CHAPTER VII

THE NEW PANAMA CANAL COMPANY

The task entrusted to the receiver of the Panama Canal Company was an extremely difficult one. If the affairs of the Company should be wound up it would be impossible to save the shareholders from total, or almost total, loss of their investments, for the property and work which was estimated as worth $90,000,000 depended for its value upon a continuation of the operation.

The gravity of the situation, in which two hundred thousand persons, the majority of them in moderate circumstances, were involved, was fully appreciated by the Government, and special legislation was effected for the purpose of affording the Company temporary relief from the pressure of its liabilities.

Several circumstances militated against the endeavors of the receiver to reorganize the enterprise. The most serious of these was the public scepticism which had followed the failure of de Lesseps to make even a respectable approach towards the achievement of his undertaking. The shareholders had learned at last that systematic deception had been practised upon them for years, and they felt that they had no reliable knowledge as to the state of affairs at the Isthmus.

AN EFFORT TO RESTORE PUBLIC CONFIDENCE

The first step in the process of restoring public confidence was the investigation of the commission to which reference was made in the preceding chapter. In addition to the statement of the amount of work done and the value...
of the plant, the commission gave an opinion that a lock canal might be completed in eight years at a further cost of $100,000,000.

Any hope that might have been derived from this report was, however, dependent upon the success of the receiver in negotiating new concessions with the Colombian Government, for the time limit, under the contract, for the completion of the canal, neared its termination. Lieutenant Wyse, who had secured the original grant, was sent to Bogota immediately following the submission of the commission’s report. After pourparlers that extended over four months, a new agreement was signed December the tenth, 1890, providing for an extension of ten years.

In the meanwhile Joseph Brunet had died and was succeeded by Achille Monchicourt. The new receiver applied himself with remarkable energy and acumen to the organization of an active company. He had contrived to keep the work going upon the Isthmus, although the scale of operations was greatly reduced. During the years 1891–93, he settled, by a series of compromises, most of the lawsuits existing with the old company and successfully resisted certain creditors and bondholders who would otherwise have ruined the interests of all concerned.

STEPS TOWARDS THE REORGANIZATION OF THE COMPANY

In April, 1893, Colombia made a further concession to the receiver, by granting an extension until October 31, 1894, for the organization of a new company and ten years from that date for the completion of a canal. A few months later “a special law for the liquidation of the Interocéanic Canal Company” was passed and had the effect of suspending the most obstructive actions before the courts. Early in the following year, death relieved Achille Monchicourt and his place was filled by M. Gautron. There remained but a few months in which to effect the organization of the new company and, with the co-operation of the attorney
for the bondholders, the receiver bent his energies to the task. They secured the co-operation of the managers of the old company, the contractors, and certain other interested persons, in the new enterprise, in the form of abatements of their claims, and subscriptions to the capital of the reorganization. The amount necessary to complete the full sum was to be asked of the old bondholders and shareholders.

The by-laws of the New Panama Canal Company were filed towards the close of June, 1894. The capital of the company consisted of 650,000 shares of $20 each, 600,000 of which were to be subscribed for, whilst 50,000, absolutely unencumbered, were to be given to the Colombian Government in consideration of the contracts granting extensions. Thus, five years after the appointment of a receiver for the Interoceanic Canal Company, what was generally known as the "New Panama Canal Company" was definitely established.

The new company, like its predecessor, was a commercial concern, pure and simple. Although the French Government, by the exercise of extraordinary legislation, had been largely instrumental in the creation of the company, neither governmental patronage nor responsibility was extended to it.

The directors of the new company appointed a Comité Technique to thoroughly examine the whole problem of the canal. This was a wise determination, for the surveys made under the direction of the old company had been of such a cursory character that little reliance could be placed upon them.

WELL-CALCULATED ACTION BY THE NEW COMPANY

The Comité Technique was composed of seven French engineers and an equal number of foreign experts, including several who had the special advantage of experience in canal work. Whilst making careful surveys and maturing plans
for the ultimate operations, the committee directed the continuance of excavations in places where they were certain to come within the specifications of any plan that might eventually be adopted. In addition to its original investigations, the Comité Technique verified and rectified the surveys and measurements of the old company. In short the technical committee performed the most valuable scientific work that had yet been done in connection with the Isthmus and handed over to the Isthmian Canal Commission maps and documents which Admiral Walker declared to be worth at least a million dollars.

REPORT OF THE COMMITTEE OF INTERNATIONAL ENGINEERS

The final report of the Comité Technique was submitted at the close of the year 1898. It estimated the cost of a canal, which could be completed in ten years, and would be equal to all the demands of commerce, at one hundred million dollars. Aside from the question of health, the Comité recognized two principal difficulties to be overcome—the cut through the divide and the control of the Chagres. The former, whilst a stupendous task, was merely a matter of excavation and involved no serious engineering problem; the latter, on the contrary, presented features sufficiently intricate and perplexing to tax to the utmost the available technical ingenuity of the world. The solution appeared to be susceptible of achievement by several different methods, and numerous plans emanated from sources that commanded respectful attention.

"The studies of the New Company were based on three fundamental principles: (1) To reject any plan that did not, independently of considerations of time and expense, offer every guarantee of a serviceable canal. (2) To reject any fanciful scheme depending on the application of new and untried devices not justified by experience; and (3) to give due weight to the peculiar tropical conditions under which the work must be executed. These must compel
the employment of a class of laborers inferior to those available in better climates, and the work will be exhausting to those supervising the constructions. No technical details should therefore be admitted involving operations of exceptional difficulty.”

THE PLAN OF THE NEW PANAMA CANAL COMPANY

The report of the Comité included two plans contemplating two summit levels, of which the bottom of the canal was respectively sixty-eight and thirty-two feet above mean tide. The relative costs of construction were nearly the same, but the fact that a canal at the higher level could be completed in much less time decided the Comité to recommend that plan.

General Abbott intimated that but for this consideration it is certain that the conclusion of the Comité would have been different. He declared that in the hands of the American Government, with expense a minor condition, “there can be no question that the low level variant should be preferred.” Since the controversy has already been settled for all time and the canal completed at an eighty-five foot level, it is useless to consider the details of the Comité’s projet, to which the plan recommended by the first Isthmian Canal Commission closely conformed. The line follows closely that adopted by the old company, which, with slight variations has been accepted by all subsequent technical surveys. More than half the distance follows straight lines, and in the remainder of the route the highly important feature of curvature leaves nothing to be desired.

This is a detail of the utmost consequence as affecting safety of transit and speed of passage. “Experience on the Suez Canal has compelled, since the route was opened to traffic, a costly increase from the original minimum radius of 700 metres (2,300 feet) to 1,800 metres (5,905 feet). On the Panama projet the ruling radius is 3,000 metres (9,842 feet),

THE NEW PANAMA CANAL COMPANY

falling occasionally to 2,500 metres (8,202 feet), the minimum being 1,700 metres (5,577 feet), and this latter only for about half a mile in approaching Obispo, where the width is sufficiently increased to justify the reduction.”

The scientific information accumulated by the Comité Technique is amongst the most valuable data relating to the Panama Canal extant and is valued at $1,000,000.

CRYSTALLIZATION OF AMERICAN INTERESTS

By the time the Comité Technique had made its report, public sentiment in this country had become strongly impressed with the desirability of a trans-isthmian canal under American control, and a majority in Congress favored immediate action to that end. The Nicaragua route appeared to be the best available at the time and general opinion favored it. The situation thus created caused extreme anxiety to those interested in the welfare of the New Panama Canal Company. It had reached precisely the stage where the directors proposed to appeal to the financiers of the world, when its prospects were thus suddenly overshadowed. Although firmly convinced that the Nicaragua route was greatly inferior to their own, the company realized that should the United States construct a waterway there, or elsewhere, commercial competition would be impossible. This and other considerations would surely deter investors from backing the private enterprise. Furthermore, with the American Government in the field, the completion of the Panama Canal would be retarded, if not prevented, by the difficulty in securing labor under competitive conditions.

In this dilemma the directors decided upon a course calculated to bring the comparative merits of the Nicaragua and Panama routes squarely before the American Government. Since the report of the Comité had not been made public, the directors were satisfied that the United States authorities could not possibly have anything like adequate
knowledge or appreciation of the superior advantages of their proposition.

The full report of the Comité Technique, including details of the projet recommended by it, was accordingly placed in the hands of President McKinley during the first week of December, 1898. On the twenty-first day of that month the Senate, by a large majority, passed a bill providing for government support of the Maritime Canal Company in its Nicaraguan enterprise, but the House adjourned without taking action upon the measure. On the reassembling of Congress the French Company secured a hearing before the Rivers and Harbors Committee of the lower house, to whom the Senate bill had been referred on an amendment. The Company's representatives frankly explained their project and expressed the willingness of the Company to re-incorporate under American laws in case the Panama route should be decided upon. The Senate amendment was defeated and, in March, 1899, Congress authorized the President to make an exhaustive investigation as to the most practicable and feasible Isthmian route for a canal that should be under the complete control of the United States and the absolute property of the nation.

APPOINTMENT OF THE FIRST ISTMHIAN CANAL COMMISSION

In accordance with these instructions President McKinley placed the work of investigation in the hands of a body which was officially styled "The Isthmian Canal Commission," and which was composed of the following members: Rear-Admiral John C. Walker, U. S. N. (retired); Hon. Samuel Pasco; George S. Morison; Lieutenant-Colonel Oswald H. Ernst, Corps of Engineers, U. S. A.; Lewis M. Haupt, C. E.; Alfred Noble, C. E.; Colonel P. C. Hains, Corps of Engineers, U. S. A.; Wm. H. Burr, C. E.; Prof. Emory R. Johnson. The Commission made an examination of the New Panama Canal Company's project, both in Paris and on the Isthmus, and then proceeded to ascertain
OLD FRENCH MACHINERY RUSTING IN THE JUNGLE.

A pathetic reminder of the gigantic failure of De Lesseps.
upon what terms and conditions the property and rights of
the Company might be transferred to the United States,
for the law under which the Commission was acting for-
bade the consideration of government support to a private
enterprise. The Republic of Colombia having signified its
willingness to consent to the alienation of the concession,
it only remained for the Commission to learn the purchase
price in order to make its report to the President. There
was considerable delay and some misunderstanding about
this last detail. The Company was naturally reluctant to
submit a definite figure to a body which "had no authority
to accept or reject any terms," but proposed instead to
make a tentative offer subject to an itemized valuation and
arbitration where necessary. To this the Commission would
not listen, but insisted upon a statement of the Company's
price in a lump sum without reservation.

THE REPORT OF THE COMMISSION FAVORS THE
NICARAGUA ROUTE

The report of the Isthmian Canal Commission was
presented to the President in November, 1901. It dis-
carded altogether the detailed memorandum of valuations
submitted by the Company and briefly declared that the
"total amount for which the Company offers to sell and
transfer its canal property to the United States" is $109,-
141,500. The value set upon it by the Commission was
$40,000,000. It needs no extensive calculation to deter-
mine that this was an underestimate, even when due allow-
ance is made for the usual depreciation of second-hand prop-
erty. It will be remembered that the receiver of the old
company valued the assets that passed into his hands at
about $90,000,000, and several millions had been expended
in a judicious manner by the new company.

The report closed with the following recommendation:
"After considering all the facts developed by the investiga-
tions made by the Commission and the actual situation as
it now stands, and having in view the terms offered by the New Panama Canal Company, this Commission is of the opinion that 'the most practicable and feasible route' for an Isthmian canal, to be 'under the control, management, and ownership of the United States' is that known as the Nicaragua route."

THE FRENCH COMPANY MEETS OUR BID

When this finding became known at Paris the directors of the New Panama Canal Company immediately resigned, and at a general meeting of stockholders held in the last days of the year it was decided to meet the terms of the Commission's estimate. Accordingly an offer to sell out all assets, rights, and interests for the sum of $40,000,000 was telegraphed, the owners realizing that with only one possible purchaser and the certainty of the property becoming practically valueless unless taken by that purchaser, no alternative existed. The Company's change of base impelled the Commission to make a supplementary report, in which it stated that "the unreasonable sum asked for the property and rights of the New Panama Canal Company when the Commission reached its former conclusion overbalanced that route, and now that the estimates by the two routes had been nearly equalized, the Commission can form its judgment by weighing the advantages of each and determining which is the more practicable and feasible. . . . After considering the changed conditions that now exist, the Commission is of the opinion that 'the most practicable and feasible route' for an Isthmian canal to be 'under the control, management, and ownership of the United States' is that known as the Panama route."

THE SENATE INVESTIGATES THE QUESTION OF ROUTE

In the meanwhile, and before the Isthmian Canal Commission had filed its report, an ill-considered bill had been passed by the House, authorizing the President to secure
a concession from Nicaragua and to proceed at once to the construction of a waterway by that route. Fortunately the Hepburn Bill was not hastily disposed of in the Senate. The matter was thoroughly investigated in committee and extensively debated in the chamber. The weight of engineering opinion was overwhelmingly in favor of the Panama route, but, perhaps, the most effective statement in its favor was delivered by Senator Hanna, who had made a close personal investigation of the question. A series of practical inquiries submitted by him to eighty shipowners, shipmasters, officers and pilots engaged in operating the most important intercontinental steamship lines and sailing vessels elicited replies which were without exception strongly in favor of the Panama route. More than ten per cent of these emanated from persons interested in sailing ships and familiar with the navigation of them, a result especially significant in view of the fact that one of the very strongest objections advanced against the more southerly location is its assumed disadvantage to sailing craft.* The debate in the Senate was followed by the passage in both branches of Congress of the Spooner Bill. This measure authorized the President to acquire the rights and property of the New Panama Canal Company for a sum not to exceed $40,000,000 and to secure by treaty with the Republic of Colombia the perpetual control of the territory needful for operating the canal; it also provided for the prosecution of the work by an Isthmian Canal Commission consisting of seven members to be appointed by the President.

We have already recited briefly the incidents of the imbroglio that followed the failure of the Colombian Legislature to ratify the Hay-Herran Treaty and culminated in the independence of Panama. Sufficient has been said to show how nearly the American people came to being committed to the Nicaragua route. What, in such an event, would have been the actual outcome it is impossible

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*Full details of this interesting information will be found in the Congressional Record, June 9, 1902.
to conjecture, but there is ample ground for the belief that the undertaking would have proved more hazardous, more difficult, and less satisfactory when completed, than the Panama project.

It will be convenient at this point to consider briefly the most important features of difference between the two routes. In the first place, the verified data upon which to work was very much greater in the case of Panama, not to mention the fact that a considerable proportion of the task had already been accomplished at that point. In fact the Nicaragua project is still a mass of theory which application might prove to be infinitely erroneous, whilst at Panama the stage of uncertainty had been virtually passed and the operation presented definite and calculable tasks.

THE NICARAGUAN ROUTE COMPARED WITH THAT OF PANAMA

The American Isthmus does not contain a single natural harbor on the Nicaraguan coast. A satisfactory approach to a canal might be excavated upon the Pacific side, but the Atlantic littoral offers no such facility. The harbor of Greytown, which was once a good one, has long since been closed by the formation of banks whose material is constantly carried down by the San Carlos and Serapiqui Rivers. These obstructions could be cleared, but only at great expense and the maintenance of the necessary channel would involve incessant dredging. At Panama, an excellent entrance was available at either end of the Canal.

Whilst both routes lie within the zone of seismic disturbances, there was no recorded convulsion, nor any physical evidence of one, in the Isthmus of sufficient force to have seriously damaged a lock level canal, much less one upon the sea level. Nicaragua, on the other hand, presents volcanic features, including Lake Nicaragua itself, which betoken tremendous upheavals in the past. The earth-
quake that occurred in that region in 1844 must have caused great destruction to a canal had one been in existence at the time, as well as to the shipping on it. The proposed line passes close to the active volcano Ometepe, which was in violent eruption as late as 1883. The great volcano, Momotombo, on the edge of Lake Managua, after fifty years of inactivity, burst out with great violence in the month of February, 1905. This eruption was preceded by earthquakes.

NICARAGUAN ROUTE PRESENTS MANY EXTRAORDINARY DIFFICULTIES

The region traversed by the Nicaraguan route is subject to strong winds and heavy rainfall, which would militate against the safe navigation of a canal. The latter preventing clear observation would tend to delay or prevent passage at night. It is true that Panama is also subject to heavy rainfall, but it is neither so continuous nor so great as upon the Atlantic coast of Nicaragua, which has no definite dry season. Moreover, any delays occasioned from this cause would be of shorter duration and of less consequence in Panama owing to the difference in length of passage.

Serious difficulties in the case of the Nicaragua construction would be created by the San Juan River, which may be considered as at least equal to those involved in the regulation of the Chagres. The course of the former stream is extremely tortuous, and expert opinion holds that it would be impossible to reduce it to a safe curvature. General Abbott says: “This long river route, exceeding in length the entire distance from ocean to ocean by the Panama line, must remain subject to the combined effects of strong winds, sharp curvature, and longitudinal and cross currents, to say nothing of the obscuration due to heavy rainfall. It may well be doubted whether any system of artificial lighting could render night transit safe for large ships, and without it delays and possible congestion could
hardly be avoided.” A popular idea prevails that the Nicaragua route offers a great advantage in the seventy miles of lake section, but this is fallacy. Something like one half of the distance is over bottom that presents a similar problem to that encountered at Lake Menzeleh in the construction of the Suez Canal, to wit, the opening and maintenance of a channel through soft mud. The Isthmian Canal Commission estimated the cost of this portion of the operation at $8,000,000. Even when made, this expensive and difficult channel would be a source of frequent danger, for Lake Nicaragua is subject to violent storms, during which there would be serious liability of vessels grounding. To quote General Abbott: “It remains to refer to what from an engineering point of view would be perhaps the most serious objection to the Nicaragua route if completed and opened to traffic. This would be the risk of longer or shorter interruptions liable to result from the complicated systems of water supply in seasons of drought of long duration; and the lake lies in a district where they are far from uncommon. It has been claimed that a vast lake about 3,000 square miles in extent must furnish an ideal source of supply, but the matter will bear a little examination.

CONTROL OF LAKE NICARAGUA A SERIOUS PROBLEM

“By the dam on the lower San Juan river the channel of the present stream would be transformed into an arm of the lake, maintained sensibly at the same level, and through this arm all shipping must pass, the depth of water depending wholly on the stand of the lake. This stand is now subject to a natural oscillation of about 13 feet. Under the projected conditions the entire outflow must pass over the dam at a distance of 50 miles from the main lake, and if the level is allowed to rise above the present high water stand, valuable lands under cultivation on the west shore of the lake would be flooded and claims for
damages would result. On the other hand, the bed of the river is crossed by many ledges of rock, and the cost of excavation fixes a limit to the depth economically practicable. . . . The level of the lake must be held approximately between 111 feet and 104 feet above tide and the bed of the present river must be excavated sufficiently to afford a sailing depth of 35 feet at all times. But the records establish that years of high lake and years of low lake follow in no regular succession. As it is impossible to provide a reserve sufficient to control the level of an immense body of water 3,000 square miles in extent, the regulation of this vital element must be left to the foresight and good judgment of the operator controlling the outflow of the dam. . . . Carelessness or bad judgment on the part of the operator at the dam, or an abnormal season, might therefore involve the stoppage of traffic for an indefinite period. A really desirable canal should be subject to no such contingency."

The Nicaragua route shows some savings in distances between important shipping points as measured upon the map, but these would almost certainly be made up for by the much shorter time of passage through the Panama Canal.

It must be borne in mind that the decision of the Isthmian Canal Commission in favor of Nicaragua was prompted by the price asked by the Company for its interests in the Panama enterprise and that decision was promptly reversed as soon as the Commission’s estimate was accepted. As the cost of constructing and maintaining the respective waterways was practically equal in the Commission’s opinion, it is evident that the alacrity with which they turned to the Panama proposition when the terms were favorable was due to a conviction of the superior merits of that project.
CHAPTER VIII

THE AMERICAN ENTERPRISE

The Hay—Bunau-Varilla Treaty was negotiated between the respective representatives of the United States and Panama in the autumn of 1903 and fully ratified February, 1904. The most important features of this convention are as follows:

Article 1. "The United States guarantees and will maintain the independence of the Republic of Panama."

Article 2. "The Republic of Panama grants to the United States in perpetuity the use, occupation and control of a zone of land, and land under water for the construction, maintenance, operation, sanitation and protection of said Canal, of the width of ten miles, extending to the distance of five miles on each side of the center line of the Canal to be constructed, the said zone beginning in the Caribbean Sea three marine miles from mean low-water mark and extending to and across the Isthmus of Panama into the Pacific Ocean to a distance of three marine miles from mean low-water mark, with the proviso that the cities of Panama and Colon and the harbors adjacent to said cities, which are included within the boundaries of the zone above described, shall not be included within this grant. . . . The Republic of Panama further grants in like manner to the United States in perpetuity all islands within the limits of the Zone above described and, in addition thereto, the group of small islands in the Bay of Panama, named Perico, Naos, Culebra and Flamenco."

Article 3. "The Republic of Panama grants to the United States all the rights, power, and authority within the Zone mentioned and described in Article 2 of this agree-

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THE INTERSECTION OF THE AMERICAN CANAL WITH THE OLD FRENCH CANAL AT MINDL.

This picture also shows the dredges operating in the Atlantic Entrance to the Canal.
ment . . . which the United States would possess and exercise if it were the sovereign of the territory within which said lands and waters are located, to the entire exclusion of the exercise by the Republic of Panama of any such sovereign rights, power or authority.

Article 6 provides for compensation to private property owners, by the United States, for any damage to private property occasioned by the canal operations and for the assessment of such compensation by arbitration.

UNITED STATES AUTHORITY IN COLON AND PANAMA

Article 7. "... The Republic of Panama agrees that the cities of Panama and Colon shall comply in perpetuity with the sanitary ordinances, whether of a preventive or curative character, prescribed by the United States and, in case the Government of Panama is unable, or fails in its duty, to enforce this compliance by the cities of Panama and Colon with the sanitary ordinances of the United States, the Republic of Panama grants to the United States the right and authority to enforce the same.

"The same right and authority are granted to the United States for the maintenance of public order in the cities of Panama and Colon and the territories and harbors adjacent thereto in case the Republic of Panama should not be, in the judgment of the United States, able to maintain such order."

Provision is made in this article for the reimbursement of the United States for any outlay it may make, under the discretionary authority referred to above, in "works of sanitation, collection and disposition of sewage, and distribution of water, in the cities of Panama and Colon."

Article 9. "The United States agrees that the ports at either entrance of the canal and the waters thereof, and the Republic of Panama agrees that the towns of Panama and Colon shall be free for all time, so that there shall not be imposed, or collected, custom-house tolls, tonnage, anchor-
peace and other officers discharging duties usually devolving upon these officers of the law, will be continued in office if they are suitable persons. . . . The laws of the land, with which the inhabitants are familiar, and which were in force on February 26, 1904, will continue in force in the Canal Zone and in other places on the Isthmus over which the United States has jurisdiction until altered or annulled by the said Commission,” but the principles of government set forth in the Constitution of the United States are to be observed in the administration of the Zone.

In a later letter to the Secretary, the President makes an important declaration of the broader policy of the United States towards the Republic of Panama as follows:

ATTITUDE OF THE UNITED STATES TOWARDS PANAMA

“The United States is about to confer on the people of the State of Panama a great benefit by the expenditure of millions of dollars in the construction of the canal: but this fact must not blind us to the importance of so exercising the authority given us under the treaty with Panama as to avoid creating any suspicion, however unfounded, of our intentions as to the future. We have not the slightest intention of establishing an independent colony in the middle of the State of Panama, or of exercising any greater governmental functions than are necessary to enable us conveniently and safely to construct, maintain, and operate the canal under the rights given us by the treaty. Least of all do we wish to interfere with the business and prosperity of the people of Panama. However far a just construction of the treaty might enable us to go, did the exigencies of the case require it, in asserting the equivalent of sovereignty over the Canal Strip, it is our full intention that the rights which we exercise shall be exercised with all proper care for the honor and interests of the people of Panama. The exercise of such powers as are given us by the treaty within

*See Article 3, of the treaty quoted above.
the geographical boundaries of the Republic of Panama may easily, if a real sympathy for both the present and future welfare of the people of Panama, is not shown, create distrust of the American government."

It is not our purpose to enter into a discussion of the political aspects of the treaty, but a careful reading of the portions which have been reproduced will give an idea of the great scope of this convention. To draw attention to but one direction in which its potency extends, the provision for the maintenance of order by the United States in the cities of Colon and Panama is a practical preventive of future revolution in the Republic.

At the close of the year Secretary Taft visited the Isthmus and entered into an agreement with President Amador, covering several supplementary matters of importance. A tariff adjustment, satisfactory to the Panamans, was effected. It was arranged that only supplies for the canal, and goods in transit, were in future to be entered at the Zone ports, thus assuring the Government of Panama of all customs receipts and port dues. The Republic agreed to reduce its tariff from fifteen to ten per cent, except upon wines and alcohol, and to place its postal rates upon the two-cent basis. Panama also agreed to adopt the gold standard, a very necessary measure for the welfare of that republic, as well as for the facility of transactions between the two nations. At the time this understanding was arrived at, the Colombian currency had become so debased that a five-dollar bill was exchangeable for an American nickel, and there was one cent change due at that.

A FUTILE REVOLUTIONARY MOVEMENT

Just before the arrival of Secretary Taft, General Huertas had planned one of the puny revolutions which have furnished librettists with inexhaustible material. He had mobilized the army of 182 half-clad men and boys, with the design of subverting the Amador government. The
threat of calling upon half a dozen American marines who happened to be in the city with their side-arms on, induced him to give up the idea. He was placed upon the retired list and the army of the Republic was disbanded.

At a banquet given in his honor by the Panaman President the Secretary delivered a timely homily on the subject of revolutions and urged upon his auditors the necessity of the government preserving the rights of the minority. The speech, which was in the nature of a friendly warning and an intimation that the United States expected the Republic to refrain from any revolutionary disturbances in the future, was well received by the representatives of both political parties, and doubtless had a salutary effect.

THE COMMISSION VISITS THE Isthmus

The Canal Commission arrived at the Isthmus in April, 1904. The only work in progress at the time was the excavation of the Culebra Cut, where a few French machines were employed with a force of about seven hundred men. Owing to the long lapse of time since the New Panama Canal Company ceased operations, a chaotic condition prevailed along the entire line of the canal and the plant and equipment transferred by that Company was in such a deteriorated and scattered state as to require months for its collection and repair. Whilst the task of straightening up was being carried out Engineer Wallace tested some American steam excavators and established important data as to units of cost and expenditure of time. Meanwhile the Commission proceeded, by means of new surveys and examinations, to gain such information as might afford a satisfactory basis for the ultimate plans. As has been stated, the French companies performed a great deal of accurate scientific work along the same lines, but much of the data secured from them needed to be modified in order to bring it into harmony with the more extensive scheme of the American project. The Commission was not restricted
by the limitations which governed the plans of the purely commercial enterprises, and whilst its work was entirely of a tentative nature, a waterway much larger than any contemplated by the French companies was a foregone conclusion.

THE PLAN OF THE WALKER COMMISSION

The Commission formulated a plan for a lock canal at an 85-foot level with a dam at Bohio and a lake 38.5 square miles extending from that point to Obispo. The Commission rejected the sea-level plan, prefacing its conclusion with the following statement: "If a sea-level canal be constructed, either the canal itself must be made of such dimensions that maximum floods, modified to some extent by a reservoir in the Upper Chagres, could pass down its channel without injury, or independent channels must be provided to carry off these floods. As the canal lies in the lowest part of the valley, the construction of such channels would be a matter of serious difficulty, and the simplest solution would be to make the canal prism large enough to take the full discharge. This would have the advantage, also, of furnishing a very large canal, in which navigation under ordinary circumstances would be exceptionally easy. It would involve a cross section from Obispo to the Atlantic, having an area of a least 15,000 square feet below the water line, which would give a bottom width of at least 400 feet. The quantity of excavation required for such a canal has been roughly computed, and is found to be about 266,228-000 cubic yards. The cost of such a canal, including a dam at Alhajuela and a tide lock at Miraflores, near the Pacific end, is estimated at not less than $240,000,000. Its construction would probably take at least twenty years."

The investigations of the Commission were necessarily directed chiefly to the various suggestions for the control of the Chagres. The question had to be considered from
the point of view of a sea level canal as well as that of a waterway with locks. In the former case the flood waters of the river, if admitted into the canal, would create dangerous currents and carry in heavy deposits, necessitating extensive dredging. The various dam projects were examined by the Commission as well as the plans of the French companies for diverting the river through a tunnel to the Pacific Ocean.

Before the Commission closed the first year of its existence the question of its efficiency and adaptability to the work in hand was widely raised. Secretary Taft, upon his return from the Isthmus in December, 1904, had expressed to the President an opinion that the Commission, whilst it had “made as much progress in the necessary preparations for the buildings of the canal as could be expected in the short time since its appointment,” was unwieldy and so constituted as to render difficult the apportionment of specific work and responsibility among its members. Chief Engineer Wallace complained that his plans were repeatedly changed and that he was hampered in the effort to carry them out.

THE OBJECTIONS TO THE COMMISSION

In a message sent to Congress on the 13th of January, 1905, President Roosevelt plainly expressed his objections to the existing arrangement. He asked for “greater discretion in the organization of the personnel” to be employed in the management of the enterprise.

“Actual experience has convinced me,” he said “that it will be impossible to obtain the best and most effective service under the limitations prescribed by law. The general plans for the work must be agreed upon with the aid of the best engineers of the country, who should act as an advisory or consulting body. The consulting engineers should not be put upon the Commission, which should be used only as an executive instrument for the executive and adminis-
MANDINGO STOCKADE FOR ZONE CONVICTS ENGAGED IN ROAD BUILDING.

A tropical prison. Zone convicts are profitably employed in building government roads.
trative work. The actual work of executing the general plans agreed upon by the Commission, after receiving the conclusions of the advising engineers, must be done by an engineer in charge; and we now have an excellent engineer." The President went on to state that the Commission should consist at most of five members and preferably of three.

In response to this message, the House passed a bill to abolish the Commission and place the government of the Zone and the construction of the Canal entirely in the hands of the President, but the measure was defeated in the Senate. Failing Congressional relief the President determined, in his characteristic way, to deal with the situation himself. He secured the resignation of the entire Isthmian Canal Commission and reformed that body, placing the control of affairs definitely in the hands of an Executive Committee composed of three of the seven members required by law to constitute the whole. Each of the executive members had distinct duties assigned to him. Chairman Shonts was placed in charge of the entire enterprise, with powers resembling those of a railroad president. Engineer Wallace was made field manager, with full control of the construction. Judge Magoon was created Governor of the Canal Zone and United States Minister to Panama. The other four members of the Commission were: Mordecai T. Endicott, Peter C. Hains, Oswald H. Ernst and Benjamin M. Harrod.

WALLACE RESIGNS AND STEVENS STEPS IN

The new arrangement had been in force less than sixty days when the Chief Engineer, for some cause which has never been fully explained, resigned his position. The resignation, coming as it did without warning or adequate explanation, naturally aroused resentment on the part of Secretary Taft, and Mr. Wallace retired from the service under a cloud. The place thus made vacant was promptly and satisfactorily filled by the selection of John F. Stevens,
who had been engaged by the War Department to supervise the construction of the new railroads in the Philippines. Mr. Stevens assumed charge of the canal operations in August, 1905.

On the first day of the following month the International Board of Consulting Engineers met in Washington. This body had been formed with the co-operation of several foreign governments for the purpose mainly of examining the principal problems involved in the construction of the Canal.

THE PRESIDENT’S ADDRESS TO THE CONSULTING ENGINEERS

The President addressed the assembled Board at length, explaining that his remarks were to be taken as suggestions rather than as instructions. “I hope,” he said, “that ultimately it will prove possible to build a sea-level canal. Such a canal would undoubtedly be best in the end, if feasible, and I feel that one of the chief advantages of the Panama Route is that ultimately a sea-level canal will be a possibility. But, while paying due heed to the ideal perfectibility of the scheme from an engineer’s standpoint, remember the need of having a plan which shall provide for the immediate building of the canal on the safest terms and in the shortest possible time.

“If to build a sea-level canal will but slightly increase the risk, then, of course, it is preferable. But if to adopt a plan of a sea-level canal means to incur hazard, and to insure indefinite delay, then it is not preferable. If the advantages and disadvantages are closely balanced I expect you to say so.

“I desire also to know whether, if you recommend a high-level multi-lock canal, it will be possible after it is completed to turn it into, or substitute for it, in time, a sea-level canal, without interrupting the traffic upon it. Two of the prime considerations to be kept steadily in mind are: 1. The utmost practicable speed of construction.
2. Practical certainty that the plan proposed will be feasible; that it can be carried out with the minimum risk."

After a thorough study of the maps and documents in the possession of the Isthmian Canal Commission, the Board of Consulting Engineers spent three weeks on the Isthmus, and on February 19, 1906, presented their report to Congress through the President, advocating a sea-level canal. A dissentient minority of five members, all Americans, made however a detailed report advocating a lock canal eighty-five feet above mean sea-level.

THE MILITARY BOARD

In April, 1907, Mr. John F. Stevens resigned from the position of Chief Engineer. President Roosevelt, with the hearty approval of Mr. Taft, who was then Secretary of War, immediately installed a military organization, in accordance with an idea that had been entertained for some time previous. A new Commission was created, with Colonel George W. Goethals, Corps of Engineers, U. S. A., as Chairman and Chief Engineer. The other members were Lieutenant-Colonel H. F. Hodges, U. S. A.; Lieutenant-Colonel William L. Sibert, U. S. A.; Lieutenant-Colonel D. D. Gaillard, U. S. A.; Civil Engineer H. H. Rousseau, U. S. N.; Colonel W. C. Gorgas, U. S. A.; and Honorable J. C. S. Blackburn. Mr. J. B. Bishop was retained in the position of Secretary to the Commission and Editor of the weekly "Canal Record." The only change in the composition of the membership was occasioned by the retirement of Senator Blackburn at the close of his third year's service. The vacancy was filled by the appointment of Mr. M. H. Thatcher, on April 12, 1910, to the head of the Department of Administration.

When Colonel Goethals and his aides came into control of the Canal, the lock plan, as advocated by the minority of the Board of Consulting Engineers, had been authorized by Congress and accepted by the people of the United States
as representing the form which the waterway would ultimately take.

The opportunity of still further strengthening the position of the Chairman of the Commission was not neglected by the President. Colonel Goethals was also made the chief executive of the Canal Zone, exercising the power formerly vested in the Governor, and President of the Panama Railroad Company, thus centering in him the absolute authority upon the work and making him superior to all save the President and the Secretary of War.

THE INVESTIGATING BOARD

In February, 1909, the President ordered Secretary Taft and a board of experts, especially appointed for the purpose, to make an inspection of the work upon the Canal, with particular reference to the Gatun Dam. In the resultant report the Commissioners expressed the opinion that the site of the structure met all the requirements of safety and that excess of precaution characterized the design and measures for its execution. They recommended a reduction in the height of the dam and also suggested some modifications of other parts of the Canal plan.

The changes which were adopted in 1909, and a few that had been previously determined upon, were the last of any consequence to be effected.

The chief departures from the plan as previously described were the removal of the terminal locks at the Pacific end from Sosa to Miraflores, and the consequent elimination of the proposed lake between the divide and the Pacific Ocean, certain increases in the dimensions of the channel; enlargement of the lock capacities; decrease in the height of the Gatun Dam, and the construction of breakwaters at Colon and Panama.
CHAPTER IX

THE HEALTH PROBLEM

The question of sanitation, closely allied as it is to that of labor, has always been an important factor in operations conducted upon the Isthmus of Panama, but fortunately, with the advance of time, the difficulties presented by it have become ever more susceptible to scientific treatment. The Panama railroad was built at an appalling sacrifice of life. At that time a blind contest was waged with disease, but no serious effort was made to mitigate the conditions that produced it. The French companies adopted some preventive measures and their provision for the care of the sick was admirable, but it remained for American administration to attack the problem in the determined and radical manner that minimized effects by reducing causes.

It was recognized at the outset that the Panama Canal could not be built by Americans unless the Canal Zone was first made healthy in order that Americans could live here with reasonable safety. So long as health conditions were bad it would be impossible to recruit a stable labor force, not only on account of actual conditions, but also because the Isthmus of Panama had been given a world-wide reputation for unhealthfulness during the construction of the Panama railroad and the work of the French on the Canal.

A knowledge of conditions as they existed on the Isthmus at the time of the American occupation is necessary to a realization of the truly marvelous results which have been accomplished.

The Isthmus itself was truly a valley of death, in which (187)
surgeons, Jesse W. Lazear, Walter Reed, James Carroll and Aristides Agramonte. After various experiments they decided to test the theory of transmission by mosquitoes. To do this it was necessary to secure human subjects for experiment, and they decided to make the first experiments on themselves. The mosquitoes were to be secured, allowed to infect themselves with the disease by biting a yellow fever patient, and then in turn to bite them.

One of these officers, Dr. Agramonte, was immune to the disease through previous attacks; another, Dr. Reed, was recalled from the island before undergoing the experiment. Doctors Carroll and Lazear were bitten by infected mosquitoes, with the result that Dr. Carroll suffered a very severe attack of yellow fever from which he barely escaped with his life. Dr. Lazear was not so fortunate. He contracted the disease in its most severe form and died of it. It must be understood that these surgeons fully realized the great danger which they ran in making these experiments, in order to realize their extreme bravery and high devotion to duty. No appreciation of the marvelous achievement of the Canal itself can be complete without a full measure of praise being given to the high courage of these men who made the discovery through which the execution of the work was made possible.

To further demonstrate the truth of this theory a call for volunteers to undergo mosquito infection was made, and it is a high tribute to the bravery of the American soldier to note that there were instant and abundant responses.

It had been demonstrated by the tests of Doctors Lazear and Carroll that considerable time must elapse between the infection of the mosquito and the time at which it could infect another person. One of the soldiers chosen for the test was submitted to the ordeal of being bitten by infected mosquitoes, and it was discovered that the dangerous period began about twelve days after the infection of the mosquito. Experiments made by soldiers to determine whether or not yellow fever was a contagious disease, by wearing
A ROOM IN BACHELOR QUARTERS AT CULEBRA.

This shows a typical room such as is provided for bachelor Americans. The government has taken great pains to provide good food, clothing and living conditions, including amusements, for its employees.
THE HEALTH PROBLEM

Clothes of a yellow fever patient, and sleeping in a bed previously occupied by a patient who had died of yellow fever, amply proved that it was not possible to transmit the disease in this way. Thus it was fully demonstrated that the *stegomyia* mosquito was the sole means of transmitting this dread disease.

MALARIA TRANSMISSION

The discovery that malaria was transmitted not by poisonous air or water, but by the *anopheles* mosquito solely, was made by a British army surgeon, Major Ronald Ross, who, after studying the problem of transmission of malaria, was successful in infecting birds with this disease by means of mosquito bites. This principle was afterwards applied to human beings successfully, and the theory proven that this was at least one of the methods of transmitting malaria. Later on, by means of further experiments, it was demonstrated that it was not possible to infect beings with malaria by means of either air or water from places in which the disease was epidemic.

Armed with this knowledge the surgeons drew up a new set of regulations for the government of Havana during the American occupation. These regulations were put into effect immediately, and consisted mainly of the segregation of all those attacked by the yellow fever in wire-screened houses so that the mosquitoes could not bite them and make themselves the means of carrying the disease. The infected houses were carefully fumigated, swamps, stagnant water and all likely places for the breeding of mosquitoes drained, with the result that within ninety days the disease was entirely stamped out; and with very few exceptions there has not been a recurrence of it in Havana since 1901.

Similar tactics were carried out in the case of the malaria-carrying mosquito, and with signal success, bringing the death rate from malaria down to about forty-five per year or about one-sixth of the previous rate.
The work in Havana was under the direction of Surgeon Major W. C. Gorgas, and the marvelous success achieved there was largely due to his painstaking work and administrative ability. The work accomplished there, of course, pointed the way directly to the sanitation of the Isthmus. President Roosevelt, realizing the value of the work which had been done, and the necessity for a similar but much greater task on the Isthmus, instructed the first commission to pay particular attention to the problem of sanitation. Colonel Gorgas, as the organizer and director of the campaign in Havana, was unanimously chosen as the best man for the leadership in the work on the Isthmus.

The first Isthmian Canal Commission to take charge of the work of constructing the Canal was appointed by the President on February 29, 1904, and confirmed by the Senate on March 3. The Commission arrived on the Isthmus on April 5 on a visit of inspection, accompanied by Col. W. C. Gorgas, Medical Corps, U. S. A., John W. Ross, Medical Director, U. S. N., Capt. C. E. Gillette, Corps of Engineers, U. S. A., and Maj. Louis A. LaGarde, Medical Corps, U. S. A., as experts on sanitation. After a thorough examination of conditions on the Isthmus these experts returned to Washington and reported a plan for the sanitation of the Canal Zone and the cities of Panama and Colon, and on May 8, 1904, Col. Gorgas, as Chief Sanitary Officer, was authorized to proceed with the work. He returned to the Isthmus, arriving on June 28. Between May 19, 1904, and June 30, 1904, Dr. L. W. Spratling, U. S. N., was acting health officer. As the representative of the Commission on the Isthmus, Gen. George W. Davis, Governor of the Canal Zone, issued an order on June 30, 1904, announcing the organization of the Sanitary Department, with Colonel Gorgas as its head.

**IDEAL CONDITIONS FOR SPREADING DISEASE**

At the beginning of the American occupation the Isthmus of Panama was afflicted with a plague of mosquitoes. The
THE HEALTH PROBLEM

high temperature, which varies little during the year, allowed constant breeding and the pools of water left by the almost continuous rains during the rainy season, which lasts for nine months out of the year, open tanks and water barrels, which formed the water supply system, were ideal breeding places. The interior of the Isthmus was a tropical jungle, another condition likewise ideal for mosquito propagation. Practically all of the inhabitants were subject to malaria, and the mosquitoes had a constant source of infection from which to draw. Somewhat similar conditions prevailed with regard to yellow fever.

The methods to be adopted in the war on the disease were clearly defined, and were resolved into a war on mosquitoes, a campaign for cleanliness, and the education of the natives looking to the suppression of the dangerous practices which had before been in operation. The cities of Panama and Colon must have a sewage and water system which would be strictly sanitary. All houses would be carefully screened and their inhabitants protected from mosquito bites in order to limit the spread of the disease. The extermination of the mosquitoes must be accomplished by the draining of all stagnant pools and the elimination of all standing water in every case possible, and where this could not be accomplished spraying with crude oil must be resorted to in order to kill the mosquito larvae. The brushwood of jungle growth had to be cut and burned, and a general cleaning up process adopted along the whole of the route of the Canal wherever occupied by Canal forces. These portions were cleared of undergrowth of all kinds for a distance of two hundred yards around all habitations.

No deaths from yellow fever had occurred among the employees of the French Company since 1897, although a few cases had been treated on the Isthmus in the year preceding the arrival of the Americans. A large part of the population of Panama was immune, and it was among the new arrivals that the disease first showed itself. In July, 1904, Charles Cunningham, a white employee of the Police Depart-
ment, was taken ill with it and died. No other cases were reported for about a month. On November 21, a case developed in Santo Tomas Hospital in the city of Panama, and in December, 1904, seven cases developed in that city.

In the month of January, 1905, the disease broke out in Colon, and in the two cities 19 cases were recorded that month. In February, 14 cases developed; March, 11; April, 8; May, 33. The maximum was reached in June, when 62 cases were reported, and from that month there was a steady decrease, the number of cases that developed in July being 42; August, 27; September, 7, and October, 3. The last case in the city of Panama developed on November 11, and, the last in Colon, on December 11, 1905. In all there were 246 cases in 1904 and 1905, and 84 deaths. Of this number 134 of the cases and 34 of the deaths were among Commission employees.

The disease had been confined to the cities of Panama and Colon. It was fought by preventing the introduction of more cases from the fever ports of nearby countries, keeping patients in screened rooms where mosquitoes could not gain access to them, and by an energetic campaign for the extermination of mosquitoes. The work was carried on at first without the cooperation of the people, but within a year they had been taught to assist in the destruction of the mosquito.

The first work against malaria was undertaken in Empire, Culebra, and Ancon in July, 1904, and by September it had been extended to Gorgona, Paraiso, and Balboa. The situation with regard to malaria in July, 1904, is accurately illustrated by the conditions at Ancon Hospital, and in the various villages. Anopheles and stegomyia mosquitoes were found in large numbers in the buildings and wards. Mosquito breeding took place within a few yards of the wards and none of the buildings were screened. The decorative plants and shrubs in the grounds were surrounded with clay vessels containing water and vegetation in which mosquitoes were breeding, and all ditches in the grounds
were producing mosquito life. There is no doubt that many cases of malaria and yellow fever had been contracted in the hospital itself previous to this time. Examinations of blood taken from the inhabitants of one town in the Canal Zone showed that 80 per cent of the people were infected with the malaria organism, and that Ancon was not an isolated instance was proved by the large percentage of cases from all the villages. In Colon one-sixth of the entire population was suffering from malarial attacks during each week, this deduction being based on the number of cases treated in the hospitals.

The permanent work for the prevention of malaria has been practically accomplished, although certain measures such as grass and brush cutting, oiling pools, and similar routine work must necessarily be continued indefinitely.

Only two cases of bubonic plague have developed on the Isthmus since American occupation. On June 15, 1905, a negro longshoreman, at Balboa (formerly La Boca), was taken ill, and a microscopic examination showed that he was suffering with bubonic. He died eight days later. The village was cleaned and disinfected, and a crusade against rats, the common carriers of bubonic, was begun. On July 9, a “rat brigade” was set at work in Panama, and a systematic effort to exterminate the rats around the docks and throughout the city was made. Rat traps were issued free to all persons who wished them. Later a bounty was placed on each rat delivered to the health department, and this bounty is still in effect.

In January, 1904, Dr. C. C. Pierce, of the Public Health and Marine Hospital Service, took up the work on the Isthmus of despatching ships bound to San Francisco and also of making a sanitary survey of the Canal region. In May, by an arrangement between the State Department in Washington and the Government of Panama, he took charge of the quarantine work for the port of Panama, and since that time the quarantine on the Isthmus has been under American control. In spite of the fact that ports
on both the Atlantic and Pacific sides of the Isthmus, north and south, have been infected with bubonic, smallpox, cholera, and yellow fever, the quarantine has been successfully maintained. In both of the stations, Panama and Colon, screened rooms are set aside for yellow fever suspects, and every precaution is taken to guard them from the bite of mosquitoes.

PRESENT HEALTH CONDITIONS

The Canal Zone is at the present day more healthful to the white man than many parts of the United States. There has been an absence of yellow fever during the past nine years and it is safe to say that no epidemic of that disease will ever again occur upon the Isthmus. Malaria is being rapidly reduced and its source eradicated by the persistent labors of the Sanitary Department. The general health of Canal employees, both white and colored, is better than that of the several communities from which they were drawn, but, with regard to the former, it must be considered that they are picked men in the prime of life, and that those among them who succumb to climate or disease are quickly weeded out and sent home.

A total of about $20,000,000 has been spent upon the Canal Zone for sanitation, but in spite of this fact the Isthmus cannot be regarded as a health resort. It is a reasonably healthy place to live, but it must be remembered that this condition can only be maintained so long as the stringent methods of health precaution are enforced.

The fact that medical services are entirely free, and that removal to a hospital is compulsory on the part of the attending physician, has much to do with the excellent conditions of health maintained there. It must be confessed, however, that in spite of all these precautions malaria still exists upon the Isthmus and must be regarded as a serious problem, the only solution of which is the entire extermination of the anopheles mosquito. The Canal operating forces must
continue to live in screened houses, take quinine in large quantities, remain indoors at night and continue the various precautions which have been adopted.

Considering the nature of the work, the living conditions and the length of time occupied by the enterprise, the death roll has been comparatively small, and to the date of the opening of the Canal there have been in the neighborhood of 6,000 deaths, of which less than 300 were Americans. Of the total number somewhat over 1,000 died from accidents. This really compares very favorably with that of the French, who lost in the nine years of their occupation about 16,000, or nearly three times as many.
CHAPTER X

THE LABOR PROBLEM

Each of the enterprises that preceded the American occupation of the canal territory found the difficulty in securing satisfactory labor one of the greatest deterrents to success.

The health conditions were so forbidding, the problem so apparently hopeless that even the most adventurous spirits of the races of the world looked askance at Panama. When the Americans took charge, however, all this was changed. The Canal Zone was made healthy and the completion of the work assured by the ample credit of the United States. High pay was offered and many other inducements which soon brought the adventurous of all lands flocking to the Isthmus. Hardly a nation is lacking in representatives on the construction force and the census of the Canal Zone taken in 1912 showed forty nationalities from eighty-six different geographical subdivisions, so that the world at large can justly feel proud in the achievement so truly international in its scope.

RECRUITING A FORCE

The number of men upon the rolls of the Commission has varied greatly. When Wallace took charge in 1904 there were 746 men employed upon the Canal. Immediately recruiting stations were opened in the United States, the West Indies and Europe, with the result that about 45,000 men were imported under contract up to 1912. The force has been anything but permanent, especially during the early days of the enterprise, when many of those employed (148)
CULEBRA CUT LOOKING NORTH FROM CUNETTE.

The two steam shovels shown in the foreground are working on the bottom, elevation +40. The water standing in the outer drainage channel is about six feet below the bottom, elevation +34.
THE LABOR PROBLEM

departed on the same ship that brought them after one look at the conditions. These were improved, however, and the promise of high pay, free lodging, good and cheap food and all the other inducements offered by the Commission kept a steady stream of labor flowing to the Isthmus.

The high water mark of employees on the Isthmus was reached in 1910 when there were 38,676 men upon the rolls. Of these 5,573 were Americans who usually compose from one-sixth to one-seventh of the total working force. Since 1910 the gradual reduction in the force has been permitted by the completion of various parts of the project and at the time of the opening of the Canal only a small operating and maintenance force will be kept there in addition to the military garrison.

The Americans employed on the Isthmus are in positions of supervision or skilled labor in the various trades, steam engineers, steam shovel men, railroad brakemen, conductors, firemen, policemen and in the higher offices.

Few women came to the Canal Zone in the early days, but according to the census of 1912 there were over four thousand women and children of American employees on the Isthmus. Most of the laborers are colored and come from the islands of the West Indies, Barbadoes, Martinique, Jamaica, Trinidad, etc., to the number of about 30,000. Europe has supplied about half as many. Of the Europeans employed over eight thousand were Spaniards and they proved the most satisfactory of all the common laborers employed by the Canal Commission.

The suggested employment of Chinese coolies to dig the canal met with such opposition in the United States that no move was made to put it into effect. Furthermore, little difficulty was experienced after the work was under way in obtaining all the common labor desired.

THE GOLD AND SILVER ROLLS

Some distinction had to be made between skilled and unskilled labor and this was accomplished by dividing the
employees into "gold" and "silver" men. The gold roll included all the Americans and those drawing over $75.00 per month who are paid in gold. The silver roll includes all the common and unskilled laborers and these men are paid in the silver money of the Republic of Panama. This distinction is useful in many ways but chiefly in allowing the Commission to draw the color line as it could not do directly, because of the United States Constitution and for other reasons. The distinction, however, is not a hard and fast one, and, consequently, is not open to criticism from that standpoint. In uniformity with this there are separate facilities provided everywhere for the two grades of employees. There are second-class railway cars, special commissary clerks and separate eating-houses.

QUARTERS

The types of quarters furnished for the gold and silver employees of course differ radically, although in both cases living accommodations, together with food, light and water, are supplied by the Government without charge. The gold employees live in two types of quarters, known as bachelor quarters and married quarters, and assignments to these are made by district quartermasters according to a code of rules, which takes in the date of the applicant's entry into the service, the rate of salary, etc. The quarters for both bachelors and married men are provided with modern plumbing and all necessary furniture. The types of houses differ somewhat according to the salary of the employee, but all are constructed from ingenious designs which adapt them both for convenience and comfort to a tropical climate.

The bachelor employees on the gold roll are housed in quarters like dormitories, and take their meals at hotels established and maintained by the Government.

The silver bachelor employees live in barracks, each of which accommodates seventy-two men. They sleep in a triple tier of bunks, which are fitted with laced canvas
THE LABOR PROBLEM

bottoms. These barracks are cleaned daily by janitors and are kept in good order, no baggage or effects of any kind being allowed on the floor.

AMUSEMENTS

One of the most difficult problems about the labor situation on the Isthmus has been the amusement of the employees after working hours. The cities of Panama and Colon do not supply many forms of amusement, besides the fact that they are inaccessible to those employed inland. To meet this difficulty the Commission has gone to great pains and expense to provide club houses, which are operated by the Young Men's Christian Association, and of which there are seven, located at Cristobal, Gatun, Gorgona, Empire, Culebra, Corozal and Porto Bello. These club houses have facilities for billiards, pool, bowling, gymnasium, reading rooms, and also facilities for social, church and lodge functions. Moving pictures are given in the club houses about once a week. There is also the Isthmian Canal Commission band, an excellent organization which gives regular concerts at the towns throughout the Canal Zone.

In spite of the efforts which have been made, however, it is extremely difficult to maintain a steady force on the Isthmus. For instance in 1911, the force of employees on the gold roll changed to the extent of sixty per cent, and statistics show that the average length of stay of mechanics on the Isthmus is one year. There are very few of the original employees who went to the Isthmus in 1904 who remained to the end of the work. Another reason for this constant change of workmen is that the men who compose the force are to a large extent adventurous spirits, who go to the Canal largely to see the big enterprise and be able to say afterward that they had a hand in its completion.

AN AMERICAN MANUFACTURING COMMUNITY

Few people realize how many different classes of work enter into this great enterprise. The great distance between
Panama and this country has necessitated the establishment of an American manufacturing community with all the facilities of an American community of the same sort, including houses, schools, churches, club houses, municipal improvements, such as waterworks, electric light plants, etc. From a labor standpoint the great machine shops at Gorgona and Empire are very interesting. These shops are equipped to build, assemble and repair all of the machinery used in the construction of the Canal. The raw material is purchased in the United States and made into the finished product. Locomotives, trains, dredges, etc., are purchased in the United States, knocked down and shipped to the Isthmus in sections, to be assembled and put into working condition after arrival there. In many cases it is cheaper to manufacture small articles on the Isthmus than to transport them from the United States.

The item of repairs is a serious one, for the reason that the Canal machinery is driven at a very high speed in the effort to obtain phenomenal results. This results in frequent breakage, so that the shops are ever busy with this class of work. One plant alone, that at Gorgona, covers twenty-two acres of ground, and has a railroad trackage of seven miles. These shops have had to be entirely removed before the opening of the Canal, since the rising waters of Gatun Lake will entirely cover their location before the eighty-five foot level is reached.

The old adage that "Necessity is the mother of invention" has been largely demonstrated during the construction of the Canal. Gigantic obstacles have arisen, only to be met and conquered by the ingenuity of the engineers in charge of the work. Many clever devices have been invented and put to practical use. Among these may be mentioned the lock gate operating device, of which a cut and full description will be found in the chapter on "The Plan and Operation of the Canal." Another extremely clever device, which has resulted in a tremendous saving of time, money and labor, is that known as the track shifter,
invented by W. G. Bierd. This consists of a huge crane with a long boom, which is run out upon the section of track to be moved. Chains are attached to the rails which are spiked to the ties, and the boom is lifted and drawn to one side, shifting the track some three or four feet. The machine is then moved forward and a new grip is taken on the track farther on and the operation repeated. In this way large sections of track may be shifted to one side in a short space of time. The device has proved of great value, especially on the dumps and fills where the excavated material is deposited.

Another clever device is the unloading plow. A long train of cars filled with earth is run to the proper unloading point, and the plow operated by wire ropes is drawn over the beds of the cars, pushing all the material off to the side desired, and effecting a great saving in time and labor.

Strikes upon the Isthmus have not had great success, for the reason that the Government considered that the main object was to complete the Canal in the least possible time and with the least possible trouble, holding that the good of the nation was above any small private grievance. To this end the Commission was given the authority to expel anyone from the Canal Zone who was not necessary to the work, or who became objectionable for any reason. This was upheld by the Supreme Court, which ruled that the Canal Zone was not a part of the United States, and therefore not subject to the Constitution, but could be treated as a military reservation. Men who stirred up trouble in the work by threatening strikes or making themselves objectionable in any way have been promptly deported and their places filled. The Canal Commission has directed the work with a strong hand, as the only method of pushing it forward to a profitable and successful conclusion.

As a matter of fact, there has been no occasion for a strike on the Isthmus, as the sole grounds have been a desire for more money. When it is considered that these men are working under conditions which have been modified to an
almost unreasonable extent for their ease and well being, it is hard to see any just grounds for a strike. The men work on an eight-hour day schedule, with an intermission of two hours at noon. They get their food cheaper than they could buy it in the United States, free light, water, fuel, quarters, medical services, low railroad rates, and their wages and salaries average from thirty to eighty percent more than for similar positions in the United States. It would be hard to find a better treated body of men from any standpoint. They are allowed an annual vacation of forty-two days for gold employees, and should they desire they may save up this leave from year to year and take the accumulated vacation in any one year. They are allowed sick leave also on pay.

The net result of all this is that the work has gone forward practically without any serious interruption from labor troubles.

COMMISSARY

The problem of supplying quarters, food, clothing and the necessaries and luxuries of life for the enormous army of workmen at Panama has been a very considerable one. It has, however, been worked out by the Quartermaster's and Subsistence Departments, which respectively have charge of the buildings and physical property of the Commission, together with the recruiting of labor, storage of the material and supplies, and operation of the commissary store system, which sells merchandise to canal employees at prices but little higher than those at which the articles are bought in quantities. In addition the Subsistence Department has charge of operating the hotels, kitchens and messes in which the gold and silver employees are fed. Central stations have been established for this purpose, with huge bakeries, refrigerating plants and storehouses.

The commissary system consists of twenty-two general stores in as many Canal Zone villages and camps along the relocated line of the Panama Railroad. It is estimated
that with employees and their dependents there are about 65,000 people supplied daily with food, clothing and other necessaries. The main supply station of this system is located at Cristobal, from which a supply train of twenty-one cars is dispatched every morning, consisting of refrigerator cars containing ice, meats and other perishable articles, and ten cars containing other supplies. These are delivered at stations along the line, and distributed to the houses of employees by the Quartermaster’s Department. Some idea of the volume of this business may be gained from the fact that the purchases of this department in the United States amount to about $12,000,000 worth of supplies annually, which require a discharge of one steamer each day.

The hotel branch maintains the well known Hotel Tivoli at Ancon, together with eighteen hotels along the line for white and gold employees, at which meals are served at thirty cents each. At these hotels there are served monthly about 200,000 meals. There are seventeen messes for European laborers, who pay forty cents per ration of three meals. There are also operated for the West Indian laborers sixteen kitchens in which they are served by ration of three meals for twenty-seven cents per ration. The supplies for one month for the line hotels, messes and kitchens cost about $85,000; labor and other expenses, $16,500. The monthly receipts, exclusive of the revenue of the Hotel Tivoli, amount to about $105,000.

The commissary stores have on sale a very large variety of articles which are purchased in large quantities under the contract system in the United States, and this business is managed by the Government on a profit just large enough to make both ends meet, including the costs of transportation, handling and delivering.

The commissary stores are run entirely on a charge basis. Employees are issued coupon books of varying face values with which they purchase supplies. At the end of the month the value of the coupons used is deducted from
the employee's salary. The net result of this great system is that the employees and the Canal Commission are not troubled by the prevailing high prices in the United States, and are a well satisfied and contented body of men.
THE GREAT CULEBRA CUT.

At this point the Canal is cut through what is practically a mountain range. The material excavated consisted largely of rock and formed one of the hugest engineering problems in the world's history. The cut is 9 miles long, 300 feet wide, 272 feet greatest depth and required the excavation of 100,000,000 cubic yards of material.
CHAPTER XI

PLAN AND OPERATION OF THE CANAL

During the past twenty years a wondrous transformation has taken place in the narrow strip across the Isthmus over which the United States holds dominion, but most of this change has been wrought since the American occupation began. The French did a great deal of work, but it was mainly of the pioneer sort that makes little appeal to the eye and is fully appreciated only by the technician. Their surveys were of incalculable value to our engineers. The buildings and machinery which they left saved us much trouble and expense. They dug a ditch for a few miles inland from the Atlantic and took an enormous mass of material out of Culebra, but the one was as a scratch in the ground, and the other as a notch in the hill, compared with the full extent of the necessary excavation.

The earlier period of the American tenancy was wisely devoted to preliminary measures of the utmost importance, but unimpressive in their immediate results. Plans were carefully considered in detail. Organization was effected. The railroad was reconstructed, machinery and methods were tested. Civil government was installed. And, most important of all, the field of action was made sanitary and the task thereby rendered possible.

When the army engineers assumed charge of the operation, the period of preparation had just closed. The type of the waterway and its main features had been finally decided upon. The labor supply was assured and life on the Isthmus involved no unusual menace to the health of the white man. In short, the period of construction had begun, the plans were drawn, the tools provided, the foun-
PLAN AND OPERATION OF THE CANAL 161

enclosing a mixture of sand and clay. The top and upstream slopes are heavily riprapped.

The spillway is a concrete-lined opening, 1,200 feet long and 300 feet wide, cut through a hill in the center of the dam, the bottom of the opening being ten feet above sea level. During the construction of the dam, all the water discharged from the Chagres River and its tributaries was carried through this opening. After construction had sufficiently advanced to permit the lake to be formed, the spillway was closed with a concrete dam, fitted with gates and machinery for regulating the water level of the lake, as described below.

The water level of Gatun Lake, extending through the Culebra Cut, is maintained at the south end by an earth dam connecting the locks at Pedro Miguel with the high ground to the westward, about 1,700 feet long, with its crest at an elevation 105 feet above mean tide.

The small lake between the locks at Pedro Miguel and Miraflores is formed by dams connecting the walls of the locks at the latter point with the high ground on either side. The dam to the westward is of earth, about 2,700 feet long, having its crest about 15 feet above the surface of Miraflores Lake. The east dam is of concrete, about 500 feet in length, and forms a spillway for the lake, with crest gates similar to those of the Gatun Dam.

Lake Gatun covers an area of 164 square miles, with a depth in the ship channel varying from 85 to 45 feet. The channel through the lake for the first 16 miles from Gatun is 1,000 feet in width; for the next four miles it is 800 feet, and for the remainder of the distance 500 feet wide. The summit level of the lake extends through the cut and to the Pedro Miguel Locks.

SPILLWAY, GATUN DAM

The Spillway is a concrete lined channel 1,200 feet long and 285 feet wide cut through a hill of rock nearly in the center of the Dam, the bottom being 10 feet above
GATUN DAM, SPILLWAY AND LOCKS.
sea level at the upstream end and sloping to sea level at the toe. Across the upstream or lake opening of this channel a concrete dam has been built in the form of an arc of a circle making its length 808 feet, although it closes a channel with a width of only 285 feet. The crest of the dam is 69 feet above sea level, or 16 feet below the normal level of the lake which is 85 feet above sea level. On the top of this dam have been placed 13 concrete piers with their tops 115.5 feet above sea level, and between these there are mounted regulating gates of the Stoney type. Each gate is built of steel sheathing on a framework of girders and moves up and down on roller trains placed in niches in the piers. They have been equipped with sealing devices to make them water-tight. Machines for moving the gates are designed to raise or lower them in approximately ten minutes. The highest level to which it is intended to allow the lake to rise is 87 feet above sea level, and it is probable that this level will be maintained continuously during wet seasons. With the lake at that elevation, the regulation gates will permit of a discharge of water greater than the maximum known discharge of the Chagres River during a flood.

HYDROELECTRIC STATION AT GATUN

Adjacent to the north wall of the spillway has been located a hydroelectric station capable of generating through turbines 6,000 kilowatts for the operation of the lock machinery, machineries, drydock, coalhandling plant, batteries, and for the lighting of the locks and Zone towns and, if desirable, operating the Panama railroad. The building is constructed of concrete and steel, and is of a design suitable for a permanent power house in a tropical country. The dimensions are such as to permit the installation of three 2,000-kilowatt units, and provision is made for a future extension of three additional similar units. It is rectangular in shape, and contains one main operating floor, with a turbine pit and two galleries for electrical equipment. The
building, with machinery and electrical equipment has been laid out upon the unit principle, each unit consisting of

an individual head gate, penstock, governor, exciter, oil-switch and control panel.

Water supply is taken from Gatun Lake, the elevation of which will vary with the seasons from 80 to 87 feet above sea level, through a forebay which is constructed
Culebra Cut looking south from bend in East bank near Gamboa.

The train and shovel are standing on the bottom of the cut. The water in the drainage canal is about 10 feet below the bottom of the Canal, or at elevation +30.
as an integral part of the curved portion of the north spillway approach wall. From the forebay the water is carried to the turbines through three steel plate penstocks, each having an average length of 350 feet. The entrances are closed by cast iron headgates and bar iron trash racks. The headgates are raised and lowered by individual motors which are geared to rising stems attached to the gate castings. The driving machinery and the motors have been housed in a small concrete gatehouse erected upon the forebay wall directly over the gate recesses and trash racks. The gate house has been constructed for the present requirements of three head gates, and provision made for a future addition of three more units.

WATER SUPPLY OF GATUN LAKE

Gatun Lake impounds the waters of a basin comprising 1,320 square miles. (See Map, p. 162.) When the surface of the water is at 85 feet above sea level, the lake will have an area of about 164 square miles, and will contain about 183 billion cubic feet of water. During eight or nine months of the year, the lake will be kept constantly full by the prevailing rains, and consequently a surplus will need to be stored for only three or four months of the dry season. The smallest run-off of water in the basin during the past 22 years, as measured at Gatun, was that of the fiscal year, 1912, which was about 132 billion cubic feet. Previous to that year the smallest run-off of record was 146 billion cubic feet. In 1910 the run-off was 360 billion cubic feet, or a sufficient quantity to fill the lake one and a half times. The low record of 1912 is of interest as showing the effect which a similar dry season, occurring after the opening of the Canal, would have upon its capacity for navigation. Assuming that Gatun Lake was at elevation plus 87 at the beginning of the dry season on December 1st, and that the hydroelectric plant at the Gatun Spillway was in continuous operation, and that 48 lockages a day were being made, the eleva-
tion of the lake would be reduced to its lowest point, plus 79.5, on May 7th, at the close of the dry season, after which it would continuously rise. With the water at plus 79 in Gatun Lake there would be 39 feet of water in Culebra
Cut, which would be ample for navigation. The water surface of the lake will be maintained during the rainy season at 87 feet above sea level, making the minimum channel depth in the Canal 47 feet. As navigation can be carried on with about 39 feet of water, there will be stored for the dry season surplus over 7 feet of water. Making due allowance for evaporation, seepage, leakage at the gates, and power consumption, this would be ample for 41 passages daily through the locks, using them at full length, or about 58 lockages a day when partial length is used, as would be usually the case, and when cross filling from one lock to the other through the central wall is employed. This would be a larger number of lockages than would be possible in a single day. The average number of lockages through the Sault Ste. Marie Canal on the American side was 39 per day in the season of navigation of 1910, which was about eight months long. The average number of ships passed was about 1½ per lockage. The freight carried was about 26,000,000 tons. The Suez Canal passed about 12 vessels per day, with a total tonnage for the same year of 16,582,000.

The water level of Gatun Lake, extending through the Cul-
ebra Cut, is maintained at the southern end by an earth dam connecting the locks at Pedro Miguel with the high ground to the westward, about 1,400 feet long, with its crest at an elevation of 105 feet above mean tide. A concrete core wall, containing about 700 cubic yards, connects the locks with the hills to the eastward; this core wall resting directly on the rock surface and being designed to prevent percolation through the earth, the surface of which is above the Lake level.

A small lake between the locks at Pedro Miguel and Miraflores has been formed by dams connecting the walls of Miraflores locks with the high ground on either side. The dam to the westward is of earth, about 2,700 feet long, having its crest about 15 feet above the water in Miraflores Lake. The east dam is of concrete, containing about 75,000 cubic yards, about 500 feet in length, and forms a spillway for Miraflores Lake, with crest gates similar to those at the Spillway of the Gatun Dam.

THE LOCKS

There are twelve locks in the Canal, all in duplicate; three pairs in flight at Gatun, with a combined lift of 85 feet; one pair at Pedro Miguel, with a lift of 30½ feet; and two pairs at Miraflores, with a total lift of 54½ feet at mean tide. The dimensions of all are the same—a usable length of 1,000 feet, and a usable breadth of 110 feet. Each lock is a chamber, with walls and floor of concrete, and water-tight gates at each end.

The side walls are 45 to 50 feet thick at the surface of the floor; they are perpendicular on the face, and narrow from a point 24½ feet above the floor, until they are eight feet wide at the top. The middle wall is 60 feet thick and 81 feet high, with vertical faces. At a point 42½ feet above the surface of the floor, and 15 feet above the top of the middle culvert, this wall divides into two parts, leaving a U-shaped space down the center, which is 19 feet broad at
the bottom and 44 feet broad at the top. In this space is a tunnel, divided into three stories or galleries. The lowest of these divisions is for drainage; the middle for the wires that will carry the electric current to operate the gate and valve machinery, which is installed in the central wall, and the upper division forms a passage-way for the operators. The lock chambers are filled and emptied through lateral culverts in the floors, connecting with main culverts, 18 feet in diameter in the walls, the water flowing in and out by gravity.

The lock gates are steel structures, seven feet thick, 65 feet long, and from 47 to 82 feet high. They weigh from 300 to 600 tons each. Ninety-two leaves are required for the several locks, the total weighing 57,000 tons. Intermediate gates are being used, in order to save water and time, and permit of the division of each lock into two
chambers, respectively, 600 and 400 feet long. In the construction of the locks there were used 4,500,000 cubic yards of concrete, which required about the same number of barrels of cement.

The time spent in filling and emptying a lock averages about fifteen minutes, without opening the valves so suddenly as to create disturbing currents in the locks or approaches. The time required to pass a vessel through all the locks is estimated at 3 hours; one hour and a half in the three locks at Gatun, and about the same time in the three locks on the Pacific side. The time of passage of a vessel through the entire Canal is estimated as ranging from 10 to 12 hours, according to the size of the ship, and the rate of speed at which it can travel, since the twenty-four mile passage of Gatun Lake may be made at full speed.

GATE-MOVING MACHINERY

The machinery for opening and closing the miter gates was invented in the office of the Assistant Chief Engineer by Edward Schildhauer. It consists essentially of a crank gear, to which is fastened one end of a strut or connecting rod, the other end of which is fastened to a lock gate. The wheel moves through an arc of 197 degrees, closes or opens the gate leaf, according to the direction in which it is turned. One operation takes 2 minutes. The crank gear is a combination of gear and crank, is constructed of cast steel, is 19 feet 2 inches in diameter, and weighs approximately 35,000 pounds. It is mounted in a horizontal position on the lock wall, turns on a large center pin, and is supported at the rim in four places by rollers. The center pin is keyed into a heavy casting anchored securely to the concrete. The crank-gear has gear teeth on its rim and is driven through a train of gears and pinions by an electric motor in a contiguous room. The motor is remotely controlled by an operator who is stationed at a center control house near the lower end of the upper locks. A simple
GATE MOVING MACHINERY.

This shows the relation of the bull wheel to strut and gate. A. Strut or connecting rod. B. Bed plate. C. Bearing wheel.
pull of a small switch is sufficient to either close or open a 700-ton gate, the operation being perfectly automatic.

No ship is allowed to pass through the locks under its own power, but is towed through by electric locomotives operating on tracks on the lock walls. The system of towing provides for the passing through the locks of a ship at the rate of 2 miles an hour. The number of locomotives varies with the size of the vessel. The usual number required is: 2 ahead, 1 on each wall, imparting motion to the vessel, and 2 astern, 1 on each wall, to aid in keeping the vessel in a central position and to bring it to rest when entirely within the lock chamber. They are equipped with a slip drum, towing windlass and hawser which permits the towing line to be taken in or paid out without actual motion of the locomotive on the track. The locomotives run on a level, except when in passing from one lock to another they climb heavy grades. There are two systems of tracks: one for towing, and the other for the return of the locomotives when not towing. The towing tracks have center racks or cogs throughout, and the locomotives always operate on this rack when towing. At the incline between locks the return tracks also have rack rails, but elsewhere the locomotives run by friction. The only crossovers between the towing and return tracks are at each end of the locks, and there are no switches in the rack rail.

PROTECTIVE DEVICES

Several protective devices have been used to safeguard the gates in the locks.

First. Fender chains, 24 in number, each weighing 24,098 pounds, have been placed on the up-stream side of the guard gates, intermediate and safety gates of the upper locks, and in front of the guard gates at the lower end of each flight of locks. They prevent the lock gates from being rammed by a ship that might approach the gates under its own steam or by escaping from the towing loco-
GATUN UPPER LOCKS, EAST CHAMBER.

The view is looking north from the forebay showing the upper guard gates and emergency dam.
motives. In operation, the chain is stretched across the lock chamber from the top of the opposing walls, and when it is desired to allow a ship to pass, the chain is lowered into a groove made for the purpose in the lock floor. It is raised again after the ship passes. The raising and lowering is accomplished from both sides by mechanism mounted in chambers or pits in the lock walls. This mechanism consists of a hydraulically operated system of cylinders, so that 1 foot of movement by the cylinder accomplishes 4 feet by the chain. If a ship exerting a pressure of more than 750 pounds to the square inch should run into the fender, the chain is paid out gradually by an automatic release until the vessel comes to a stop. Thus, a 10,000-ton ship, running at 4 knots an hour, after striking the fender can be brought to a stop within 73 feet, which is less than the distance which separates the chain from the gate.

Second. Double gates have been provided at the entrances to all the locks and at the lower end of the upper lock in each flight, the guard gate of each pair protecting the lower gate from ramming by a ship which might possibly get away from the towing locomotives and break through the fender chain.

Third. A dam of the movable type called an emergency dam has been placed in the head bay above the upper locks of each flight for the purpose of checking the flow of water through the locks in case of damage, or in case it is necessary to make repairs, or to do any work in the locks which necessitates the shutting off of all water from the lake levels. Each dam is constructed on a steel truss bridge of the cantilever type, pivoted on the side wall of the lock approach, and when not in use rests on the side wall parallel to the channel. When the dam is used, the bridge is swung across the channel with its end resting on the center wall of the lock. A series of wicket girders hinged to this bridge are then lowered into the channel with their ends resting in iron pockets embedded
in the lock floor. After the girders have been lowered into place, they afford runways for gates which can be let down one at a time, closing the spaces between the wicket girders. These gates form a horizontal tier spanning the width of the Canal and damming the water to a height of 10 feet. Another series of panels is then lowered, and so on until the dam, constructed from the bottom upward, completely closes the channel. When the dam has checked the main flow, the remainder, due to the clearance between the vertical sides of the gates, may be checked by driving steel pipes between the sides of the adjacent panels. These dams are operated in three movements, and the machinery for operating is, therefore, in three classes, gate-moving, raising and lowering the wicket girders, and hoisting the gates on the girders, all driven by electric motors.

CAISSON GATES

To permit examining, cleaning, painting, and repairing the lower guard gates of the locks, and the Stoney gates of the Spillway dam, and for access in the dry to the sills of the emergency dams, there have been provided floating caisson gates of the molded ship type. When their use is required the caissons are towed into position in the forebay of the upper lock, above the emergency dam, or between the piers of the Spillway, and sunk. The caissons are equipped with electric motor driven pumps for use in pumping out the caissons and for unwatering the locks.

ELECTRIC CONTROL OF LOCK MACHINERY

The gates, valves, and fender chains of the locks are operated by electricity, and remotely controlled from a central point; that is, there is a central control station for each of the series of locks at Gatun, Pedro Miguel, and Miraflores. In passing a ship through the locks it is necessary to open and close the miter gates weighing from 380 to 730 tons, to fill and empty lock chambers containing
from three and one half to five million cubic feet of water, to raise and lower fender chains weighing 24,098 pounds each, and to tow the vessel through the locks. All these operations, except that of towing, are controlled by one man at a switchboard.

The control system for Gatun Locks is typical. Water is let into the lock chambers or withdrawn from them by means of culverts under the lock floors, which connect with larger culverts in the lock walls, through which water is carried from the higher to the lower levels. The main supply culverts are 18 feet in diameter, and the flow of water through them is controlled by rising-stem gate valves, which can be completely opened or closed in one minute. In the center wall the culvert feeds both lock chambers, and therefore at each outlet into the lateral culverts there is a valve of the cylindrical type, in order that water may be let into or withdrawn from either chamber at will. A complete opening or closing of these cylindrical valves takes ten seconds. The miter gates are never opened or closed with a head of water on either side of them, the chambers being first emptied or filled by means of the valve and culvert system. The time required either to open or close the miter gate is two minutes.

A ship to be raised to the lake level comes to a full stop in the forebay of the lower lock, prepared to be towed through one of the duplicate locks by electric towing locomotives. The water in the lower lock chamber is equalized with the sea level channel, after which the miter gates are opened, the fender chain lowered and the vessel passed into the first chamber, where the water is at sea level. Then the miter gates are closed. The rising stem gate valves at the outlet of the main culverts are closed, while those above are opened, allowing water to flow from an upper level into the lower chamber, which, when filled, raises the vessel 28½ feet, to the second level. This operation is repeated in the middle and upper locks until the ship has been raised to the full height of 85 feet above the level of
the sea. At Gatun, in the passing of a large ship through the locks, it is necessary to lower 4 fender chains, operate 6 pairs of miter gates and force them to miter, open and close 8 pairs of rising stem gate valves for the main supply culverts, and 30 cylindrical valves. In all, no less than 98 motors are set in motion twice during each lockage of a single ship, and this number may be increased to 143, dependent upon the previous condition of the gates, valves and other devices.

Each gate leaf, valve, and fender chain is operated by a separate motor mounted near the machinery in chambers in the lock wall, the motors acting through suitable gears (or pump in the fender chain) upon the various machines. In each machinery chamber is erected a starting panel containing contactors by which current will be applied to the motor and these panels are in turn controlled from a main unit in the central control house. Some of the machinery chambers at Gatun are 2,700 feet distant from the point of control; 90 per cent of them are within 2,000 feet, and 50 per cent of the total within 1,200 feet.

The station from which control is exercised over the movement of all the machines is on the center wall at the lower end of the upper flight of locks at Gatun, and similarly placed at Pedro Miguel and Miraflores. It is in a building raised high enough above the top of the wall to allow a towing locomotive to pass under, a height of 16 feet, and to command an uninterrupted view of every part of the locks. In this house is a double control board duplicated to conform to the duplication in locks. The control board is in the nature of a bench or table, 32 inches above the floor, containing a representation, part model and part diagrammatic, of the flight of locks controlled by the respective series of switches. Standing at his switchboard the operator throws the switches, and sees before him in model or diagram the progress of the fender chains as they rise and fall, the movement of the miter gates inch by inch, the opening and closing of the gate valves in the main cul-
verts at every stage, the operation of the cylindrical valves, and, in addition, indication of the gradual rise or fall of the water in the lock chambers. The switches controlling the various motors, together with their indicators, are mounted upon the board in the same relative position as the machines themselves in the lock walls. Some distortion of scale will be allowed, to give room for the switches. The board is not over 4 feet in width, in order that the operator may be able to reach beyond the middle of it, and the length of the board is limited to 30 feet at Gatun, and proportionally at the other locks.

The system is interlocking, so that certain motors can not be started in a certain direction until other motors are operated in a proper manner to obtain consistent operation on the whole, and to avoid any undesirable or dangerous combinations in the positions of valves, gates, or fender chains. In this way and by the use of limit switches the factor of the personal equation in operating the machines is reduced to a minimum, almost mechanical accuracy being obtained. Before the operating pair of valves in the main culverts can be opened, at least one pair of valves at the other ends of the locks, both upstream and downstream, must first be closed. This limits an operator to the act of equalizing water levels between locks, and keeps him from allowing water to flow from, say the lake level to the middle lock past the upper lock, thus preventing a possible flooding of the lock walls and machinery rooms. Interlocks, devoted to the control of action between the gate valves in the main culverts and the miter gates, prevent valves being opened a lock length above or below a miter gate which is being opened or closed, and thus prevent an operator causing a flow of water while the miter gates are being moved. Interlocks for the cylindrical valves guarding the openings from the center wall culvert to the lateral culverts keep those of one side or the other closed at all times, except when it is desired to cross-fill the chambers, when they may be opened by special procedure. An
interlock prevents the operator from starting to open a miter gate before unlocking the miter-forcing machine. The miter gates guarded by a fender chain must be opened before the chain can be lowered, and the chain must be raised again before the gate can be closed, or more exactly the switches must be thrown in this order, but the operations may proceed at the same time. The simple interlocks will prevent such a mistake as leaving the chain down through lapse of memory when it should be up to protect the gate.

LIGHTING THE CANAL

The general scheme of lighting and buoying the Canal includes the use of range lights to establish direction on the longer tangents and of side lights spaced about 1 mile apart to mark each side of the channel. The range lights are omitted in Culebra Cut, where their use is hardly practicable, and on four of the shorter tangents on the remainder of the Canal. In the Cut have been placed three beacons at each angle, and between these intermediate beacons in pairs on each side of the Canal. By keeping his ship pointed midway between these beacons, the pilot is able to adhere closely to the center of the Canal. At each tangent it is necessary to have two ranges of two lights each to prolong the sailing line in order that the pilot may hold his course up to the point of turning. These range lights will be situated on land. There are three types, all of reinforced concrete. The more elaborate structures are used on the Gatun locks and dam and in the Atlantic and Pacific Divisions, where they are closer to the sailing lines of the vessels, while simpler structures have been placed in the Gatun Lake, where they are under less close observation. A light and fog signal on the west breakwater in Limon Bay is also included. The illuminants are gas and electricity, the latter being used whenever the light is sufficiently accessible. For the floating buoys, and for the towers and beacons which are in inaccessible places,
the system using compressed acetylene dissolved in acetone has been adopted. The buoys are composed of a cylindrical floating body or tank, surmounted by a steel frame which supports the lens at a height of about 15 feet above the water level. The buoys are moored in position along the edge of the dredged channel by a heavy chain and a concrete sinker, and should remain lighted for six to twelve months without being recharged. The candlepower of the range lights varies according to the length of the range, from about 2,500 to 15,000 candlepower. The most powerful lights are those marking the sea channels at the Atlantic and Pacific entrances, they being visible from about 12 to 18 nautical miles. The beacons and gas-buoy lights will have about 850 candlepower. White lights will be used throughout, and, in order to eliminate the possibility of confusing the lights with one another and with the lights on shore, all range lights, beacons, and buoys will have individual characteristics formed by flashes and combinations of flashes of light and dark intervals.

EXCAVATION

The total excavation, dry and wet, for the Canal as originally planned, was estimated at 103,795,000 cubic yards, in addition to the excavation by the French companies. Changes in the plan of the Canal, made subsequently by order of the President, increased the amount to 174,666,594 cubic yards. Of this amount, 89,794,493 cubic yards were to be taken from the Central Division, which includes the Culebra Cut. In July, 1910, a further increase of 7,871,172 cubic yards was made, of which 7,330,525 cubic yards were to allow for slides in Culebra Cut, for silting in the Chagres section, and for lowering the bottom of the Canal from 40 to 39 feet above sea level in the Chagres section. These additions increased the estimated total excavation to 182,537,766 cubic yards. In 1911, a further increase of 12,785,613 cubic yards was made,
of which 5,257,281 cubic yards was for slides in Culebra Cut, and the remainder for additional excavation and silting in the Atlantic and Pacific entrances, raising the grand total of estimated excavation to 195,323,379 cubic yards. In 1912 an increase of 17,180,621 cubic yards was made, of which 3,545,000 cubic yards was for slides in Culebra Cut and the remainder for dredging excavation at Gatun locks, silting in the Atlantic entrance, and for the Balboa terminals, and in 1913 came a still further increase of 20,126,000 cubic yards, of which 9,067,000 cubic yards was due to slides and breaks in Culebra Cut, bringing the grand total of estimated excavation to 232,353,000 cubic yards. Deducting Balboa terminal excavation, the total for the Canal proper, according to the estimate of 1913, is about 223,559,000 cubic yards, or nearly double the amount of the original estimate made in the minority report of the International Board of Consulting Engineers in 1906. The points of deepest excavation are in Culebra Cut, 495 feet above the bottom of the Canal at Gold Hill, and 364 feet above at Contractor's Hill opposite. The widest part of the Cut is opposite the town of Culebra, where owing to the action of slides on both banks, the top width is about half a mile. Active excavation work on a large scale did not begin until 1907, when 15,765,290 cubic yards were removed. In 1908, over 37,000,000 cubic yards were removed, and in 1909, over 35,000,000 making a total for the two years of over 72,000,000 yards, or a monthly average for those two years of 3,000,000 cubic yards. In 1910, 31,437,000 cubic yards were removed; in 1911, 31,603,000; in 1912, 30,269,000; and to July 1, 1913, 18,324,637 cubic yards, including both wet and dry excavation, and leaving a total of 25,748,051 yet to be taken out.

SLIDES AND BREAKS

There have been in all 26 slides and breaks in Culebra Cut; 17 covered areas varying from 1 to 75 acres and 9
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FORTY TONS OF DYNAMITE DESTROY THE LAST BARRIER BETWEEN THE OCEANS.

The blowing up of Gamboa Dike, the last of the dikes in the Panama Canal. This dike separated the water in the Gatun locks from Culebra Cut. The removal of the dike by a discharge of 40 tons of dynamite set off by President Wilson, was the last stage in the completion of the great waterway. Dredges were put to work immediately widening the channel at Cucaracha slide in Culebra Cut so that within a short time the Canal was ready for use throughout its entire length.
covered areas of less than 1 acre each, making in all a total of 225 acres. One variety of slide is caused by the slipping of the top layer of clay and earth on a smooth sloping surface of a harder material. The largest slide of this character is that known as Cucaracha on the east bank of the Canal just south of Gold Hill. This gave the first French company trouble during the final years of its operations. It first gave the Americans trouble in 1905, and between that date and July 1, 1913, over 12,000,000 cubic yards of material were removed from the Canal because of it. It broke nearly 1,900 feet back from the axis of the Canal and covers an area of 47 acres. Another variety of slide, properly called break, is due to the steepness of the slopes and the great pressure of the superincumbent material upon the underlying layers of softer material. The largest slide or break of this type is on the west side of the Cut at Culebra just north of Contractor's Hill and covers an area of 75 acres. Over 7,000,000 cubic yards of material have been removed from this slide. On the east side of the Cut a similar slide covers an area of about 50 acres, breaking back about 1,300 feet from the center of the Canal. About a half million cubic yards have been taken out of this slide and more remains to be removed. It is estimated that the total amount of material removed from the Canal because of the slides will aggregate between 21,000,000 and 22,000,000 cubic yards.

DRILLING AND BLASTING

Most of the material excavated in Culebra Cut has consisted of rock varying from very soft, which readily disintegrates on exposure to the atmosphere, to very dense rock of great hardness. It has been necessary before excavating this material to drill and blast it. Two kinds of drills have been used—tripod and well—both obtaining their power from a 10-inch compressed air main on the west bank of the Cut which is supplied by three batteries of
air compressors placed at equal distances along the 9 miles of the Cut. The usual depth of drill holes has been about 27 feet, three feet deeper than the steam shovels have excavated. The drill holes, placed about 14 feet apart, are loaded with 45 per cent potassium nitrate dynamite in quantities depending upon the character of the rock, and are connected in parallel and fired by means of a current from an electric light plant. The maximum number of drills in use at any one time in Culebra Cut was 377, of which 221 were tripod and 156 well. With these over 90 miles of holes have been drilled in a single month. A pound of dynamite has been used to about every 2½ cubic yards of material blasted, and the quantity used in Culebra Cut during several years has averaged about 6,000,000 pounds a year.

CAPACITY OF STEAM SHOVELS AND DIRT TRAINS

There have been several classes of steam shovels engaged in excavating work, equipped with dippers ranging in capacity from 1½ cubic yards to 5 cubic yards, and a trenching shovel, which has a dipper with a capacity of ½ of a cubic yard. In Culebra Cut excavation the 5-yard dippers have been used almost entirely.

Each cubic yard, place measurement, of average rock weighs about 3,900 pounds; of earth, about 3,000 pounds; of "the run of the Cut," about 3,600 pounds, and is said to represent about a two-horse cart load. Consequently, a five cubic yard dipper, when full, carries 8.7 tons of rock, 6.7 tons of earth, and 8.03 tons of "the run of the Cut."

Three classes of cars were used in hauling spoil—flat cars with one high side, which were unloaded by plows weighing from 14 to 16 tons, operated by a cable upon a winding drum, and two kinds of dump cars, one large and one small. The capacity of the flat cars is 19 cubic yards; that of the large dump cars 17 cubic yards, and that of the small dump cars, 10 cubic yards. The flat car train was
ordinarily composed of 20 cars in hauling from the cut at Pedro Miguel, and 21 cars in hauling from the cut at Matachin. The large dump train was composed of 27 cars, and the small dump train of 35 cars.

The average load of a train of flat cars, in hauling the mixed material known as “the run of the Cut,” was 610.7 tons (based on a 20-car train); of a train of large dump cars, 737.68 tons, and of a train of small dumps, 562.5 tons.

The average time consumed in unloading a train of flat cars was from 7 to 15 minutes; in unloading a train of large dump cars, 15 to 40 minutes; and in unloading a train of small dump cars, 6 to 56 minutes. The large dump cars were operated by compressed air power furnished by the air pump of the locomotive, while the small dump cars were operated by hand.

The record day’s work for one steam shovel was that of March 22, 1910, 4,823 cubic yards of rock (place measurement), or 8,395 tons. The highest daily record in the Central Division was on March 11, 1911, when 51 steam shovels and 2 cranes equipped with orange peel baskets excavated an aggregate of 79,484 cubic yards, or 127,742 tons. During this day, 333 loaded trains and as many empty trains were run to and from the dumping grounds.

The greatest number of shovels in use at one time in the Cut was 43, and the greatest monthly excavation in any single month, in the Cut, was obtained in March, 1911, when 1,728,748 cubic yards of material, mostly rock, were excavated.

To handle this amount of material required the services of 115 locomotives and 2,000 cars, giving about 160 loaded trains per day to the dumps, which on the average were about 12 miles distant, the haul one way varying from about one mile to 33 miles. To serve properly the trains and shovels employed in excavation work in the Cut, although it is less than nine miles in length, about 100 miles of track have been required, or an average of over nine parallel tracks at all points.