N O ONE can dispute the wisdom of the United States in deciding to build a lock canal. To have undertaken a sea-level canal would have involved this Government in difficulties so great that even with all the wealth and determination of America, failure would have ensued. It is, perhaps, putting it too strongly to say that a sea-level canal is a physical impossibility, but it is not too much to say that such a canal would take so much money and so much time to build that the resources and patience of the American people would be exhausted long before it could be made navigable.

The advocates of a sea-level canal declared that a channel could be dug through Culebra Mountain with the excavation of 110,000,000 cubic yards. As a matter of fact, Culebra Cut, with its bottom 85 feet above sea level, required the excavation of almost that same amount.

Engineers who advocated a sea-level canal declared that the material in Culebra Mountain was stable, and that only moderate slopes would be necessary. As a matter of fact, the material in the mountain proved highly unstable, and, except for a few short sections, slides and breaks were encountered all during the construction period. The
result was that practically two Culebra Cuts were dug. The engineers, in beginning the present canal, calculated that 53,000,000 cubic yards would be excavated in Culebra; the amount actually removed was 105,000,000 cubic yards. Upon this basis a sea-level Culebra Cut might have required the excavation of 230,000,000 cubic yards.

Calculating an average monthly excavation of a million cubic yards, the task would have required 17 years to complete. In other words, if a sea-level canal had been undertaken and had been physically possible, the celebration of the opening of the waterway would have been set for 1925 instead of 1915.

Among all of the members of the majority of the board of consulting engineers who favored a sea-level canal, only one, E. Quellenec, Consulting Engineer of the Suez Canal, showed any appreciation of the difficulties which were to be expected in Culebra Cut. He announced, in voting in favor of a sea-level canal, that he could not do so without first reminding the United States Government of the great difficulties that would lie before it in Culebra Cut. Henry Hunter, Engineer of the Manchester Ship Canal, declared that Culebra Cut presented no serious problems at all; that a sea-level cut could be dug more quickly than the locks of the other type of canal could be built. He further declared that it was as clearly demonstrable as any engineering problem could be, that it would be possible to use 100 steam shovels in Culebra Cut. No one has accused the engineers on the canal of lack of ability in maneuvering shovels, yet at no time were they able to use more than 46.
If President Roosevelt had followed the recommendation of the majority of the board of consulting engineers in favor of a sea-level canal, it seems probable that the United States would have followed the French in retiring defeated from the Isthmus, or else would have reconsidered its purpose to build a sea-level canal and have undertaken a lock canal, as the French had done. But, even if it had been possible to build a sea-level canal at Panama, it appears that such a canal would not have been as satisfactory as the present one. While the canal the United States possesses at Panama to-day is a great waterway 300 feet wide at its narrowest part, in which ships can pass at any point, the sea-level canal projected would have been a narrow channel winding in and out among the hills, too narrow for half its length for the largest ships to pass. Currents, caused by the Chagres River, and by the flow of other streams into the canal, would have made navigation somewhat dangerous.

The principal ground upon which the majority members of the board of consulting engineers voted in favor of a sea-level canal was that it was less vulnerable. This contention, in the light of what has happened at Panama, seems to carry no great weight. Such a canal would have required a masonry dam 180 feet high across the Chagres at Gamboa, to regulate the flow of that river into the canal. This dam, very narrow and very high, would have been a much fairer mark than the great Gatun Dam for the wielder of high explosives. Furthermore, while earth dams, like that at Gatun, have weathered earthquake shocks of great sever-
ity, masonry dams, like that proposed for Gamboa, have been tumbled to the earth by shocks of much less power. The regulating works at Gatun will take care of a volume of water approximately twice as great as the Chagres has ever brought down. On the other hand, the proposed dam at Gamboa would have cared for only one-third as great a discharge as the highest known flow of the Chagres.

It was calculated that the lake made by the dam at Gamboa would always be held at low stage between floods, but if two floods came in quick succession this might have been impossible. Such a situation would have made the Chagres River always a menace to the canal, instead of its most essential and beneficent feature.

Those who objected to the lock type, on the ground that the locks could be destroyed, seemed to forget that even the sea-level project demanded a set of locks to regulate the tides of the Pacific. While, contrary to the usual idea, there is no difference in the mean level of the Atlantic and the Pacific Oceans, the difference in the tides at Panama is about 18 feet. This is due to the shape of the Bay of Panama. As the tide sweeps over the Pacific and into that bay, it meets a funnel-shaped shore line, which gradually contracts as the tide travels landward. The result is that the tide rises higher and higher until it reaches a maximum of 10 feet above average sea level. When it flows out it reaches a point 10 feet below average sea level, thus giving a tidal fluctuation of 20 feet. On the Atlantic side the tidal fluctuation is only 2 feet.

Under these conditions the canal could not be operated during many hours of the 24 without the
tidal locks, if at all, and it would be almost as great a hindrance to have the tidal locks destroyed as to have the present locks injured. Another perpetual menace in a canal with a bottom width of only 150 feet for half of its distance, would be the danger of a ship sinking and blocking the channel. When the Cheatham sank in the Suez Canal it wholly blocked the waterway for nine days, and partially blocked it for a month.

According to the Isthmian Canal Commission, the present canal affords greater safety for ships and less danger of interruption to traffic by reason of its wider and deeper channels; it provides for quicker passage across the Isthmus for large ships and for heavy traffic; it is in much less danger of being damaged, and of delays to ships because of the flood waters of the Chagres; it can be enlarged more easily and much more cheaply than could a sea-level canal. The lock canal has a minimum depth of 41 feet, and less than 5 miles of it has a width as narrow as 300 feet. It can take care of 80,000,000 tons of shipping a year, and, by the expenditure of less than $25,000,000 additional, can increase this capacity by at least a third. It can pass at least 48 ships a day, doing all that a sea-level canal could do, and many things that a sea-level canal could not do.

No one denies that if it were possible to have a great Isthmian waterway at sea level as wide as the present lock canal, it would be the ideal inter-oceanic waterway. But, as such a proposition is out of the question, the American people have at least one thing for which to thank Theodore Roosevelt — that at a critical time in the history
of the canal project he allowed himself to be converted from the advocacy of a sea-level canal to the championship of a lock-level canal, in the face of a majority report of one of the strongest boards of engineers ever assembled, and prevented a situation at Panama that would have been humiliating to America, and which probably would have ended for all time the efforts of centuries to let ships through the American Isthmus.
CHAPTER XXIV

FORTIFICATIONS

WHEN Congress decided that the Panama Canal should be regarded as a part of the military defenses of the Nation, it became necessary to fortify it in such a way as to make it practically impregnable to naval attack. It was, therefore, decided that there should be ample coast defenses at the two ends of the canal and that these defenses should be protected from land attack by the quartering of a sufficient number of mobile troops to hold in check any landing parties that might attack the works by an overland route.

In carrying out this plan Congress met every demand of the military experts. When the plans for the fortifications were pending before the Appropriations Committee of the House every military authority, from Gen. Leonard Wood and Col. George W. Goethals down, who appeared before the committee was asked if he considered the defenses recommended as sufficient for the purposes intended, and each replied in the affirmative.

These defenses consist of large forts at each end of the canal, with field works for some 6,000 mobile troops. The defenses on the Pacific side will be somewhat stronger than those on the Atlantic side,
probably for the reason that better naval protection ordinarily could be afforded to the Atlantic than to the Pacific entrance, on account of the proximity of the Atlantic waters of the canal to American shores.

At the forts on the Atlantic side four 12-inch guns, sixteen 12-inch mortars, six 6-inch guns and four 4½-inch howitzers will be mounted. The guns at this end of the canal will be distributed between Toro Point on the west side of the entrance channel and Margarita Island on the east side. There will be two big 14-inch disappearing guns at each of these points. They will be so placed as to sweep the horizon in the seaward direction, and at the same time will be able to concentrate their fire on the enemy as he steams in toward the channel entrance between the great breakwaters which cut off Limon Bay from the ocean.

At the Pacific end all of the defenses will be on the east side of the channel. They will consist of one 16-inch gun, six 14-inch guns, six 6-inch guns and eight 4½-inch howitzers. There are three small islands on the east side of the Pacific entrance channel known as Naos, Perico, and Flamenco. They rise precipitously out of the water and offer ideal sites for heavy defense. A huge dump or breakwater has been built from the mainland at Balboa out to Naos Island and this, in turn, has been connected with Perico and Flamenco by large stone causeways. The great dump has made several hundred acres of available land for quartering the eight companies of coast-defense troops which will be stationed at the Pacific end of the
canal. These islands are 3 miles from the mainland and their guns will completely bar the way to any hostile ships which might seek to enter the canal.

On the other side of the channel, at a distance of about 12 miles, lies the island of Taboga where the Canal Commission maintains the sanitarium for its employees. It had been suggested by some that fortifications should be planted there, but it was declared by the military authorities that the guns of Naos, Perico, and Flamenco would completely command this island and prevent a hostile nation from using it as a base of operations.

The range of the guns extends more than a mile beyond Taboga Island. The big 16-inch gun which will be mounted on Perico Island is the largest ever built. It was made at the Watervliet Arsenal. It carries a projectile weighing more than a ton for a distance of 21 miles. At 17 miles it can toss its death-dealing 2,400-pound shell at an enemy as accurately as a base-ball player throws a ball to a team-mate 17 yards away. Its projectiles are filled with powerful explosives, a single one of which in the vitals of any battleship would be enough to place it out of commission. The big guns and the mortars are intended primarily for defending the canal from attack by water. The smaller guns and howitzers would come into play when an enemy approached within a mile and would be used to repel his efforts to effect a landing. Nearly all of these howitzers may be moved from place to place to meet the needs of the field troops in case of land attack. Eight of them will be permanently stationed at Gatun Locks. There
will be other field works at Gatun, Miraflores, and Pedro Miguel ready for occupancy at a moment’s notice by the field troops stationed on the Isthmus. These howitzers are so located that 12 of them may be concentrated at any given point in case of danger.

The big guns of the permanent forts are all mounted on disappearing carriages so that they are exposed to fire only at the moment of discharge. The 12-inch mortars will not only play their part in defending the canal from water attack, but will be able to sweep the country on the Atlantic side as far inland as the Gatun Locks and on the Pacific side as far inland as the locks at Miraflores. They have a range of nearly 4 miles, and when loaded with shrapnel will prove a most effective weapon against field troops operating anywhere within the vicinity of the locks.

The land lying contiguous to the sea-level ends of the canal will be platted off into squares exactly as a city is laid out. Should hostile troops come upon this territory the men in the fire-control station would simply ascertain the number of the block or blocks on which they were operating, and the mortars would be so oriented as to throw their big projectiles thousands of yards into the air to fall directly on those blocks. They would, therefore, be practically as useful in land operations as in the water defense.

Every feature of the armament defending the entrance of the canal will embody the latest improvements known to military science. The carriages for the big guns have been specially designed, and were put through the most thorough
and exacting tests before their adoption. The fire-control stations are said to be the last word in insuring the effective use of the guns. Determining how a big gun shall be aimed so that its projectile will hit a target 10 miles away is not an easy task. Of course, the gun can not be pointed directly at the target, since this would cause the projectile to fall far short of the enemy, and also the effect of the wind and the motion of the enemy would carry it wide of its mark. To guess the range and to secure it by experimentation would be to prevent any effective fire whatever. Therefore, it is necessary first to determine the approximate range, the motion of the enemy and the velocity of the wind.

There is an ingenious instrument known as the range finder, by which the approximate distance of the target is determined. This instrument looks something like a cross between an opera glass and a small telescope. The operator puts his eyes to the opera glass part of the range finder and locates the enemy just as one would with an ordinary pair of glasses. When he locates the hostile ship he sees two images of it. There is an adjusting screw which he turns until the two images blend together and become one. The turning of this screw automatically adjusts a scale on the instrument, and when the two images exactly coalesce the distance of the ship is registered on the scale. The operators in the fire-control station make the necessary calculations as to the effect of the wind, the motion of the enemy and other elements entering into marksmanship, and telephone the results below to the men who aim the gun.
It takes two men to aim each gun; one takes care of its up-and-down movement, and the other of its right-and-left movement. When the man in the fire-control station telephones that the enemy is so many miles away, the man who has charge of the up-and-down movement of the gun so adjusts his telescopic sight on a registering scale that when it is pointed directly on the enemy the muzzle of the gun will be elevated high enough to carry the projectile that distance. The man who has charge of the right-to-left movement adjusts his sight so that when it is pointed directly at the enemy the muzzle of the gun will be pointed far enough to the right or to the left to land its projectile amidship on the enemy. Each man stands on a platform and operates a little wheel on an endless screw. He turns this wheel backward or forward just enough to keep his sight exactly on the enemy.

After the gunners have received their instructions the first shot is fired. This is called a "ranging" shot, and as the best range finder can not register the distance to the exact yard it is necessary for the fire-control station to gauge exactly how far short of, or how far over, the target the projectile has carried. The up-and-down sight is adjusted in accordance therewith and usually the second, or at most the third, shot gets the exact range. This method of locating the enemy will be used on all the fortifications of the canal.

It is unanimously agreed by military authorities that no naval force will risk an open attack upon such fortifications, since almost inevitably it would result in the disabling, if not the sinking, of a number of battleships and a great crippling of the
enemy's force that he could not afford to risk unless he had first swept the seas of our own naval strength.

In order to make certain that no surprise attack could be successful, one of the most complete searchlight equipments to be found in any fortress in the world has been authorized for the canal fortifications. There will be 14 searchlights, with 60-inch reflectors, made so that they will send the brightest of white lights out to sea and over the land as far as the range of the guns may reach. These searchlights cost more than $20,000 each, and it requires a year to construct the big mirror which is placed in each of them. Electric plants at each fortress will generate electricity for the operation of the guns and of the searchlights.

In anticipation of sudden need nearly $2,000,000 worth of reserve ammunition will be kept on the Isthmus. There will be 70 rounds for the big 16-inch gun—enough to operate it constantly for two hours, providing for a shot about every two minutes. The big 14-inch guns will carry a shell weighing 1,400 pounds, propelled by a 365-pound charge of smokeless powder which will drive it through the air at an initial speed of nearly half a mile a second—enough momentum to carry it through at least 5 feet of wrought iron. The charge of powder by which these guns will hurl their projectiles on their death-dealing mission, generates a force which would lift the great Masonic Temple of Chicago 2 feet in a single second.

Three regiments of infantry, 1 squadron of cavalry, 1 battalion of field artillery, and 12 com-
panies of coast-defense troops will be permanently stationed on the Isthmus. The field troops, consisting of the infantry, cavalry, and field artillery, will be stationed at Miraflores, where permanent quarters will be provided together with the necessary drill grounds. These quarters will cost in the neighborhood of $3,000,000. At this point they can be maneuvered to advantage and moved to any part of the Canal Zone needing defense. It was originally intended to place these troops at Culebra on the east side of the channel, but this would necessitate their going a distance of about 5 miles to get to a point where they could conveniently cross with the artillery to the other side of the canal.

Quarters for eight companies of coast-defense troops are being established on the Naos Island dumps. Quarters for two companies of these troops are being provided at Toro Point, and for two other companies at Margarita Island. These will afford sufficient strength at the Atlantic side to man the guns temporarily, in case of hostilities, until any additional troops needed can be brought up. All of the troops, both field and coast defense, will be adequately housed and the permanent structures erected for them will be as substantially built as those of any modern army post in continental United States. There will be drill grounds large enough to maneuver the troops stationed on the Isthmus. Roads affording access to all parts of the Canal Zone have been built.

In addition to the provisions for the permanent forces on the Isthmus, additional field works will be provided to accommodate the 20,000 troops
which might be brought to the Isthmus in case of war. These field works will take the form of barricaded positions, entrenchments, and other protective breastworks which will enable the troops to undergo a state of siege. It has been estimated by the engineers that behind such works as have been planned one defender can stand off six assailants, so that a body of 20,000 mobile troops under these conditions could hold the Isthmus against a siege of 100,000 for a reasonable time. These field works will be constructed principally around Gatun and Pedro Miguel. The buildings for the permanent force stationed on the Isthmus will be constructed on the unit system so that any necessary expansion can be made.

The question of fortifying the canal was one which engaged the serious attention of Congress for a long time. There were two main viewpoints as to what policy should be pursued. One contention was that the canal should be made neutral, open to the ships of all nations, including the United States, on equal terms even in case of war between the United States and any other country. It was contended by those who took this view that to declare it neutral would render it immune from any attack and guarantee its perpetuity as a great commercial undertaking under the control of the United States.

They contended, furthermore, that the United States was bound, under the terms of its treaty with Great Britain, to make the canal neutral and that to fortify it would be to violate the Hay-Pauncefote treaty. They asserted that the United States was under solemn obligations to
recognize the principle of neutrality as applied at Suez and offered the express terms of the Hay-Pauncefote treaty in proof of their contention. This treaty provided that "the United States adopts, as the basis of the neutralization of such a ship canal, the following rules substantially embodied in the Convention of Constantinople, signed the twenty-eighth of October, 1888, for the free navigation of the Suez Canal; that is to say:

"First, the canal shall be free and open to the vessels of commerce and of war, all nations observing these rules on terms of entire equality so that there shall be no discrimination against any such nation, or its citizens or subjects, in respect of the conditions or charges of traffic, or otherwise. Such conditions and charges of traffic shall be just and equitable.

"Second, the canal shall never be blockaded, nor shall any right of war be exercised, nor any act of hostility be committed within it. The United States, however, shall be at liberty to maintain such military police along the canal as may be necessary to protect it against lawlessness and disorder.

"Third, vessels of war of a belligerent shall not revictual nor take any stores in the canal except so far as may be strictly necessary; and the transit of such vessels through the canal shall be effected with the least possible delay in accordance with the regulations in force, and with only such intermissions as may result from the necessities of the service."

It will be seen from this that the language of the treaty seems plainly to imply that the United
States had no right to fortify the canal. It is interesting to note, however, that when the controversy over the tolls between the United States and England arose, the English Government expressly conceded the right of the United States to fortify the canal and to exercise absolute rights of sovereignty so far as military considerations were concerned. It would constitute an interesting chapter in diplomatic history if someone would tell the real reason why the English Government waived its rights of demanding a neutral canal under the Hay-Pauncefote treaty.

Those who advocated the fortification of the canal contended that the United States had acquired practical sovereignty over the Canal Zone, and that thereunder it had a perfect right to provide for the defense of the territory. They asserted that the canal was undertaken because of the military necessities of the United States, as demonstrated by the trip of the Oregon from the Pacific to the Atlantic, during the Spanish-American War and that to fail to fortify the canal would be to lose the military advantages which its construction had given to the United States.

It was further contended that to allow the canal to be neutral would, in the case of war between the United States and some foreign power, compel the United States to keep its own warships out of the canal its own blood and money had built, or else compel its permanent operating force at Panama to commit a sort of legal treason by putting the enemy's ships through the big waterway on the same terms with American ships.

This contention was answered by those who took
the opposite view with the statement that all treaties would be suspended in case of war and that neutralization would cease between the United States and its enemies at such a time.

The other side replied that if this were true, it would then be too late properly to fortify the Isthmus, and that if the United States expected ever to deny to any country the neutrality provisions of the Hay-Pauncefote treaty, the fortifications should by all means be built in advance.

The long and earnest debate brought forth from some the prediction that England would not acquiesce in such a construction of the treaty, and from others the statement that under the terms of that instrument other nations had a right to protest against the fortification of the canal. In the face of these arguments, however, Congress determined by a substantial majority to fortify the canal, and the whole world has acquiesced. England not only did not protest, but in its toll controversy notes expressly declared that the United States had the right to fortify the canal.