,000 spot cash and $250,000 a year during the life of the concession. That annual payment was continued as long as the Isthmus remained a part of the Republic of Colombia. Under the terms of the treaty between the United States and the Republic of Panama it was resumed again in 1913, to be paid by the United States to the Republic of Panama throughout all the years that the United States maintains and operates the Panama Canal.

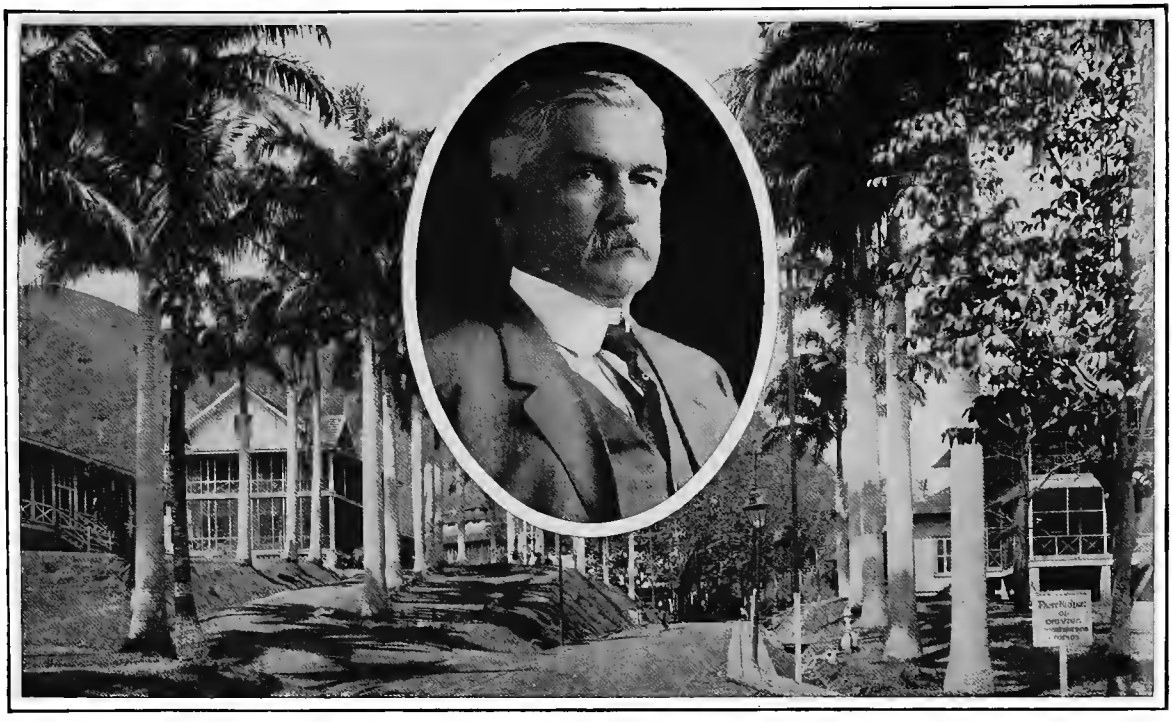
CHAPTER IX

SANITATION

PRIMARILY, the conquest of the Isthmian barrier was the conquest of the mosquito. Not mountains to be leveled, nor wild rivers to be tamed, nor yet titanic machinery to be installed, presented the gravest obstacles to the canal builders. Their most feared enemies were none of these, but the swarms of mosquitoes that bred in myriads in every lake, in every tiny pool, in every clump of weeds on the rain-soaked, steaming, tropical land. For these mosquitoes were the bearers of the dread germs of yellow fever and of malaria; and the conditions that encouraged their multiplication bred also typhoid and all manner of filthy disease. Each mosquito was a potential messenger of death. The buzzing, biting pests had defeated the French in Panama without the French ever having recognized the source of the attack. It was because the Americans, thanks to Great Britain and to Cuba, knew the deadly qualities of the mosquitoes that they were able to plan, under the leadership of Col. W. C. Gorgas, a sanitary campaign of unprecedented success. It achieved two victories. One was that it made of the Canal Zone the most healthful strip of land under tropic skies. The other is the Panama Canal.

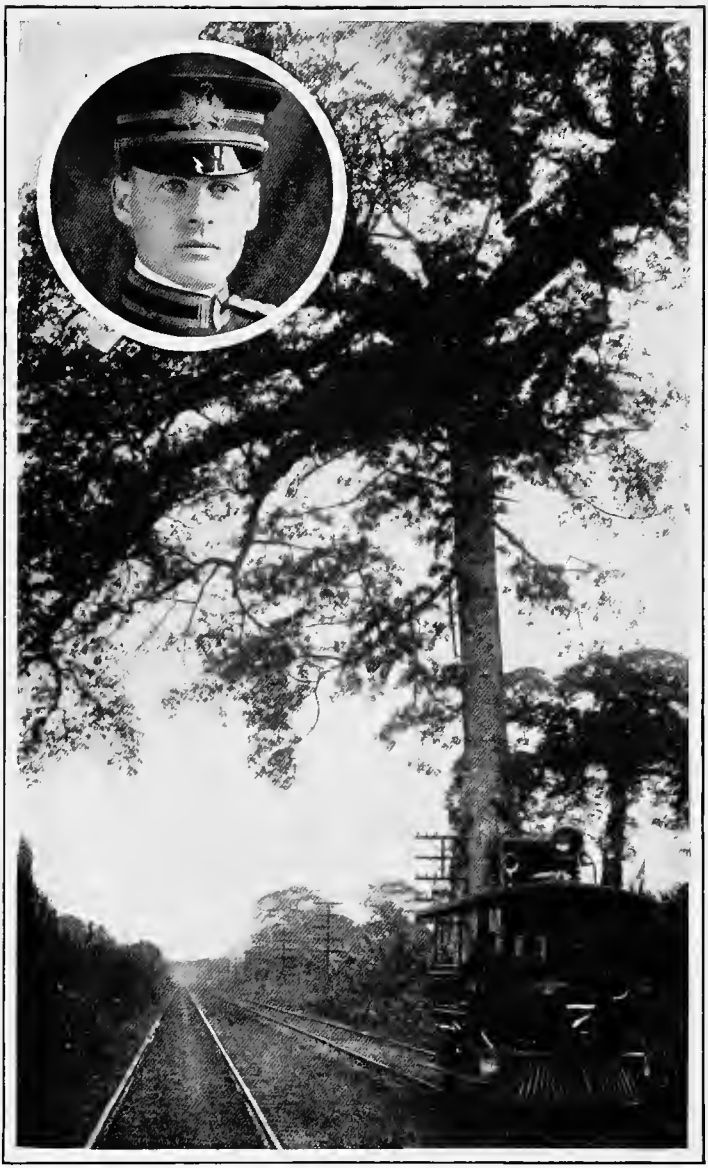
When one looks about in an effort to place the credit for these great sanitary achievements he must go back to Cuba, where the yellow fever commission, consisting of Reed, Carroll, Lazear, and Agrimonte, made the remarkable investigations proving that yellow fever is transmissible only through the bite of a mosquito. He must go still further back to Maj. Roland Ross of the British Army, and his epoch-making discovery that malaria is conveyed only by the bite of another kind of mosquito. And, if he is just to all who have contributed to the establishment of the insect-bearing theory of disease, he must not forget Sir Patrick Manson who first proved that any disease could be transmitted by insect bites. It was he who discovered that filariasis is transmissible by this method alone. It was from him that Ross gathered the inspiration that is releasing humanity from one of the most insidious of all the diseases to which mortal flesh is heir. And it was from Ross's malaria discoveries, in turn, that Reed carried forward to successful proof the theory which had persisted in some quarters for generations that yellow fever was transmissible through mosquitoes; a theory already partially proved by Dr. Carlos Finley, of Havana, 20 years earlier.

But all of the surmises and theories came short of the truth until Reed, Carroll, Lazear, and Agrimonte (Lazear at the cost of his life and Carroll at the cost of a nearly fatal attack of yellow fever) took up the work of proving that there was only one way in which yellow fever could be transmitted; namely, by the bite of the mosquito.



COL. WILLIAM C. GORGAS

THE HOSPITAL GROUNDS, ANCON



LIEUT. FREDERIC MEARS

THE OLD PANAMA RAILROAD

Sleeping with patients who had yellow fever, wearing the clothes of those who had died from it, eating from utensils from which yellow fever victims had eaten — in short, putting to the most rigid test every other possible method of infection, they proved by every negative test that yellow fever could not be produced in any way other than by the bite of a mosquito.

The next step was to give affirmative proof that yellow fever was caused by the bite of the female "stegomyia" — she of the striped stockings and the shrill song. This meant that someone had to have enough love for humanity to risk his life by inviting one of the worst forms of death to which human flesh is heir. Those doctors knew that they could not as brave men ask others to undergo the risks that they themselves might not accept, so in a little council chamber in Havana the three Americans — Reed, Carroll, and Lazear — entered into a compact that they themselves would permit infected mosquitoes to bite them. Reed was called home, but Carroll and Lazear stood with the keen and cold eyes of scientists and saw the mosquitoes inject the fateful poison into their blood. Later, after Lazear had died and Carroll had stood in the jaws of death, soldiers of the American army in Cuba volunteered in the interest of humanity to undergo these same risks. And it was thus, at this price, that the world came to know how yellow fever is caused, and that the United States was to be able to build the Panama Canal.

After the guilt of the female "stegomyia" mosquito was firmly established the next problem

was to find a method of combating her work. Dr. Reed and his associates thought that it might be done through a process of immunization, using the mosquito to bite patients with very mild cases and, after the necessary period of incubation, to transmit the disease to those who were to be rendered immune. It was soon found, however, that there was no method of transmitting a mild infection, and the next problem was to combat the work of the mosquito by isolation of yellow fever patients, and by the extermination of the mosquitoes themselves.

In Havana at this time there was another army surgeon who was destined to write his name high upon the pages of medical achievement. He was Dr. William C. Gorgas. Under the patronage of Gen. Leonard Wood, himself a physician and alive to the lessons of the yellow fever commission's investigations, Maj. Gorgas undertook to apply the doctrine of yellow fever prevention promulgated by the commission, and his efforts were attended with brilliant success. The result was that Havana, in particular, and Cuba, in general, were freed from this great terror of the Tropics. When President Roosevelt came to provide for the building of the Panama Canal one of his early acts was to appoint Dr. Gorgas the chief sanitary officer of the Canal Zone.

At first there was difficulty in establishing practical sanitation at Panama. The chief sanitary officer was then a subordinate of the commission, and, along with all of the other men who were trying to do things on the Isthmus, he found

himself hindered by unsatisfactory conditions both as to supplies and as to force; consequently, his work was no more satisfactory to himself than it was to the commission or to the American people. Under these conditions an epidemic of yellow fever broke out in Panama in 1905, and it was not long before the yellow fever mosquito had seemingly established an alibi and had secured a reopening of her case before the jury of public sentiment. People, to emphasize their disbelief in the mosquito theory of the transmission of the disease, tore the screens from their doors and windows, and otherwise proclaimed their contempt for the doctors and their doctrines. This matter went so far that the Isthmian Canal Commission proposed not only a change in method but a change in personnel as well.

At this juncture Charles E. Magoon became governor of the Canal Zone, and he declared that Dr. Gorgas should have adequate financial and moral support. He was determined that the panic which the yellow fever outbreak had engendered should be halted — and a panic it was, for men rushed madly to Colon and defied the efforts of the commission, and of the captains and crews of the Panama Railroad steamships, to prevent them from returning to the States without other transportation arrangements than a determination to get aboard and stay there until the Statue of Liberty had been passed in New York Harbor. So great was this panic that Chief Engineer Stevens declared that there were three diseases at Panama: Yellow fever, malaria, and cold feet; and that the greatest of these was cold feet. The news-

papers of the United States at that time quoted the poetry of such writers as Gilbert, who said:

"Beyond the Chagres River
'Tis said (the story's old)
Are paths that lead to mountains
Of purest virgin gold;
But 'tis my firm conviction
What e'er the tales they tell,
That beyond the Chagres River
All paths lead straight to hell."

It did not matter that in four months there were only 47 deaths on the Isthmus from yellow fever as compared with 108 from malaria in the same period — men do not stop to study mortality tables and to compare the relative fatalities of diseases when yellow fever stares them in the face.

But after all, the yellow fever panic of 1905 served a good purpose, for if the mosquito thereby secured a reopening of its case, it stirred the United States Government to give to the sanitary officers of the Canal Zone the powers they needed, and the means required to prove finally and forever in the court of last resort, the guilt of the mosquito, and to establish for once and all the method of combating its stealthy work.

The whole world recognizes the remarkable results in sanitary work that have been achieved at Panama. While it must be remembered that the population of the Canal Zone is made up largely of able-bodied men, and that, therefore, the death rate naturally would be lower than under like

conditions with a normal population of infancy and old age, the fact remains that sanitary science has converted the Zone from a mosquito paradise of swamp and jungle into a region where mosquitoes have all but disappeared, and where men are as free from danger of epidemic diseases as in the United States itself.

The sanitary statistics of the Canal Zone, and of the cities of Panama and Colon, were based for several years upon an erroneous assumption of population. The Department of Sanitation estimated the population of the Canal Zone by deducting the recorded emigrants from the recorded immigrants and assumed that the difference represented a permanent addition to the Zone's population. Under this method of estimating population a serious error crept in, since hundreds of people came into Panama from the Panaman outports and were recorded as arrivals, but who, departing in small sailing vessels and launches at night after the port officers had gone home, were not recorded as having departed. In this way the sanitary department estimates of population in the Canal Zone reached a total of 93,000 in 1912. The census taken that year showed only 62,000 population in the Zone. This served to make the death rate given out by the Department of Sanitation 50 per cent lower than was justified by actual population conditions.

But one does not need to consider figures to realize what has been accomplished at Panama. Anyone who goes there and sees the remarkable evidence of the success of the efforts to conquer the disease of the tropical jungles, finds a lesson

taught that is too impressive to need the confirmation of medical statistics.

The United States, after the yellow fever outbreak of 1905, never counted the cost when the health of the canal army was at stake. Not only was Uncle Sam successful in his efforts to make the Canal Zone and the terminal cities of Panama and Colon healthful places of abode, but no worker on the canal was denied the privilege of the best medical care. An average of $2,000,000 a year was expended in the prevention of sickness and the care of those who were sick. At Ancon and at Colon large hospitals were maintained where the white American and the West Indian negro had their respective wards. At Taboga a large sanitarium was maintained to assist the recuperation of those who had recovered sufficiently to leave the hospital. Besides this there were rest camps along the line for those not ill enough to be removed to the hospitals, and dispensaries where those who felt they were not in need of other medical attention could consult with the physicians and get the necessary medicines. All medical services to the employees of the Canal Commission and the Panama Railroad were free, and only nominal charges were made for members of their families. No passenger train crossed the Isthmus of Panama without carrying a hospital car for taking patients to or from the hospitals. No way station was without its waiting shed bearing the inscription: "For Hospital Patients Only." Each community had its dispensary, its doctor, and its sanitary inspector.

During the year 1912 there were 48,000 cases

of sickness in the Canal Zone, of which 26,000 were white and 22,000 colored. During the same year 633,000 trips to the dispensaries were made by employees and nonemployees, divided almost evenly between white and colored. The average number of employees constantly sick in Ancon Hospital was 712; in Colon Hospital 209; and in Taboga Sanitarium 54. An average of 119 were in the sick camps all the time and 50 in the quarters. The average number of days' treatment per employee in the hospitals was a little over 14; in the sick camps a little under 3; and in quarters $2\frac{1}{3}$. It cost $160,000 a year to feed the patients in the hospitals and $739,000 a year to operate the hospitals.

The work of sanitation proper cost some $400,000 a year. This includes many items. During one year about 16,000,000 square yards of brush were cut and burned; a million square yards of swamp were drained; 30,000,000 square yards of grass were cut; 250,000 feet of ditches were dug; and some 2,000,000 linear feet of old ditches were cleaned. During the same year nearly a million garbage cans and over 300,000 refuse cans were emptied. In addition to looking after the health of the Canal Zone itself, it was necessary to care for that of the cities of Panama and Colon. In the city of Panama 11,000 loads of sweepings and 25,000 loads of garbage were removed in one year; 3,000,000 gallons of water were sprinkled on the streets and as much more distributed to the poor of the city.

During one year the quarantine service, which keeps a strict lookout for yellow fever, bubonic plague, and other epidemic diseases, inspected

over 100,000 passengers coming into the Zone. It required about 150,000 gallons of mosquito oil a year to keep down the mosquitoes. There are 50 known breeds of these insects on the Isthmus and perhaps some 20 species more which have not been identified. Of the 50 or more species of mosquitoes 11 belonged to the malaria-producing family — anopheles. Their cousins of the yellow-fever-producing family — the stegomyias — boast of only two species. What the other 40 or more kinds are doing besides annoying suffering humanity has not been determined. The mosquito is comparatively easy to exterminate. Its life habits are such that a terrific mortality may be produced among them during infancy. The average young mosquito, during its "wriggler" state of development, lives under the water and has to make about 8,000 trips to the surface for air before it can spread its wings and fly. If oil is poured upon the water it can get no air and death by asphyxiation follows. Two classes of larvaecide are used on the waters to exterminate the baby mosquitoes: One is an oil used to make a scum over the surface; the other a carbolic solution which poisons the water. At the head of every little rivulet and tiny, trickling stream one sees a barrel out of which comes an endless drip! drip! drip! These drops of oil or poison are carried down the stream and make inhospitable all of the mosquito nurseries of the marshes through which the waters flow. In addition to these barrels, men go about with tanks on their backs, spraying the marshy ground and the small, isolated pools of water with larvaecides.

SANITARY DRINKING CUP

MOSQUITO OIL DRIP BARREL

SPRAYING MOSQUITO OIL

TYPICAL QUARTERS OF THE MARRIED LABORER

A NATIVE HUT

This method of treatment has not exterminated all mosquitoes on the Isthmus, but it has so materially reduced their number that one may stay in the Zone for weeks without seeing a single one. This is a freedom, however, that must be paid for by vigilance of the most painstaking and unremitting sort. The moment the work is relaxed the mosquitoes again spread over the territory.

The United States Government will have to continue with the utmost care its work of sanitation and quarantine at Panama. If, after the canal is completed, an epidemic of bubonic plague or yellow fever should break out, it might very seriously interfere with the operation of the canal in several ways. To begin with, it would demoralize the operating force. Further than this, India and China are afraid of yellow fever because in both of these countries the stegomyia mosquito abounds. If the disease should obtain a foothold there it would be difficult to exterminate. Europe, also, might be expected to quarantine against Panama under such conditions. A 10,000-ton freighter carrying cargo through the canal would lose at least a thousand dollars for every day it was detained in quarantine by reason of having visited the canal.

A shrewd observer has said that the successful sanitation of the Isthmus of Panama is a triumph at once of medical science and of despotic government. Probably this does not overstate the case. The methods employed at Panama were arbitrary, and had to be. They probably could not be enforced at all in a democratic community

in ordinary times. The people would rebel against the severity of the regulations and against the incidental invasion of their privacy. But strike any community, however free, with the fear of a swift and deadly disease and it will submit — as witness the shot-gun quarantines that used to demark the northern limits of the yellow fever zone in our own Southern States, or the despotism that governed New Orleans in the terror of 1905. At Panama this fear is ever present, so there is little danger that a responsible majority there ever would resist the sanitary work on the grounds of outraged democracy. It may be that a popular government would become careless, or inefficient, but it would not renounce the pretension. This has been proved in Cuba.

The sanitarians at Panama gave to the workers there a sense of security that contributed no little to the spirit of determination so universally remarked and commended by visitors to the Zone during the era of construction. While there was no immunity from sickness and death, yet there was no panic, no constant dread, such as destroyed the morale of the French force. The Isthmus of Panama still remained hot, its inhabitants still were forced to take the precautions that aliens must take in the Tropics; but they were inspired with a confidence that if these precautions were taken they would not be in any greater danger than if they had remained in their northern homes.

Pestilence, the scourge of the on-sweeping epidemic, the plague of swift death that is only a little worse than the panic of fear it inspires — this was the thing that was stamped out.

Not since the Science of Healing opened its doors to the Science of Prevention have physicians scored a greater victory in their fight against disease and death than on the Isthmus of Panama. Not only did they help to build the canal; they demonstráted that tropical diseases are capable of human control and thereby opened up a vista of hope undreamed of to all that sweltering and suffering mass of humanity that inhabits the Torrid Zone.

CHAPTER X

THE MAN AT THE HELM

IN 1905, William H. Taft, then Secretary of War, made a trip to the Isthmus of Panama to look over the preparations for the construction of the Panama Canal, and at the same time to consider the question of the fortification of the big waterway. On that trip a member of the General Staff of the Army, who at that time was but little known outside of Army circles, went with him. He was a tall, broad-shouldered, bronze-faced, gray-haired man, 47 years old. He came and went unheralded. Few people knew of the engineering record he had made, and no one on the Isthmus dreamed that he was destined to become the commander in chief of the army that would conquer the Isthmian barrier.

He returned to the United States and wrote his report — a report which, from the deep mastery of the subject it revealed, attracted the favorable attention of the Secretary of War. Later when the board of consulting engineers came to make its report upon the type of canal which should be built — whether it should be a sea level or a lock canal — the Secretary of War asked this officer to prepare a draft of his report to the President recommending the lock canal.

Soon after New Year's Day, 1907, the chief

engineer of the canal, John F. Stevens, dissatisfied with the relations that existed between the Government and himself, came to the conclusion that he could not build the canal hampered as he was by red tape at Washington. It then became a question of whether or not the canal should be built by contract or by the Army. President Roosevelt asked for a preliminary report upon this proposition and the unheralded Army engineer who had visited the Canal Zone in 1905, made it. A few days later there was a conference between President Roosevelt, Gen. Alexander MacKenzie, Chief of Engineers of the United States Army, and the Secretary of War. After this conference Maj. George Washington Goethals was summoned to the White House and informed by the President that it had been determined to build the Panama Canal under the auspices of the Army, and that he was appointed chairman and chief engineer of the Isthmian Canal Commission. He was requested to keep the fact of his appointment a secret and to prepare immediately to go to Panama. A ship sailed for the Isthmus three days thereafter, and he was ready to sail when the President advised him that he might wait over and arrange affairs in Washington, leaving in time to get to the Isthmus to take charge on the first of April.

When the announcement was made to the country that the work of building the canal was to be put in the hands of the Army, the whole country began to inquire: Who is Major Goethals? that inquiry revealed the fact that he was a man who had accomplished much in his 49 years. Born in 1858, of Dutch parents, whose ancestors

had settled in New York when it was still New Amsterdam, he was appointed to the United States Military Academy at West Point where he was graduated in the class of 1880 with such honors that he was entitled to enter the Engineer Corps of the Regular Army.

In 1891 he rose to the rank of captain, and in 1898 became lieutenant colonel and chief engineer of the First Volunteer Army Corps in Cuba. On the last day of that year he was honorably discharged from the volunteer service, and, in 1900, became a major in the Engineer Corps of the Regular Army. For a number of years prior to 1898 he had been instructor in civil and military engineering at West Point. He had been in charge of the Mussel Shoals canal construction on the Tennessee River, a work which won praise from engineers both in civil and in military life. It was in a measure his record made on the Tennessee River work that led to his appointment as chairman and chief engineer of the Isthmian Canal.

When he took charge of the work at Panama he was promoted to lieutenant colonel. Arriving there he immediately informed all hands that while the work of building the canal had been placed under Army engineers, no man who was then on the job and faithfully executing his work need fear anything from that administration. From that time down to the last stages of the work that statement held good. Trained at West Point, brought up in the atmosphere of the Army, a lover of its traditions and in full sympathy with its spirit, he laid aside everything that might handicap the success of the undertaking and sought

at once to get the full benefit of all that was best in the Army and in civil life as well. He put his uniform in moth balls when he started to the Isthmus, and from that day to this no man has ever seen him on the Canal Zone wearing an Army uniform.

When he took charge of the big job, the foundations upon which he was to build the superstructure of his success had been laid by his predecessors, but there were many weak points in these foundations as well as many strong ones. With a spirit of utilizing to the fullest extent every advantage that the administrations of the former chief engineers had left on the Isthmus, he undertook to make only such changes as time demonstrated were necessary to the success of the project. At that time 6,000,000 cubic yards of material had been removed from the big waterway. Confronting him was the task of removing some 215,000,000 yards the while building a great dam containing 21,000,000 cubic yards, constructing a series of gigantic locks containing four and a half million cubic yards of concrete, and providing for the happiness and welfare of the sixty-odd thousand people who constituted the canal army and its camp followers.

In the years that followed his appointment he proved himself in every way worthy of his assignment as the managing director of the most stupendous piece of work ever undertaken by man. Furthermore, he established a claim to the title of the "Great Digger." No other man in the history of the world has ever superintended the excavation of an amount of earth half as

great as that which has been taken out of the Panama Canal during his administration. Since he went to the canal to "make the dirt fly" the material excavated under his command, together with that placed in the locks and dams, equals the amount necessary to take out to cut a tunnel 13 feet square through the earth at the Equator.

No man ever carried to a great position less fuss and feathers than Colonel Goethals took to his work as chairman and chief engineer of the Panama Canal. When, during the construction period, one visited his office at Culebra, on almost any afternoon, he would find there an unpretentious little room in the corner of the administration building, about 18 feet square, containing four windows, overlooking the cut from two sides, its painted walls hung with maps, its floors uncarpeted, and in the center a large double-sided, flat-top desk covered with papers. A swivel chair at the desk and two or three other chairs constituted the furnishings of this room. The visitor walked directly into the office of his private secretary and the chief clerk, and if he had anything worth while about which to see the chairman and chief engineer he was detained only long enough for the man ahead of him to get out. With "no time like the present" as his motto in handling the business of his office, he, the busiest man on the Isthmus, and one of the busiest in the world for that matter, always seemed to have more time than many men of lesser responsibilities and far fewer burdens. He once declared that he had a contempt for the man who always tried to make it appear that he was too

busy to see his callers, because his callers were frequently as busy as he himself.

The fact is that he is a man with a very unusual gift in the dispatch of work. System has been the key-note of his success. With thousands of details every day to look after, he has always kept his work so well in hand that to the casual observer he seemed to be the most leisurely man on the Isthmus. He maintained a well-established routine all through his career on the canal. His mornings usually were spent going over the work. When the morning trains passed Culebra at 7 o'clock they found him up, breakfasted, and at the station.

Although these trains carried parlor cars, one would seldom see the chairman and chief engineer riding in them. Rather, he consistently chose to ride in the ordinary day coaches with his sub-engineers, with the steam-shovel men, and with the rank and file of the Americans who made possible the success of the work at Panama. There were few of these Americans whom he did not know by name, and with whom he did not pass a pleasant word whenever he chanced to meet them.

A morning trip over the work with this presiding genius of the big ditch reveals perhaps better than anything else the makeup of the man and the secret of his success.

"Meet me on the early train to-morrow morning at Miraflores," said he to one of his visitors in the early summer of 1913, "and we will go over the Pacific end of the work."

This meant that both the chief engineer and the visitor had to leave comfortable beds at 5

o'clock in the morning to keep the appointment. At 7 o'clock they met at Miraflores. "We will walk through the tunnel if you don't mind," said he, "as I don't want to hold up a dirt train if it can be avoided."

At the other end of the railroad tunnel, the only one on the Isthmus, a railway motor car stood on the siding ready to pick up the distinguished engineer and carry him to the Miraflores Locks. This motor car is something like a limousine on railroad trucks, and was affectionately known by the people on the Isthmus, as "the yellow peril" and "the brain wagon." The first stop was at the concrete work on the spillway dam at Miraflores.

"How soon do you expect to have this dam up to its full height?" he asked of the division engineer who joined him there. "Can't you find room to operate another temporary concrete mixer down there?" he queried further. "Is there anything else you need to keep the work moving forward so as to be certain to complete the dam by the time you promised?"

Going a little farther he came to a place where one division was doing some work for another division. "Don't you think it would be more satisfactory to keep both parts of that work under one division? Why don't you allow it all to be done by the other people?"

Walking across the locks on the temporary bridge the chief engineer and his assistant came to a point where the concrete lamp posts for lighting the locks were being set up. "Don't you think that it would better avoid any settling

if you were to place beams of railroad iron across those spaces and rest the posts on them?" he queried.

A little farther on he met the engineer in charge of the work of the company erecting the gates. "When do you think you will have the gates in the west chambers completed so that we can put the dredge through?" he inquired of Mr. Wright.

"Well, sir," replied Mr. Wright, "if we have good luck I hope to have them done by the first of September; if we have fair luck we ought to have them completed by the middle of September; but at the lowest calculation I can promise them to you by the first of October."

"But have you taken into consideration all of the time you are likely to lose as the result of heavy rains?" queried the chief engineer.

"I have made full allowance therefor, I think," responded Mr. Wright.

Walking on, the watchful eye of the chief engineer fell upon a new baby railway track which was being laid through the eastern lock chambers. "What are you planning to do there?" he asked of the division engineer.

"We wanted to get some additional material through the locks and Mr. Wright informed us that if we would furnish the timbers, he would make it so that we could run these little engines through there," responded the engineer.

"But did you have a definite understanding with him that this should afford no excuse for any further delay in completing the gates?" queried Colonel Goethals.

"We did, sir," responded the division engineer.

"All right then, go ahead."

At this point the party boarded the motor car again and was taken to the big dike which was to hold the Pacific Ocean from flooding the locks after a dike a mile farther down had been blown out. "How much water do you have in the stretch between the two dikes?" he asked of the division engineer. He next wanted to know how many million cubic feet they were able to pump and siphon in, and how much the Rio Grande was bringing in per day. Then he wanted to know if every possible precaution had been taken to insure the watertightness of the new dike; how many thousand pounds of dynamite had been placed under the one to be blown up; how many holes this dynamite was placed in; and a large number of other bits of information which would tell him whether every safeguard had been thrown around the plan to insure its success.

Going up on the other side of the canal the party came to the earth dam joining the west lock walls with the hills, so as to impound 58 feet of water in Miraflores Lake. "How soon do you expect to get that connection made between the lock walls and the dam proper?" he queried of the engineer in immediate charge.

"In four weeks, sir."

"All right," answered Colonel Goethals, "you can't get that done any too soon to suit me."

And so he went over the work around Miraflores from beginning to end, talking now with an Irishman in charge of dumping the material on the inside of the dam, now with a man in charge of some

concrete work, and now with the division engineer himself. By 11 o'clock he had inspected every part of this division and was ready to take his car back to Culebra. In four hours he had seen every man responsible for any important work around Miraflores; had offered a suggestion there, a word of encouragement here, and had obtained a bit of information at another place.

Each day's morning program was like this one except as to the place he visited and the people with whom he talked. One morning he might be tramping over Cucaracha Slide, studying the prospects of its future. Another morning he might be down at Gatun watching an official test of an emergency dam. On these trips he usually wore either a most unmilitary-looking blue serge or gray cheviot, with a somewhat weather-beaten sailor straw hat, and carried a cheap dollar umbrella.

When Colonel Goethals went to the Isthmus he promised that every man with a grievance should have a hearing. Each Sunday morning he had at his office at Culebra what he termed his Sunday "at homes," the best attended functions on the Isthmus, where the blackest Jamaica negro on the job found as much of a welcome as the highest official. These functions were for the purpose of hearing the canal employees who had grievances. Once a visitor was congratulating him upon the smooth manner in which the canal-building machine seemed to be working. "You ought to attend one of my Sunday 'at homes,'" he replied. "You would think that there was no smoothness at all to its running."

And so it went. Small affairs, big affairs, and indifferent ones were brought to his attention. In perhaps 80 per cent of them he could not do what was requested, but when able he did it so promptly, and in such a positive, straightforward manner, that his "at homes" have been compared, by the French ambassador to the United States, to the court of justice held by Saint Louis beneath the oak at Vincennes.

A railroad engineer on one of the dirt trains got drunk and ran over a negro. He was sent to the penitentiary. The railroad men issued an ultimatum saying that if he were not released by a certain hour on a certain day, every dirt train on the canal would stop. A committee conveyed this ultimatum to Colonel Goethals and asked his decision. "You will get it at the penitentiary," he replied. "This man will remain in prison and every man who quits work on that account will be dropped from the rolls. There was no strike of engineers.

At another time the waiters at the Tivoli Hotel went on strike. The whole force was promptly discharged, and the official paper of the Canal Commission carried their names with the announcement that thereafter they would not be eligible to employment in any capacity on the Canal Zone.

If the chairman and chief engineer of the canal is just and firm in his relations with his men, he is no less generous in giving credit where credit belongs. Upon one occasion he was talking about the success of the canal project with a friend, and declared that the world would never give to John F. Stevens the credit that was due him in the

construction of the canal. "You know," said he, "the real problem of building this canal has been that of removing the spoil; that problem was preeminently the problem of a railroad man and to solve it demanded the services of one of the best men in the railroad business. We have extended the facilities laid out by Mr. Stevens, and have modified them as experience and conditions have demanded, but they have been operated from that day to this under the general plan of transportation laid out by Mr. Stevens. I do not think that any Army engineer in the United States could have laid out such excellent transportation facilities."

At another time, in discussing this same matter, he declared that it was his firm opinion that the canal could have been built by either of the former chief engineers, John F. Wallace or John F. Stevens, if they had been allowed a free hand. "You see," said he, "they were men who were accustomed to handling big construction jobs. They would outline their project and the cost of executing it to a board of directors who would pass upon it and then leave them absolutely unhampered in the matter of personnel and method, with results as the only criterion of their success. When they came to the Isthmus they found their hands tied by red tape. They had never dealt with a President, a Secretary of War, a Congress, and the public at large. Naturally, they grew restive under the conditions which confronted them and resigned.

"The whole difference is largely that of training. The Army officer knows from the time he leaves

West Point that he has to work in harmony with his superiors, with the President, the Secretary of War, and Congress. That is why we have been able to stay where men from civil life have thrown up the job."

Another remarkable characteristic of the Great Digger is his desire to do his work economically as well as to do it promptly. When he went to the Isthmus there was an insistent demand that the dirt be made to fly. Along with the administration in Washington he realized that the only way to gain the faith and confidence of the people in the work, a faith and confidence essential to its full success, was to measure up to their desire that the dirt begin to fly. It was not a time to consider economies then. But, as soon as those demands had been met and the people had been shown that the Army could make good, a cost-keeping system was introduced. Men doing identical work were pitted against one another; Army engineers were placed in command of one task here and civilian engineers in command of another task there; and thus a healthy rivalry was established.

As Colonel Gaillard, member of the commission, and engineer of the Central Division, testified before a congressional committee, his early work in Culebra Cut was to get out as much dirt as possible, while his later work was given over largely to a study and comparison of cost sheets with a view to cutting down the expense of removing a yard of material, with the result that he was able to show a saving of $17,000,000 in a 9-mile section of the Panama Canal as compared with the estimates of 1908.

In other words, Colonel Goethals took that golden rule of all great soldiers, "get there first with the most men," and adapted it to read "dig the most dirt with the least money." He had ever in mind three things: Safe construction, rapid progress, and low costs. On these three foundation stones in his mind was reared the structure that stands as the highest example of engineering science, and as the proudest constructive accomplishment of the American Republic.

At the northern entrance to the Suez Canal stands a statue of de Lesseps, a beckoning hand inviting the shipping of the world to go through. Perhaps no such statue of Goethals ever will stand at Panama, but there is no need. The canal itself is his monument and its story will ever endure.