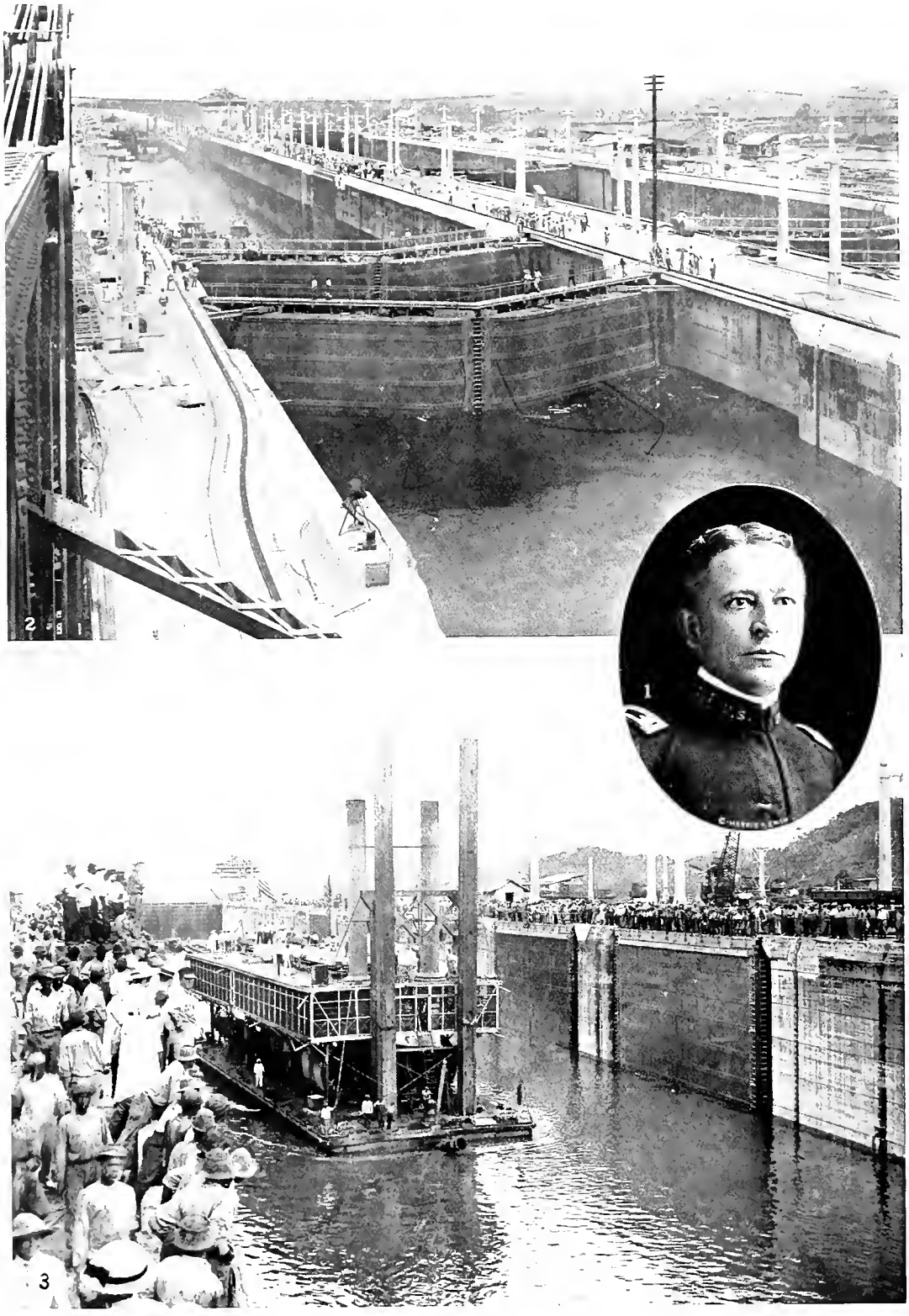
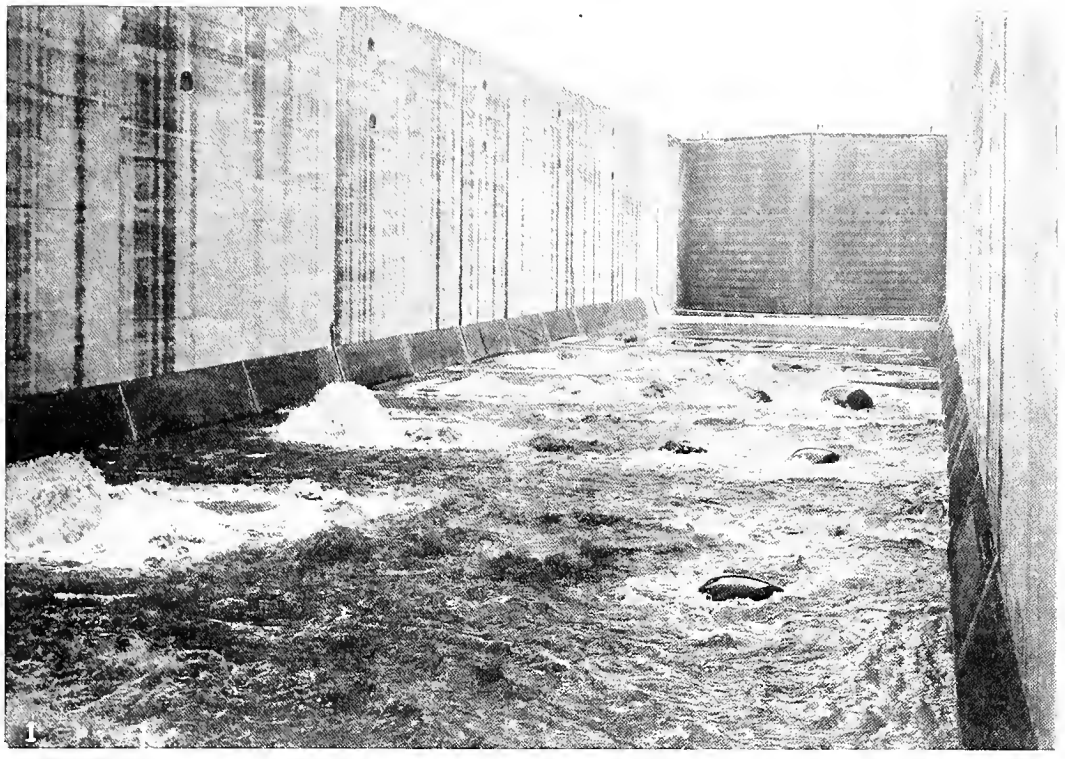
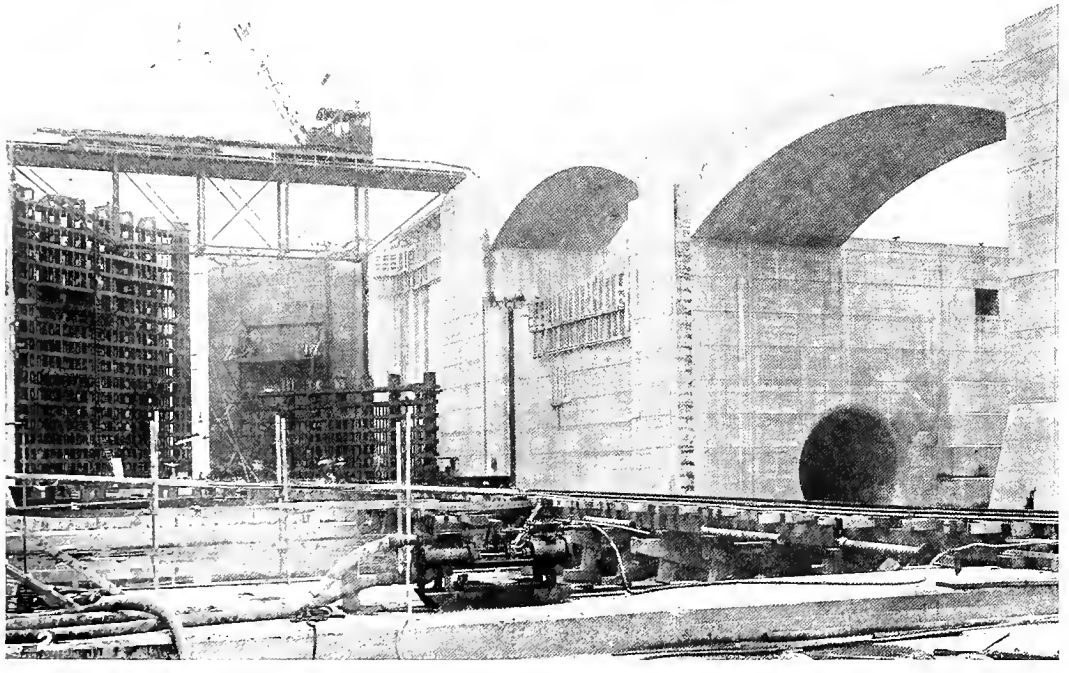


1. Brig. Gen. Harry F. Hodges, designer of locks at Panama.
2. Dredging fleet entering locks at Gatun.
3. Dredge in lock chamber at Pedro Miguel.





1. View showing gates closed across a lock chamber and water welling up through the floor of the lock.
2. From large culvert at the right the water is conveyed through cross culverts under the lock floor, and thence through openings in the floor, as shown in No. 1.

than its estimated capacity in a given time, it hastened the completion of the big waterway, for Culebra Cut was the backbone of the work, just as Culebra Mountain was the backbone of the isthmus.

When Colonel Goethals installed the cost-keeping system under which he proposed to check up the work of every man on the canal, he was carrying out the same idea that had led to keen rivalry among the Atlantic, Central, and Pacific divisions. The Atlantic division he made a military organization. Every one of its responsible heads was a military man. The Pacific division was strictly a civilian's organization—not a man in it was an army man. The Central division was made up of a military head and civilian subordinate officials. Of course the army men on the Atlantic side were not willing that the civilians over the mountain should excel them, and, of course, the civilians on the Pacific side would not think of allowing the army folk across the Continental Divide to come out ahead of them if that could be avoided; so under the leadership of Sidney B. Williamson, they toiled as though their very lives depended on the job. Meanwhile, the Central division, having little work to do that was strictly comparable to the work in the other two divisions, desired above everything else to get its work as a whole finished before the other two divisions had finished. It is asserted that they would have finished their work first but for the slides which they had to combat. These slides threw them back more than two years.

After Colonel Goethals had given the force a year's try-out, he set to work, as stated in another chapter, to reduce unit costs. He wanted rivalry not only as to expedition, but as to economy, so he instituted a cost-keeping system. This system was not popular in some quarters, being referred to as "a kindergarten for accountants." It was suggested that it would cost as much to keep the cost-sheets as it would to do the work. But in spite of these criticisms, the cost-keeping system went into effect.

The first thing to be done was to estimate all probable unit-costs as the facts in hand then indicated they would be. Every piece of work from the breakwater in Limon Bay to the fill in Panama Bay was gone over, and the estimated cost, both as a whole and for its units, was fixed.

It was estimated at that time that the cost of the concrete work at Gatun would be $7.75 a cubic yard. The cost proved to be $7.46 a cubic yard, representing a saving of about half a million dollars in the concrete work on the locks.

The showing on the Pacific locks was very much more striking than that on the Atlantic locks. To begin with, the estimates of cost were higher by fifty cents a cubic yard, owing to the fact that on the Atlantic side, the three flights of locks were all together, while on the Pacific side, there was one flight at Pedro Miguel and two at Miraflores, necessitating the practical completion of the Pedro Miguel lock before the others could be started, and calling for a removal of the plant from the former place to the latter. Therefore, the estimates of the cost of the concrete on the Pacific side, in place, called for $8.25 a cubic yard. The actual cost at Pedro Miguel was $5.87 a cubic yard, approximately, a saving of $2.38 a cubic yard on 906,000 cubic yards of concrete. At Miraflores the cost was $5.34 a cubic yard, a saving of $2.91 a cubic yard on each of 1,476,895 cubic yards of concrete, plain and reinforced, put into the locks. The saving on concrete in the locks on the Pacific side was approximately six and a half million dollars.

The greater saving on the Pacific side over that on the Atlantic side is, in a measure, explained by the difference in the cost of sand and stone. The stone used at Gatun in 1911, an average year, cost $2.34 a cubic yard delivered at the storage bins, while that at Pedro Miguel and Miraflores cost 84½ cents a cubic yard.

The selection of Porto Bello quarry was

due to the wish of Lieutenant Colonel Sibert to have the entire work of the Atlantic division done under his charge. He believed he could get stone at Porto Bello as cheaply as it could be obtained at Ancon. This addition of about a dollar and a half a cubic yard to the cost of the concrete used made a heavy extra expense on the Atlantic side. For the fiscal year 1912, the cost of stone in storage at Gatun, compared with that at Pedro Miguel, was greater by $1.69 a cubic yard. If there be deducted from this the difference between the cost of transportation and the difference between plant arbitraries, the net difference was 52½ cents a cubic yard in favor of the Ancon quarry. Sand, on the Atlantic side of the isthmus, also cost much more than on the Pacific side. Here, again, a different story might have been told if all the sand had come from Chame. The added cost of transporting stone and sand from Miraflores to Gatun would have been very small as compared with the costs encountered in using stone from Porto Bello and sand from Nombre de Dios.

It is interesting to compare the costs of many kinds of work before July 1, 1909, with the cost during the years that followed. In the Atlantic division it was costing 67.3 cents a cubic yard to excavate material with steam shovels up to that date; by 1912, the cost had fallen to 63.6 cents. At Gatun spillway, the cost of plain concrete fell from $8.00 a cubic yard to $7.42. Dry filling at Gatun dam fell from 49.4 cents a cubic yard to 38.6 cents a yard. At Gatun locks, the cost of plain concrete in position fell from $7.79 a cubic yard before July 1, 1909, to $6.94 a cubic yard in 1913. Back-filling at Gatun fell from 58.56 cents a cubic yard in 1910 to 42.56 cents in 1913.

In the Central division, the average cost of excavating prior to July 1, 1909, had been $1.03. By 1912, the cubic yard cost was reduced to 54.62 cents. This achievement stands as a monument to the lamented Lieut. Col. D. Du Bose Gaillard, who died too soon to see his wonderful work in Culebra Cut completed. It seemed that he had a positive genius for lowering unit-costs after Colonel Goethals had pointed the way with his cost-keeping system. He bore cheerful testimony to the value of that system before a committee of Congress, saying that he spent a great deal of his time studying his cost sheets and trying to discover from them where economies could be effected. As difficulties multiplied, unit-costs went down. Although slides might come down like avalanches, they could never force up the unit-cost in Culebra Cut. They might even force the bed of the canal to rise, but still the unit-costs went down. Big diversion channel embankments might burst and flood the cut, steam shovels might be caught and overturned, dirt trains might be imprisoned, trackage facilities might be injured, but Nature could not stay that steady march of Colonel Gaillard's unit-costs down the scale. More rock was encountered as the cut deepened, longer hauls had to be made in the disposal of the spoil as the work progressed, there was less elbow room for manœuvering the digging army as the sloping sides of Culebra Cut narrowed, but still the unit-cost figures went down. It was a brilliant achievement, deserving to rank among the greatest feats in the history of engineering.

Enormous sums were saved to the United States by the successful application of the cost-keeping sheets to the problem of digging Culebra Cut. During the fiscal year 1910, it resulted in the saving of about $5,000,000; in 1911, it saved some $7,000,000; in 1912, it saved nearly $9,000,000, and in 1913, it saved upwards of $5,000,000. In 1908, it was costing 11½ cents a cubic yard to load material on the cars with steam shovels; in 1912, this unit-cost had fallen to less than 7 cents. In 1908, the expense of drilling and blasting was more than 14 cents a cubic yard; in 1912, it was less than 12 cents a cubic yard. In 1908, it was costing more than 18 cents a cubic

yard to haul spoil to the dumps, an average distance of about eight miles; in 1912, this expense had fallen to less than 14 cents a cubic yard, although in the meantime the average hauling distance had increased to twelve miles. It cost 13 cents a cubic yard to dump the material in 1908 as compared with less than 5 cents a cubic yard in 1912. One pound of dynamite in 1912 was made to do the work that had been done by two pounds in 1908. Such was the story all through the great work at Culebra. Every man's work was checked every month and he could see for himself how he stood in comparison with other men doing similar work. Commanding the Culebra brigade was a master of economy and efficiency, hammering away day by day at the unit-costs.

The Pacific division also effected economies. It drove the unit-costs of dry excavation with steam shovels down from $1.01 a cubic yard to 71 cents a cubic yard. The unit-costs of plain concrete fell from $6.67 to $6.03 at Pedro Miguel, and at Miraflores it fell from $8.11 to an average of $5.01 per cubic yard.

So it was with every part of the work. Studying cost-sheets as a doctor studies temperature and pulse records, analyzing expense tables as a chemist analyzes a compound, it was easy to see every bad symptom and easy to detect every element that tended to keep unit-costs from reaching a minimum. Here it was costing too much to operate a steam shovel; there it was costing too much to lay a yard of concrete; at another place a dynamite gang was not doing as well as another group. Here the repair bill for Lidgerwood cars was too high; there too much time was being taken by spoil trains in getting a load of dirt to the dumps and back again. When the steam shovel was not making a satisfactory showing, the reason for the inefficiency was ascertained and remedied; when the repair bills in the Lidgerwood dirt cars was too high, a way was found to better center the load and thus permit the increase of capacity of cars. When there was too much time consumed by the dirt trains in making a round trip, it was found that the cause was broken cables in the Lidgerwood unloading apparatus and broken couplers on the cars. A weak link, which would break just below the parting point of the cable, overcame one delay, and a bridle that would hold the cars together, even if the coupling parted, overcame the other difficulty.

It was a case of speeding up at one place, effecting an economy at another, and making an improvement somewhere else. Now it came in the shape of a request for a little more energy at this point, now it was to save a little cement by shaking the bags, and now the saving of lubricating oil by having an inspector on the job. A saving of $50,000 by shaking cement bags was no small item. Enginemen and steam shovel men were somewhat wasteful with their lubricating oil, and the bill was moving up into six figures. Colonel Goethals detailed a man to visit all the engines and steam shovels and see how the oil was used. Then he issued instructions that a certain type of engine should have a certain amount of oil and that this oil should be furnished in standard cases. The result was a saving of tens of thousands of dollars.

The result of this careful attention to detail was such remarkable efficiency in the removal of 174,000,000 cubic yards of material and in the laying of 4,000,000 cubic yards of concrete that, out of the saving effected, Colonel Goethals was able to finance the removal of 58,000,000 cubic yards of additional materials, and carry to victory the war against the slides, one of the mightiest battles that man ever waged against Nature.

It is a remarkable record, not only in the saving of money but in setting an example of public efficiency the like of which seldom has been seen and which never has been surpassed. It shows why the canal was completed years ahead of expectations.

# CHAPTER XXVIII

## THE CANAL ARMY

Inspiring Story of Human Achievement—Splendid Personnel—Built in Spite of Law of Congress Providing for Construction—Resignation of First Commission—Second Commission Resigns—Not the Fault of Members of Commissions—Revamping the System—The Executive Order that Pulled the Teeth of the Law—Americans a Fine Lot of Fellows—The Eliminating Process—Thousands came and Hundreds Stayed—Weighed in the Balance—Long Hours and Inconveniences—The Pay Train—The Canny Scotchman—Why Worry?—Well Paid for Work—The Labor Unions—The Eight-Hour Law—Continuing the Old Wage Scale—Settling the Strikes—Colonel Goethals Takes a Hand—Accumulating Days of Leave—The Man with the A-1 Record—Two Shifts—Keeping Men at Work as Elbow Room Decreases—American Brains, Foreign Brawn—The European Laborers—How They Lived—Full Pocketbooks Too Heavy to Carry Around—The British Negro—Politeness and Deference—The Races Separated—The "Gold Roll" and the "Silver Roll"—The Postoffice—Recruiting Agents—Help Constantly Changing—Spanish Laborers—Staying with the Job.

IN ALL the history of the race there is not to be found a more inspiring story of achievement that we find at Panama, and it is largely due to the splendid personnel and the wonderful *esprit de corps* of the men who made up the canal-digging force. Whether it was the higher official in the service or the lowest switch tender in the ranks, the individual efficiency was remarkably high.

The canal was brought to a successful culmination in spite of the law of Congress providing for its construction. That law provided that the canal should be dug by a commission of seven men. The first commission was made up in such a way that there were conflicting powers in which the governor, the chief engineer, and the chief sanitary officer had independent sway, each in his particular field. So seriously did this threaten to disrupt the whole work that President Roosevelt decided to ask for the resignation of the first commission and to appoint another in which authority should be centered in three of the seven members, these three being the chairman, the governor, and the chief engineer.

This scheme did not work much better than the one which preceded it. When the resignations of the members of the second commission were asked for President Roosevelt appointed his final commission, concentrating the offices of chairman and chief engineer in one man, but leaving the power of control in the seven members of the commission. The result was just about what one might expect if seven generals of equal authority were put in command of an army in the field. Yet this was the plan Congress had laid out, and upon which it insisted. Two commissions had split upon the rock of equal authority, two chief engineers had been driven away by it, and now a third commission was about to be split and a third chief engineer was about to be driven away.

President Roosevelt soon saw that it was not the fault of the men who made up the commission, for they were all men of big caliber and good qualifications. Rather,

it was the system, and the system he determined to revamp. He ordered the concentration of authority in the chairman and chief engineer. Congress had not repealed the law that threatened the third disruption of the canal organization, but President Roosevelt pulled the teeth of it by his executive order concentrating authority in one man. This order aroused a bitter feeling in some quarters, but it built the Panama Canal.

The Americans who worked under the commission were as fine a lot of men as ever were banded together in a great constructive work. Loyal to the core, each man was ready to make any sacrifice that the interests of the undertaking demanded. Hence the work could not but move forward with a swinging stride under their direction. They were the cream of a long process of elimination. Thousands came and hundreds stayed. It was a great place for trying out a man; the weakling soon lagged behind and was dropped out. Only the upstanding, right thinking, energetic and industrious man could make good in a country where the climate bored itself into the very soul of every individual and put the acid test upon his nerves, where diversions were few and occasions for homesickness many.

In the course of a year or two of selection there was a body of picked Americans on the isthmus—a lot of men who could defy the climate, who found surcease from the pangs of homesickness through keen interest in their work, who served in the canal army without a backward look and with an "onward" spirit, just as they might be expected to serve in an army called to the defense of the American flag.

There were about 5,000 Americans on the job at Panama. Every man among them worked as many hours and put himself to as many inconveniences as the exigencies of the situation demanded. They were at it early and late. The pay train, for example, had to be loaded early in order to get the force paid off in the three days scheduled, and that meant that the paymaster had to be up and at work at 4 o'clock in the morning. During the trip across the isthmus in the pay train, sixteen hundred pounds of gold and twenty-four tons of silver were handled, in payment for a single month's work.

Upon one occasion Commissioner Rousseau was going over the work on the Pacific terminals. He had seen one engineer after another, and finally came to J. A. Loulan, a canny Scotchman in charge of the Ancon quarry, of whom it had been said that "he can get more work out of a rock crusher than the man who made the machine." The night before a Jamaican negro hostler had knocked the chock from beneath the wheels of an engine and it had run down the steep incline, off the end of the rails, and had sunk waist deep into the soft earth. At 2 o'clock in the morning Loulan was called up on the telephone and advised of the mishap. At half past two he had a force of men on the scene and at work getting the engine back on the track. When the commissioner met him he was as full of the "go ahead" spirit as though he had had nine hours' sleep and never a trace of Jamaican indifference to worry him. It was remarked that he did not look like a man who had been the victim of such carelessness, and he replied:

"Oh, what's the use to worry? That does not pay. We got the engine back on the track again, our force was at work at the usual time, and that hostler will be more careful next time; so why worry?"

Why worry? That was the philosophy heard everywhere. A thousand and one difficulties could thrust themselves into the faces of the engineers, slides could pour into Culebra Cut, dirt trains could sink into the seas of mud, sentiment at home could distrust Gatun Dam, muckrakers could assail the feasibility of a lock canal, but still the force pushed forward, surmounting each difficulty as it arose and cheerfully disposing of it with the query, "Why worry?"

The question of labor unions was one which threatened to handicap the work on

the canal, but the firm hand of the chief engineer put an end to that issue. Careful to recognize every legitimate right of labor organizations, he reserved the right of final judgment in all matters pertaining to the building of the canal. He was glad to have the American workman given the benefit of the eight-hour law, and was a champion of the plan to pay the men wages and a half for their work. When the change from the construction organization to the permanent organization took place he came to Washington and appealed to Congress to continue the old wage scale until the last finishing touch was put on the work.

When strikes were threatened, Colonel Goethals said: "Gentlemen, decide for yourselves. Quit work if you want to. That is your right and privilege. But if you do so, remember that under no circumstances will you be reëmployed." He said this in such a way that they knew that he meant it. After the boiler-makers' strike of 1910, when some of the boiler-makers walked out because they did not get their wages raised from $5.20 to $6 a day, the jobs were filled and the strikers were told that the isthmus had no more work for them. There never was another strike among the Americans there.

As work on the canal slowed down the men were permitted to accumulate eighty-four days of leave to their credit, so that when they returned to the States they would have ample time, with pay, to look around for other work. Likewise, provision was made that when a man left the isthmus, the record made by him during his services on the canal could be taken from the commissioners' card index and a transcript furnished. A man who had made an A-1 record at Panama was certified as being entitled to be rated as "excellent," and the man who came back to the States with such a record had little trouble in obtaining work.

Another evidence of the interest of the chief engineer in his men came when the steam shovel work began to fall off in Culebra Cut, because of the lack of elbow room. Colonel Goethals ordered that the work be changed to a two-shift basis, and thus the men who would have been dismissed were able to continue work for many months, with no disadvantage to the government.

It was American brains that dug the Panama Canal, but the brawn of British subjects that did the work. Perhaps nine-tenths of all the West Indian labor came from British colonies of the Caribbean region. Jamaica and Barbados were the principal recruiting grounds. Usually the Barbadoan was found out on the canal itself, while the Jamaican preferred the lighter tasks around the hotels, the quartermaster's department, and such places.

When the negro began work on the isthmus he did not have much of a reputation for industry, and very little more for strength. He was accustomed to very light work, at the hardest, on his native heath, and when he got to Panama he found the pace a strenuous one. After a brief experience with the West Indian, Chief Engineer Stevens declared that he found that one Italian or one Spaniard could do the work of three negroes, and so it was decided that the wage scale should be fixed in proportion to the working qualities of the two races. The European laborer was paid twenty cents, gold, an hour for his work and the negro, ten cents an hour. The West Indian received ninety cents a day and had the choice of feeding and lodging himself or of being subsisted and quartered by the Canal Commission for twenty-seven cents a day.

The European laborer received $1.80 a day and was charged forty cents a day for subsistence. The rations furnished the negro were practically a counterpart of the United States field rations in quantity and quality, yet the negroes preferred, as a rule, their little thatched huts and their meagre diet to the barracks and the wholesome food of the West Indian kitchen. On the other hand, the Spaniards stuck to the government quarters and the govern-

ment mess halls. In both cases the Canal Commission sought to have their menus made up by cooks of the same nationality as the men and with due regard for the habits of diet of these men at home. The Spaniards patronized the commission quarters and the commission mess hall because they were so far away from home that their wives could not come with them. The West Indian could easily save up enough to provide five dollars for steerage passage for his wife, and so he chose his home and its freedom and companionship in preference to good food and sanitary quarters. His little yam patch, his bean plot and his chickens made him perfectly happy. It mattered not that he was underfed; this system permitted him to work when he wanted to and to loaf when he preferred. Colonel Goethals once said that if the West Indian negro were paid twice as much he would work only half as long, for a full pocketbook was too heavy for him to carry around. There were many exceptions to this rule, but for most of them there was a long rest after pay day.

The British negro is deeply religious and most respectful. He has no dreams of equality. He is polite and deferential and is generally liked. He reminds one of the good old-time "darky" of the South.

The races were separated at Panama about as carefully as they are in the South to-day. The separation was not on the basis of black and white, but on that of "gold" and "silver" employees. As all blacks were on the "silver" roll it amounted to segregation of races. On the labor trains there was a separation between the Spanish laborers and the negroes. Some cars were marked "for blacks only," and others "for European laborers only," but for the most part it was "gold" and "silver." This was the rule in the railroad stations and even in the postoffices. Sometimes negroes coming down from the States would go to the postoffice and to the "gold" window for their mail. The clerk would tell them to go around to the "silver" window. This they would protest against doing, but the clerk would turn a deaf ear to all their protests. They would threaten to take the matter up with the Washington government or carry it to the courts, and expose a hypocritical policy that would make a "Jim Crow" postal service in Panama while failing to do so in the States. But they still had to go to the "silver" window for their mail.

The negroes at first had to be secured by recruiting agents. They were fearful of the Panama Canal, remembering what had happened to their brethren in the days of the French. But after the first year or two the stories of prosperity that came back from Panama proved a strong drawing card, and nearly every negro in Barbados and Jamaica who could raise the price of a steerage passage, five dollars, sooner or later found himself on board a Colon-bound steamer. The recruiting service secured about 26,000 laborers before it closed its work. The commission then depended on the natural inflow of labor to supply its demands for brawn. Every year, thousands would return to the islands whence they came, and other thousands would be on hand to take their places.

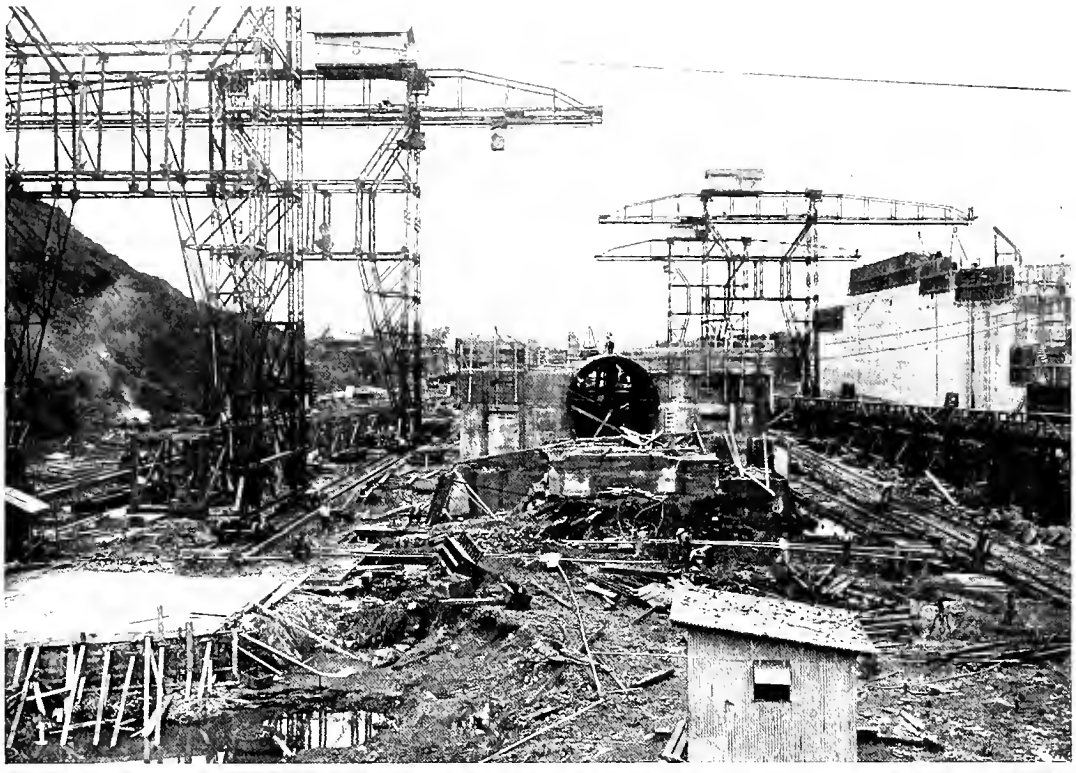
The negro help was thus constantly changing, and more than half of the force changed each year. But the labor market was always well supplied. There was always an excess of arrivals over departures, the surplus in some years amounting to 20,000 men.

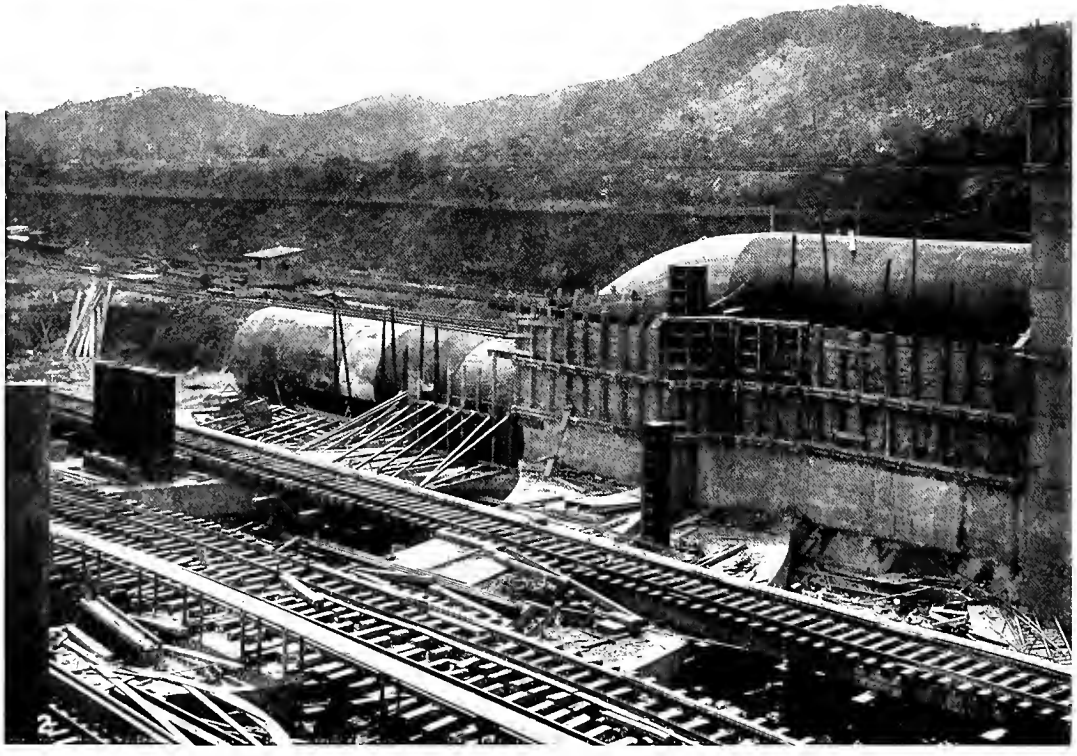
The Spanish laborers were the best and steadiest workers that ever came to the isthmus. The government was permitted to recruit them only on condition that it would pay them in gold and repatriate them when their tasks were ended. The Spaniard was a very hard worker, and saving of his shining yellow wages. He was the balance wheel of the labor situation, too. The negro knew he must make good, or the Spaniard would take his place.

After the Spaniard had been on the isthmus for several years he began to grow

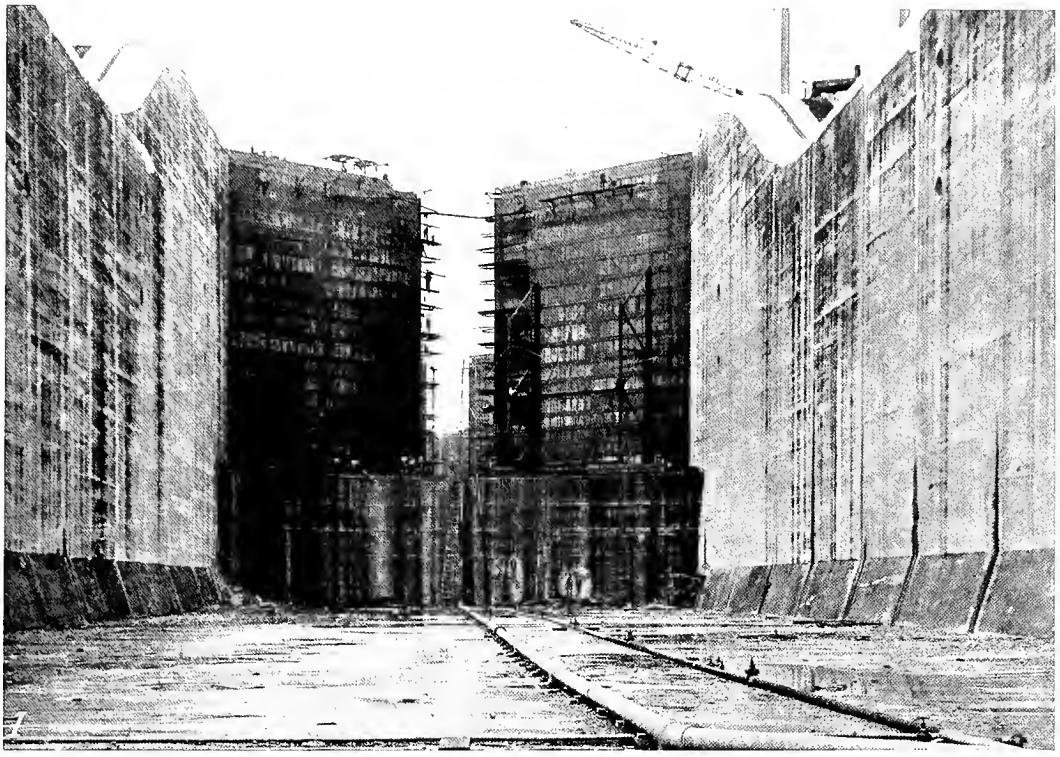
somewhat assertive of his rights as he construed them. When this condition reached a head, Colonel Goethals took a very decided stand. He told the Spaniards that he was through with their services under the terms of the agreement and was ready to send them home. He announced, however, that if any of them wanted to enter into a new contract with the government on the same terms as others, he would leave the way open for them to do so. They saw the situation and accepted the new conditions, with the result that they stuck to the job to the end and were able to go back home with enough money to make them independent for life, on the basis of their frugal method of living.

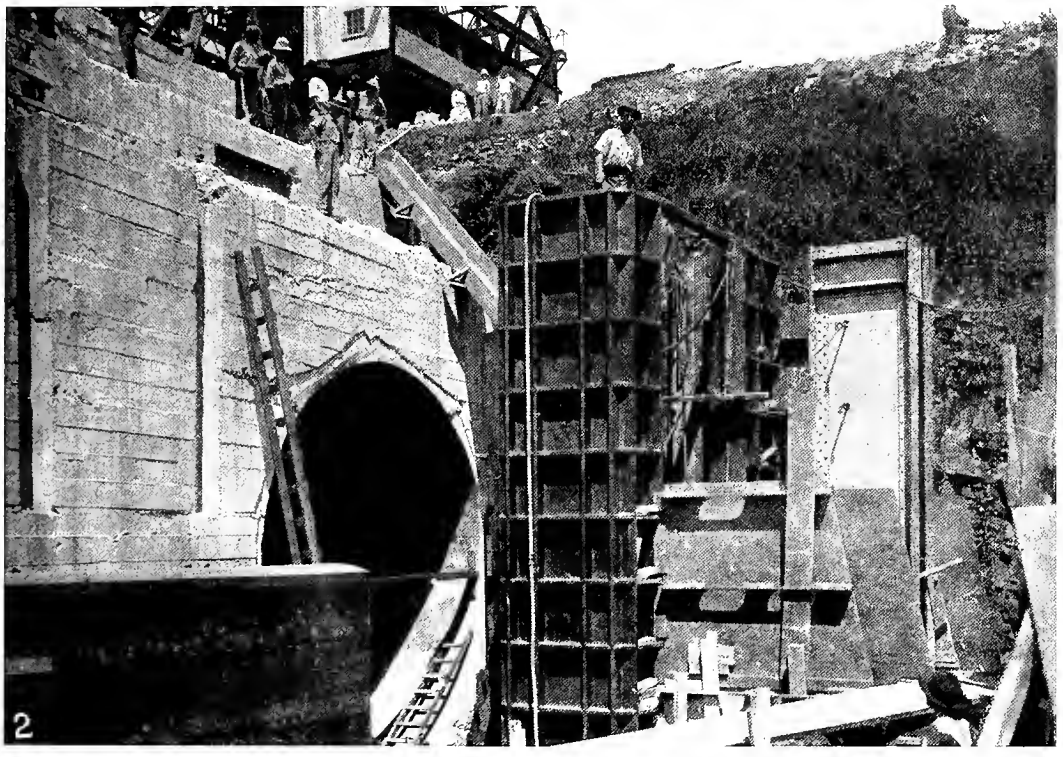
The United States owes a debt of gratitude to the men who bore the heat and burden of the great work of laying low the barrier that interposed itself between the oceans. When we think of the burning heat of the sun in the dry season, of the debilitating atmosphere of the wet season, of the tropical climate that caused clothes to mildew and shoes to turn green with mold overnight, a condition that kept up for nine months of the year, we may well imagine that the men who tugged and toiled day in and day out under such handicaps were made of sterling stuff.





1. Section of the centre wall of Pedro Miguel Lock in course of construction, with culvert built into it.
2. Framework of the same culvert, showing how the water is passed down through a gigantic gooseneck from one level to another.





1. One of the big gates nearing completion. From the bottom of the gate to the bottom of the floor below is 28⅓ feet, which represents one of the three lifts a ship gets on its way up from the sea to Gatun Lake.
2. One of the valves that control the water in the main culverts.

# CHAPTER XXIX

## QUARTERING AND FEEDING THE CANAL ARMY

FIGHTING HIGH PRICES—GOOD MANAGEMENT OF THE COMMISSARY AND SUBSISTENCE DEPARTMENTS—THE KIND AND CHARACTER OF THE FOOD SUPPLIED—PRAISE BY CONGRESSIONAL VISITORS—CHARACTER OF HOUSES SUPPLIED—JEALOUSY AMONG THE WOMEN—PROTESTS OF PANAMA MERCHANTS—ONE PRICE FOR CANAL EMPLOYEES AND ANOTHER FOR OUTSIDERS—THE GOVERNMENT MADE A SUBJECT OF EXTORTION—WORK OF THE COMMISSARY BAKERY—HOTELS AND BOARDING HOUSES RIVALS OF THOSE IN THE STATES.

IT is a military axiom that an army travels on its belly, and this might be applied to the canal army as well. And although one head of the commissary was disgraced for accepting gifts from people interested in contracts, that does not alter the fact that the commissary and subsistence departments rendered invaluable service and were instrumental in providing the people with all the necessaries of life at rates unprecedented in the retail trade.

Without the commissary and subsistence departments, the army would have had to face prices as high as the avarice of the natives could make them. With these departments they got supplies and food at prices that were usually lower than those made in price cutting sales by American department stores. The supplies were bought by the government at the lowest wholesale rates, and were sold to the people at the bare cost of handling. Clothing was much cheaper than in the United States. Foodstuffs could be bought at a bare margin over wholesale prices. Meats were good in quality and very cheap. If ever there was a kingdom around which a wall was built through which the barbarian High Price could not enter, it was the Canal Zone. Not only did this apply to the commissary, where supplies were bought, but to the subsistence department, where meals were provided. The West Indian negro got the equivalent of a United States army field ration at nine cents a meal; the Spaniard got the equivalent of a United States army garrison ration at thirteen and one-third cents a meal; the Americans in the I. C. C. dining rooms got the equivalent of modern American hotel fare for thirty cents a meal. United States Senators and members of Congress said meals were better than they could get in House and Senate restaurants at any price.

Let us take up in their order the three departments which had to do with the physical comfort of the people of Panama—the quartermaster's department, the commissary department, and the subsistence department.

The activities of the quartermaster's department covered many duties, chief among them the purchase of supplies and the maintenance of quarters. It also looked after the labor situation, the sanitation of the Canal Zone so far as it involved grass cutting and ditch digging, maintenance of the storehouses where the materials and supplies for the construction of the canal were kept, and the disposition of scrap. But we are concerned with the work of the quartermaster's department in providing homes for the people. There were divers and sundry types of houses provided. Some of these were family houses, in which the officials lived; some were two family houses, in which the lesser officials and Americans lived; some were four family houses, in which the American members of the force lived. All were screened in and all contained every necessary provision for comfort and health. There were quarters for the European laborers, and barracks for the negro laborers. The American bachelors

had a special type of house, a long row of rooms with verandas on two sides, with one or two men in each room. These quarters were light, airy, and cheerful, equipped with sufficient furniture to make them comfortable.

Married Americans were furnished with houses of such type as their position on the isthmus demanded. Applications for these houses were filed in the order of their receipt, and there was a constant waiting list for prospective vacancies. Sometimes bachelor quarters had to be fitted up for men and their wives while they waited for suitable houses. The women took their meals with their husbands at the I. C. C. hotels pending the opening of their own homes.

All houses were furnished by the government. The furnishings corresponded to the type of house, but all the houses were complete enough to make the ordinary family comfortable. There was freedom from the ordinary worries of the householder, for coal was furnished for cooking, and ice for the refrigerator. There were no electric light bills, no water rents to pay, and no drug stores accounts to meet. Free medical attendance was also provided, and the lot of the American on the isthmus was a happy one so far as the routine expenses of the householder were concerned.

But with all this the women of the Zone found frequent cause for jealousy. Miss Brown thought Mrs. Jones had better lighting facilities; Mrs. Smith thought Mrs. White was favored in the matter of bedsteads; and Mrs. Johnson was in possession of a vast amount of proof of discrimination against herself and her family. The district quartermasters had to practice the gentle art of diplomacy in such cases to so great a degree that it is certain that any one of them could now qualify for almost any diplomatic post.

The housing problem was met with satisfying results to everybody except the West Indian negro. The two family flat for Americans receiving from $200 to $300 may not have been quite as satisfactory as the six or seven room cottages, of which there were a few for this class, but on the whole the employees who lived in two family flats had little to complain of. Employees who received less than $200 a month lived in four family flats, which gave them all the comforts they could hope to get in like positions at home, and rent was free at Panama as against $300 a year at home.

The Spaniard was as happy and contented in his little bachelor quarters as the American married man in his house or flat, since the fact that he could send so much good American gold back to his people in Andalusia or Galicia made up for his absence from those he loved. The Spaniard's quarters were like those of the American bachelor, but on a largely reduced scale.

As to the negro, his quarters were barracks, with bunks that probably reminded him too much of the bunks in a prison cell. So it happened that although here he could have free quarters he greatly preferred a thatched hut in the "bush." And as tropical architecture is simple, he could provide for himself with no outlay except some work with a machete at odd moments for a week or so. Then he could invite his family from Jamaica or Barbados to the Canal Zone, which invitation was promptly accepted by wives, children, dogs, chickens, and all. So the commission quarters went begging, and not more than one-fifth of the negroes made use of them.

The commissary was one of the most effective of all the adjuncts of the canal building organization. When the United States started to build the canal it saw at once that if the canal army were not protected from the avaricious disposition of the tropical American, it would result in the demoralization of the forces. Therefore the commissary organization of the Panama railroad was utilized for supplying the canal army with its day-to-day needs. This protected the canal forces from the cut-throat prices in Panama, at the same time leaving the canal diggers free to buy where they could buy to the best advantage.

The Panama merchants protested energetically against the commissary, for they saw in the canal army a trade that would make them rich. But the canal authorities stood firm, and the commissary continued to the end. It finally came about that the native merchant made two prices, one for the canal employee and the other for the outsider. The canal employee was given a price in keeping with those at the commissary, else the native merchant could get none of this trade. The outsider did not have the privilege of buying at the commissary, and when he went to the native merchant he was charged "all the traffic would bear."

The rapacious character of local business is shown by the way the government fared on a number of occasions when the commissary supplies had to be replenished in the local markets. Once a ship bringing coffee to the commissary went aground and the commissary authorities ran short. They replenished their stock in the local wholesale market, but paid six cents a pound more for the coffee at wholesale than it had been selling for at retail before the ship went aground. At another time a vessel carrying milk failed to arrive and that commodity jumped to double its ordinary price over night. High waters in the Chagres River cut off the train service on the Panama Railroad at another time, and the price of ice ran up the scale from fifty cents a hundred pounds to one dollar a hundred pounds. In view of such instances as these, which occurred every time the commissary had to go out into the local market for its supplies, the United States is to be congratulated that Uncle Sam decided to play the rôle of merchant at Panama.

The main reason why the commissary was operated through the Panama Railroad rather than through the Canal Commission itself was because of the requirement that all moneys received by the Commission should be covered into the Treasury. With the railroad company it was different. It could turn its money over and over again without covering it into the Treasury or having it reappropriated. This enabled it to act as commissary keeper without the embarrassments which the Canal Commission would have encountered.

The commissary never sold on credit and yet never sold for cash. As it was established for the benefit of the employees only, the general public could not buy. Employees were furnished with coupon books which were paid for in cash if the employee had no wages coming to him, or charged against his account if he had already earned enough to pay for the book. When the pay roll was made up these amounts were deducted from his monthly pay. The commissary detached coupons from the books as purchases were made. An employee could buy a book and deposit it with the commissary storekeeper and then telephone his order if he desired to do so.

The commissary did a business of $7,000,000 a year during the construction period, and bought to good advantage because of the quantity handled. It was able to sell porterhouse steak for 20 cents a pound at a time when round steak was bringing 24 cents a pound in Washington. Round steak was 13 cents a pound, leg of lamb 20 cents, veal chops 24 cents, pork chops 18 cents, blue fish 15 cents, sugar cured ham 20 cents, cabbage 4 cents, white potatoes 3 cents. Everything else was equally cheap in price.

Every morning there went out of Colon a train carrying perishable supplies to the people along the line. This refrigerator train supplemented the work of the local commissary store which was to be found in every Zone settlement.

The commissary bakery baked over 6,000,000 loaves of bread a year, and about 200,000 pounds of cake. The commissary laundry washed nearly 4,000,000 pieces a year. The commissary ice cream freezer made over a hundred thousand pounds of ice cream a year, and the commissary egg testers tested over 30,000 eggs a day.

The subsistence department managed the hotels and boarding houses. There were eating places provided for all manners and conditions of men and grades and degrees of pocketbooks. First among these were the Tivoli and the Washington hotels, where one's fancy could be indulged to about the same extent as in a first class New York hotel. During 1912 the Tivoli cleared $53,000. Approximately 161,000 meals were served, the cost of food being fifty-one cents and the cost of service nineteen cents per meal.

The I. C. C. hotels were really restaurants serving meals only at the usual mealtime hours. The Americans employed in the Zone could get meals at these eating houses at thirty cents each, and the fare left nothing to be desired.

The line hotels served over 2,000,000 meals during the fiscal year 1912, at a loss of about $12,000. If a private contractor had held the contract and had made only two cents per meal, he would have been $40,000 ahead at the end of the year. The material composing each meal cost a little over twenty-five cents and the service one cent and six and one-half mills. On some days the attendance ran above 3,000, while the average was 2,000.

The European laborers' messes gave them rations at forty cents per day. There was, in 1912, a small profit made on these messes, and some writers, with money making instinct, have condemned this. But the service was worth all that was charged for it. The mess halls were large and airy, the men had cooks of their own nationality, and their appetites were catered to in every reasonable way. Nearly all the Europeans on the isthmus took their meals at the mess halls, and without exception acknowledged that never before had they known what it was to have such a liberal supply of food.

With the negroes there was difficulty. At first the Commission tried to compel them to get their meals at the West Indian kitchens. These kitchens appeared spotless in every respect. Everything was prepared in a very wholesome way. But in spite of this, and in spite of the fact that the United States was offering them the equivalent of a United States army field ration for twenty-seven cents a day, it was unsatisfactory to them, and they were finally allowed to subsist themselves. Many of them became weak from deficient nourishment and, therefore, could not do a full day's work, but even that was to be preferred to a continual shortage of negro labor.

On the whole, supplying the needs of the canal army in shelter, food, and raiment was a gigantic task in itself. It cost much to do it, but it was worth more than it cost; for the army, knowing that Uncle Sam was its shield and buckler against the high prices existing everywhere else in the world, was a contented and reasonably happy body of men, and never failed in its efforts to construct the canal in the shortest possible time.

# CHAPTER XXX

## LIVING CONDITIONS IN THE ZONE

LACK OF RATIONAL AMUSEMENTS A SERIOUS DRAWBACK—HOW COLONEL GOETHALS SOLVED THE DIFFICULTY—THE Y. M. C. A. TO THE RESCUE—CLUB HOUSES ESTABLISHED—A GREAT TEMPERANCE MOVEMENT—THEATRICALS AND MOVING PICTURES INTRODUCED—BASEBALL AND SPECIAL TRAINS—WOMEN'S CLUBS PROVE A GREAT FEATURE IN PROMOTING CONTENTMENT AMONG THE FEMALE RESIDENTS OF THE ZONE—SATURDAY NIGHT DANCES.

"OUR most serious handicap is the lack of rational amusements. The people have so few diversions that they soon yearn for their homes in the States, and that condition is followed by the loss of good men from our force." Thus spoke Colonel Goethals, upon one occasion, in discussing the needs of the great work. That was shortly after he took up the reins on the isthmus, and he was quick to meet the situation. Several Y. M. C. A. buildings had been built which were intended to serve as club houses for the men, but the plan had not been developed. New buildings were added at several places and a liberal policy adopted that made the Y. M. C. A. enter largely into the every-day lives of the men and women of the Canal Zone. The club houses were the meeting places of nearly all the organizations of Americans. Their large, spacious rooms were given over to a meeting of the women's club, or devoted to a dance or a concert, or became the scene of amateur or even professional theatricals.

The people liked the liberalized Y. M. C. A. idea, and the club houses were most beneficial. One of the first evidences of their usefulness was the falling off of liquor sales. Before they were built the men had no place of resort except the saloons. The men drank and kept drinking largely because there was nothing else to do.

This and many other causes made for discontent, and during the first two years over ninety per cent. of the Americans returned home each year.

It was perceived that if the work was to be a success the government itself would have to provide amusements for the men. Congress had made no specific appropriation for such a purpose, so President Roosevelt decided to build the club houses and discuss the matter with Congress later. But Congress never debated the subject. The good results were so obvious that there was no room for argument.

Each club house contained billiard rooms, an assembly room, a reading room, bowling alleys, dark rooms for the camera clubs, gymnastic equipment, an ice cream parlor and soda fountain, and a circulating library.

When these club houses were built drunkenness quickly fell into disrepute, and the saloon trade fell off at least sixty per cent. Men who had frequented the saloons could now be found at the club houses reading the latest paper from home, going through the new magazines, taking part in a game of billiards, or at work with their bowling teams.

The club houses were under the management of the Y. M. C. A. and trained men were put in charge, their salaries being paid by the Commission. How useful they made themselves in creating a spirit of contentedness, on the part of the American worker, is shown in the history of work accomplished.

The dues of the members were only ten dollars a year, and the operations annually left a deficit of about $7,000 at each of the larger club houses which was assumed by the Commission.

The activities of the Y. M. C. A. club houses are set forth in the annual report for 1912. It shows that during the year seven companies visited the Canal Zone from the United States, giving eighty-five entertainments, with a total attendance of 21,000; and 406 entertainments given by local talent and moving pictures scored a total attendance of 96,000. During the year the bowling alleys recorded a total of 104,000 games, and 278,000 games of pool and billiards were played. There was a total attendance of 15,000 at the gymnasium classes, while 420,000 books were withdrawn from the circulating libraries for home reading. Soft drinks, light lunches, and ice cream dispensed yielded a revenue of $60,000.

The Y. M. C. A. work was only a part of the general scheme of recreation. The commission maintained a band for the benefit of the people at an annual expense of about $12,000; band concerts were given regularly at various points, and special trains run for the benefit of employees and their families who desired to attend them.

Baseball made as strong an appeal to the American love of sport at Panama as ever it did at home, and the commission encouraged this in every way, furnishing grounds, special trains, and opportunities for practice; and no league ever fought out a more exciting series of contests than the isthmian league. Usually the pennant contenders were the teams of Empire and Culebra, and the whole isthmus became engrossed in their fight.

When the Americans first went to Panama there were few who took their wives and children with them. But after the yellow fever germ was exterminated and the malaria germ was denied admittance to the precincts of the isthmian home, men who had families in the States brought them to the isthmus, and the bachelors began to sigh, each for the girl he had left behind. The result was that there was soon a large number of American wives on the Canal Zone, and with nothing to occupy their minds they soon became the victims of discontent. Each woman thought every other woman was treated better than herself by the quartermaster and the commissary attendant, and the petty little annoyances that in a normal community would be laughed away, flourished there even as the vegetation of the untamed jungle.

To remedy this condition Miss Helen Vanck Boswell was invited to visit the isthmus to organize women's clubs. She went and was welcomed with enthusiasm by the women, who set to work with a will in all the affairs with which such clubs interest themselves. Their lonesomeness gave way to contentedness, and instead of dwelling upon fancied wrongs they developed a spirit of satisfaction at being able to help along the great work of building the canal by promoting the general welfare among both men and women.

The spirit of the commission in providing rational amusements and comforts for the people may be read in the statement that the cost of these accessories amounted to more than two and a half million dollars a year.

The Canal Commission provided good churches for both white and black, where ministers of any denomination could meet with their flocks, and several chaplains were employed at its expense to help with the religious work of the community. The negro churches were built so that the lower story could be used for worship and the upper story for lodge purposes.

The social life on the isthmus centered at the Hotel Tivoli, which was built with a spacious ballroom where the fortnightly Saturday night dances could be held. These dances were given under the auspices of the Tivoli Club, composed of representative Americans. The youth and beauty of the American contingent turned out in force at these functions.

During the latter years of the construction period the new Hotel Washington, with its ballroom opening three sides to the

sea, was opened, and on alternate Saturday nights dances were held there.

From time to time there was a word of criticism as to the liberality of the Canal Commission in providing rational diversion for the people who had to build the canal. With all that was done, however, fifty per cent. of the Americans still grew weary of the heat and the stress of the big task every year and went back to the States.

Life on the Canal Zone was all that a generous government could make it, and yet it was not one iota more pleasant or more profitable than was necessary to make it bearable to a sufficient number to enable the canal work to go forward in a satisfactory way.

# CHAPTER XXXI

## THE CANAL FORTIFICATIONS

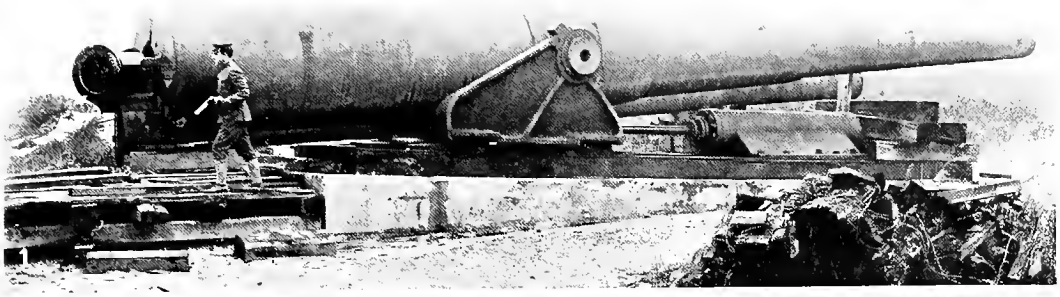
Isthmian Topography Suited to Canal Fortification—The Atlantic Defenses—The Fortified Islands of the Pacific—Size and Character of the Armament—Danger of an Open Attack from the Sea Eliminated—Remarkable Search Light Equipment—Plenty of Reserve Ammunition—The Fire Control Station—The Troops Stationed on the Isthmus—Waters Suitable for Planting of Mines—Naming the Panama Forts—A Great Military Reservation—Locks in Little Danger—Right of the United States to Fortify the Canal.

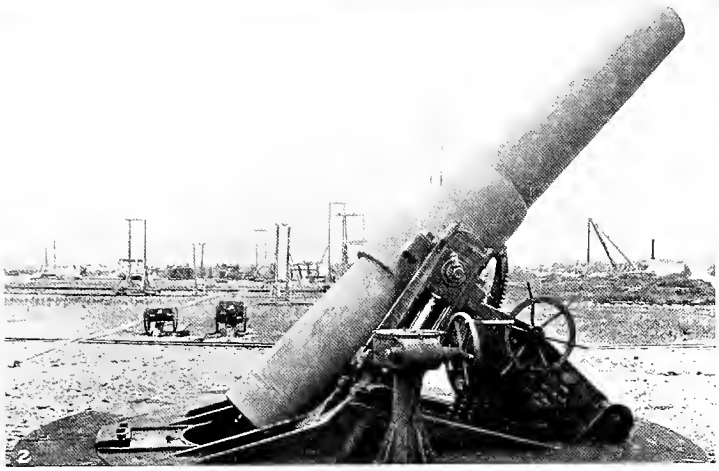
THE topography of the terminal sections of the Panama Canal lends itself admirably to the purpose of the military engineers to whom was intrusted the task of making the canal impregnable against a sea attack. At the Atlantic side the entrance to Limon Bay is somewhat narrow, and the big guns mounted at Toro Point, on one side of the mouth of the canal, and at Margarita Island, on the other side, completely command this entrance from the sea. But this narrow opening from the Caribbean into Limon Bay has been made much narrower by the building of two great breakwaters, one extending out toward the canal for a distance of two miles, and the other being about a mile long on the opposite side, but not connected with the mainland. It reaches back, however, toward the mainland to shallow water, and any hostile ship which might seek entrance would be directly under the guns of Margarita Island. The powerful armament there protects the canal against any attack by sea, since no ship would expose itself to the terrific fire of the land batteries and the great mortars planted there.

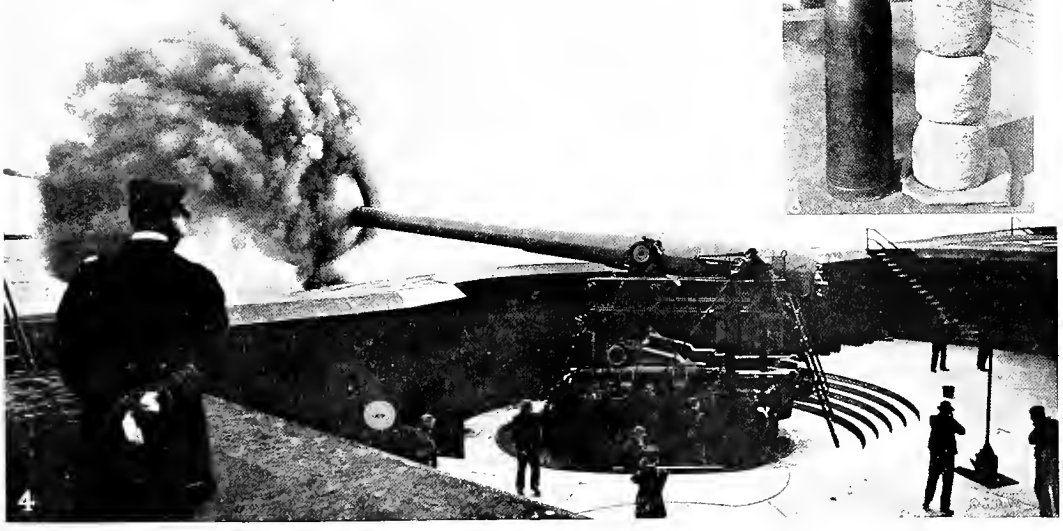
At the Pacific end all the defenses are on the east side of the channel. Several islands, among them Naos, Flamenco, and Perico, are situated a little distance east of the Panama Bay section of the canal, and some three miles from the mainland. These islands rise precipitously out of the sea and afford excellent sites for heavy armament. They have been connected with the mainland by a breakwater built from Balboa to Naos Island. This island has been connected with Perico and Flamenco by stone causeways. A railroad and a driveway provide military communication between the mainland and the fortifications.

The heaviest armament at each end of the canal consists of a 16-inch gun. These are the largest weapons in possession of the United States, and perhaps the largest in the world. Each gun is fifty feet long and weighs 284,000 pounds. At an elevation of forty-five degrees the range is over twenty-four miles, but as mounted the range is something over eleven miles. The projectile is six feet long, weighing 2,400 pounds, and containing 140 pounds of high explosive. The charge is 670 pounds of smokeless powder, the explosion of which causes a pressure of 38,000 pounds per square inch. The muzzle velocity of the projectile is 2,250 feet per second, or 1,500 miles per hour, and the muzzle energy is 84,000 foot tons. The shell will penetrate any armor plate in existence at eleven miles range. At this distance the water line of a ship would be ninety feet below the horizon.

The secondary defenses on each side consist of six 14-inch guns, six 6-inch guns, sixteen 12-inch mortars, and eight 4 7/10-inch howitzers. The mortar shells have a range of 20,000 yards, or over eleven miles; each shell weighs from 700 to 1,046







DEFENSES OF THE CANAL

1. The 16-inch gun.
2. Type of 12-inch mortar.
3. Projectile of 16-inch gun, 6 feet long.
4. Firing a 12-inch disappearing gun.

pounds, and carries from 60 to 120 pounds of high explosive. At extreme range the shell reaches an altitude of over eight miles, its target being the deck of the hostile warship.

The small guns and howitzers will come into play only when an enemy approaches within a mile of the fortification and attempts to effect a landing. These howitzers may be moved from place to place to meet the needs of the mobile forces in case of attack by land. A battery of eight howitzers will be stationed permanently at Gatun locks. At both ends of the canal the twelve-inch mortars are so placed that they will be useful in repelling attacks by land as well as holding the enemy in check at sea. They will be able to sweep the country on the Atlantic side as far inland as Gatun locks, and on the Pacific side as far as the Miraflores locks. If called upon to take part in a land defense they will be loaded with shrapnel, a most effective weapon against field troops.

The guns of the permanent forts are all mounted on disappearing carriages of the very latest models known to military science, which were especially designed and put through a most exacting test before being adopted.

With the armament now in position at Panama, the authorities at Washington do not fear any open attack upon the fortifications. Such an attack would result in disabling so many battleships that no enemy could afford to take such a risk unless it had first met and defeated the United States navy.

Surprise attacks are guarded against by a complete searchlight equipment at the fortifications. There are 14 searchlights, each with a sixty-inch reflector, capable of sweeping the entire horizon. Each of these searchlights was built at a cost of more than $20,000, the mirror alone requiring a year for its construction. The lights are operated from electric plants independent of the main plants at Gatun and Miraflores. The guns, also, are operated by electricity generated at these independent stations. A supply of more than $2,000,000 worth of ammunition will be kept on the Isthmus at all times. Each sixteen-inch gun has a supply of seventy rounds of ammunition. The fourteen-inch guns, carrying a shell weighing 1,400 pounds, have approximately the same number of rounds. These guns use a 365-pound charge of smokeless powder, and their shells will pierce the best of armor at ten miles range.

The fire control stations by which the guns find the range of the enemy are as complete as those of any other fortress in the world. With lofty lookouts and the instrument known as the range finder, the approximate distance between the guns and the enemy may be readily determined.

The defenses at Panama are manned by twelve companies of coast defense troops. Quarters for eight companies have been established on the Naos Island dumps. Two other companies are quartered at Toro Point, and the remaining two at Margarita Island. These four companies on the Atlantic side will be reinforced by those from the Pacific side in case of need. There are also three regiments of infantry, one squadron of cavalry, and one battalion of artillery stationed on the Isthmus, for which permanent quarters cost approximately $3,000,000. In addition to the quarters provided for troops stationed on the canal, field works are provided for the accommodation of 20,000 extra troops which may be sent to the Isthmus in case of war. The works are in the form of barricaded positions, intrenchments, and protective breastworks of such design as to enable the troops to undergo a state of siege. These field works are placed principally around Gatun and Pedro Miguel. All buildings for the permanent forces on the Isthmus are constructed on the unit plan so that any necessary expansion may be easily made.

When it was decided to fortify the canal, it was generally agreed that the fortifications should be impregnable. The General Board believed that such fortifications

would be an invaluable aid in the transfer of a United States fleet from one ocean to the other in the face of an opposing fleet. It pointed out that guns mounted on shore are on an unsinkable and steady platform, where they can be provided with adequate protection and accurate range finding devices. The board suggested that the mere statement of these elementary facts was sufficient proof of the value of seacoast guns in protecting the fleet while passing out to engage a waiting hostile fleet.

The appropriations committee of Congress took much testimony on the question of fortifications and their adequacy. General Weaver, Chief of the Coast Artillery Division, testified that in his opinion the defenses of the canal would be entirely adequate. He remarked that the only doubts expressed had been as to the means for preventing an enemy from using Taboga Island as a base of attack on the Pacific fortification, but that he considered this a groundless fear, because the guns of the Pacific fortification would not only cover Taboga Island but the waters for some distance beyond it. The mortars and the sixteen-inch gun range nearly five miles beyond Taboga, and the fourteen-inch guns about three miles beyond.

In addition to the defense provided by permanent fortifications, the waters at both sides of the Isthmus can be defended by mines. Provision has been made for this method of defense.

The fortifications at both entrances were named in advance of construction by Secretary of War Stimson. The Toro Point forts and batteries were named in honor of General W. T. Sherman; those on Margarita Island, in honor of General W. F. Randolph; and those in Panama Bay in honor of General U. S. Grant and Dr. Amador, the first president of the Panama Republic.

Under the plan of government the whole Canal Zone is practically a military reservation. Only such settlements are allowed as are necessary for the operation of the canal, and the governor is practically a law unto himself, exercising surveillance over the canal. Many persons have expressed fears concerning the danger of the destruction of the locks by high explosives, secretly placed by one or two men. Colonel Goethals is not one of those who entertain such fears. In order to accomplish the destruction of the locks, it would be necessary to place the charge very carefully, and even in time of peace the canal operators and watchmen are always on guard. As to airships, they could do no serious harm unless they were able to drop a huge explosive directly behind a lock gate. Aërial navigation has not yet reached the degree of skill required for such accuracy of aim.

The right of the United States to fortify the canal was at first disputed, not only abroad, but by some Americans. The confusion of thought on this subject was caused, in part, by the ambiguous language of the first and second Hay-Pauncefote treaties. While the first treaty seemed to deny the right to fortify, which in part led to the amendment of the treaty by the Senate and its consequent rejection by Great Britain, the second treaty, now in effect, tacitly recognizes the right of the United States to erect fortifications. In the notes exchanged between the two governments Great Britain explicitly recognizes this right. The temper of Congress was such, however, that even if Great Britain had not recognized this right, the canal nevertheless would have been fortified, in the absence of any stipulation binding the United States to refrain from defending its own property.

# CHAPTER XXXII

## TERMINAL FACILITIES

SUPPLYING COAL TO GOVERNMENT SHIPS—SUPPLIES FOR COMMERCIAL VESSELS—GOVERNMENT COAL PLANTS AT EACH END OF THE CANAL—OIL STORAGE TANKS—BARGE AND LIGHTER SERVICE—GOVERNMENT DOES NOT SEEK A MONOPOLY OF THE COAL BUSINESS—BALBOA DRY DOCK—DETAILS OF ITS OPERATION—CRANES FOR HANDLING CANAL GATES AND HEAVY GUNS—BUILDING THE FOUNDATIONS FOR THE PERMANENT STRUCTURES—COMMERCIAL WHARVES AND PIERS—CHARACTER OF CARGO HANDLING APPARATUS—ADMINISTRATION BUILDING—THE NEW CITY OF BALBOA—BREAKWATERS AT THE TERMINI OF THE CANAL.

THE most ample and modern facilities are provided at the Panama Canal for transferring cargo from one ship to another and for fueling, docking and repairing. Under the Spooner Act the President was directed, among other things, "to construct such safe and commodious harbors at the termini of the said canal as shall be necessary for the safe and convenient use thereof." When the estimates of 1908, fixing the total cost of the canal at $375,000,000, were adopted, authorization was made for the construction of breakwaters, but nothing was provided for other harbor improvements or facilities. These facilities were supplied and operated by the Panama Railroad Company in connection with its commercial business.

It was early seen that the canal would require freight handling facilities of much greater extent than the Panama Railroad would be warranted in furnishing. As the months lengthened into years, after the estimates of 1908 had been made, it began to appear that such terminal facilities as had not been provided for could be built out of the savings that were resulting from efficiency in the construction of the canal itself. Specific legislation was contained in the Panama Canal Act of August 24, 1912, which authorized the President to "establish, maintain and operate, through the Panama Railroad or otherwise, dry docks, repair shops, yards, wharves, warehouses, storehouses, and other necessary facilities for providing coal and other materials, labor, repairs, and supplies of the Government of the United States, and incidentally for supplying such at a reasonable price to passing vessels."

The government intends to supply its own ships with coal and to keep enough on hand at all times to supply such ships of commerce as cannot replenish their bunkers at a reasonable cost from private dealers. For this purpose a coaling plant has been established at each end of the canal. The main plant is located at the Atlantic terminus, and has a normal capacity for handling and storing 200,000 tons of coal, with a possible increase to 300,000 tons. One hundred thousand tons of this will be stored under water. The plant is located at the north end of the island at Cristobal, which is connected with the mainland over a bascule bridge crossing the French canal, and connecting with the Panama Railroad. The subsidiary coaling plant is located at Balboa, on the outer end of the south approach wall of the big dry dock. It has a frontage of 500 feet especially adapted for discharging vessels, and a frontage of 500 feet with high level bunkers adapted for loading vessels and barges. This plant is capable of handling and storing 180,000 tons of coal, with a possible increase to 300,000 tons. In addition to coal, facilities are provided at both ends of the canal for

supplying ships and the canal with fuel oil, there being two tanks at each terminus, the four having a combined capacity of 160,000 barrels of oil. Like the coal-handling plants, the fuel oil plants may be enlarged as the business of the canal expands.

A great deal of coal will be handled by barges or lighters that can be brought up alongside vessels, and the canal is equipped with a large number of them, as well as with fuel oil and fresh water lighters. It is expected that a number of steel barges of large capacity that have been used by the commission will be available for transfer to this service. A barge capacity of 16,000 tons of coal has been recommended by the Navy Department for the Atlantic terminus and one of 8,000 tons for the Pacific terminus.

It is not the intention of the government to maintain a monopoly of the business of handling coal. It will lease to individuals coal space in its coal-storage basin, and will furnish them with a means of handling the coal at a pro rata cost. It will give them the benefit of all its coal-handling machinery, charging them no more for its use than the government itself must pay.

Docking facilities are found at both termini, but mainly at Balboa. The main dry dock is large enough to accommodate any vessel that can enter the canal through the locks. Its length is 1,000 feet, its depth over keel blocks thirty-five feet, and its entrance width is 110 feet. A suitable site was found under the protection of Sosa Hill, where it is safe from bombardment from the sea. The dock was founded on rock, and its walls are lined with concrete. Diamond borings taken over the entire area proved the rock to be solid.

The dock will open from the canal, and normally it will be closed by a pair of mitering gate leaves very similar to those used on the canal locks, and operated by machines similar to those operating the lock gates. On the dock floor a seat is provided for a floating caisson at a sufficient distance from the gate to enable it to be painted and repaired when the caisson is in place. The dock is filled by means of longitudinal culverts in the concrete side walls, communicating with the dock basin through openings in the dock floor at its intersection with the side walls. The flow of water is controlled by four metal valves operated by machinery. The time required for filling the dock at extreme high water is about twenty minutes. The plant for emptying it consists of four centrifugal pumps driven by electric motors. The diameter of the stream from these pumps is approximately fifty-four inches. The time required for completely emptying the dock by pumping will not exceed two hours and ten minutes, under which circumstances nearly 6,000,000 cubic feet of water must be removed from the great basin, with an average head of approximately twenty-two and a half feet.

For smaller vessels, an auxiliary dry dock is used, for which a foundation on similar hard rock was found. This small dock was built instead of the marine railway that was once planned as a part of the canal equipment.

In anticipation of probable requirements, it was decided that two floating cranes of largest size would be necessary to handle the lock and dock gate leaves. These cranes were planned also to meet the requirements of the Navy Department. They are capable of handling the heaviest guns and armament in connection with the canal fortifications, and, also, are available for handling heavy freight. Likewise they are useful in repairing commercial vessels as well as for wrecking service, either of a military or commercial nature. Each of these cranes consists of a large steel pontoon 150 feet long, eighty-eight feet wide, and sixteen feet three inches average depth. The power is "steam electric," steam being supplied by a Scotch machinery boiler. Electric energy is generated at 220 volts direct current by steam generators. The pontoon is not self-propelling,

but is fitted with a powerful steam capstan at each of the four corners for warping the crane into any desired position. The cranes are further fitted with suitable towing bits, cleats, and two 3,000-pound anchors, handled by steam.

All of the piers and quay walls are built on reinforced concrete caissons put down to solid rock. In making these caissons, a concrete mixing plant was mounted on a train of cars in order to permit its being moved from one spot to another. From this mixing plant the concrete was poured into the space between two circular shells, where it was allowed to harden. The shells were then removed, leaving a great section of reinforced concrete piping about eight feet in diameter and six feet long. The first shell of the caisson, which was ten feet in diameter, had its lower end equipped with a sharp steel shoe. As it cut down into the earth of its own weight, laborers inside removed the material from under the shoe, allowing it to sink deeper. The remaining sections were eight feet in diameter, which permitted the full weight of the upper sections to fall upon the one at the bottom. A jet of water was forced around the lower section as it sank down, which served to make its movement more rapid. At times the weight of the upper sections was sufficient to force the caisson rapidly down through the soft mud, while at other times material was encountered which required a pressure of twenty-five tons in addition to the weight of the imposed sections above to force it down, even very slowly. A stratum of material encountered twenty-five feet below the surface at one place yielded sulphuretted hydrogen gas, which affected the laborers' eyes so much that some of them were forced to go to the hospital. When the lower caisson reached bed rock it was firmly anchored there, while the sections above were tied together with heavy iron rods. After the entire caisson was in place, concrete reinforced with rod iron was put into the caisson, practically making it a reinforced concrete pile ten feet in diameter in its bottom section, and eight feet in diameter all the way up to the proper level above the surface of the ground.

The wharves and piers for commercial use at Cristobal are situated between Cristobal Point and the canal channel. They are of permanent construction, about 1,000 feet long and 209 feet wide, with 300-foot slips between the five piers for which room has been provided. On the Pacific side, the piers for commercial use are at Balboa, and are placed at right angles to the line of the canal with the ends of the piers about half a mile from the center of the canal channel.

The superstructure of the commercial piers and wharves consists of one-story steel sheds having a clear height of twenty-five feet. They are of fire-proof construction with reinforced material used at every point.

There was some delay in the provision of cargo handling appliances, since there was no certainty as to the amount or character of freight destined to Panama for transshipment. It was found that the best type of cargo machinery could not be determined upon until the amount and nature of the business passing through the canal were more definitely known.

Most of the permanent buildings of the canal are located at the Pacific end. All of them were built of concrete blocks and structural steel. The administration building is located on an eminence about seventy-five feet above the surrounding plain at the base of Ancon Hill. It is three stories high, with a frontage of 327 feet and a depth at the end wings of 182 feet. The surface of the concrete blocks is covered with cement stucco and the roof is covered with dark red vitreous tiling. There is a central rotunda forty-three feet in diameter around which the offices are grouped. The floor area, exclusive of halls, lavatories, stairways and elevator shafts, is 67,000 square feet. The cost of this building was $375,000.

Below the knoll on which the administration building stands there once was a

great marsh. This was filled in to an elevation of twenty-five feet above sea level by material from the site of the harbor works and from Culebra Cut. On this the white settlement has been established, with its public buildings, such as the post office, police station, fire station, hotel, lodge hall, schoolhouse, commissary store, church and Y. M. C. A. building. All these buildings are connected by a continuous arcade. There is also a baseball ground, a tennis court and a band stand. The dwellings are arranged to provide for one, two, three, and four families.

Perhaps the most beautiful site on the whole Isthmus overlooks the Balboa terminal. It is the elevated plateau made by cutting into the side of Ancon Hill for the stone used in building the Pacific locks. About 500 marines will be quartered here in barracks costing $40,000.

The filled area at Balboa dump, made by dumping 30,000,000 cubic yards of material from Culebra Cut into the shallow waters of the Pacific Ocean, provided a desirable site for the eight companies of coast artillery quartered at the Pacific end of the canal.

The terminal waters of the canal are well protected by breakwaters. At the Pacific terminal the Naos Island breakwater is three miles long. It lies nearly parallel with the canal from 900 to 2,700 feet east of the channel and rises from twenty to forty feet above mean sea-level. Its top width varies from fifty to 3,000 feet and it contains nearly 18,000,000 cubic yards of material brought from Culebra Cut. It serves the double purpose of giving dry land connection between the forts on Naos and her sister islands and the mainland, and protecting the mouth of the canal against the cross currents which otherwise would bring into it millions of cubic yards of silt. A railroad track and a driveway will extend along its crest from the mainland to the islands. More than five days were required to complete this breakwater.

At the Atlantic entrance there are two great breakwaters. The one from Toro Point is two miles long, with a top width of fifteen feet and a height above sea-level of ten feet. It contains nearly 3,000,000 cubic yards of rock, that for the core coming from the Toro Point quarries, and that for the armor from the Porto Bello quarries.

The other breakwater does not join the mainland. There is an opening of 2,000 feet between it and the one from Toro Point, through which ships will pass. This breakwater is intended to prevent the filling up of the canal channel by silt deposits. The cost of the two Atlantic breakwaters was about $11,000,000, of which $7,000,000 was expended on the big one at Toro Point.

The work of designing the terminal plants for the canal was in the hands of Civil Engineer H. H. Rousseau.