

The Journal

OF THE

Manchester Geographical Society.

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THE PANAMA CANAL.

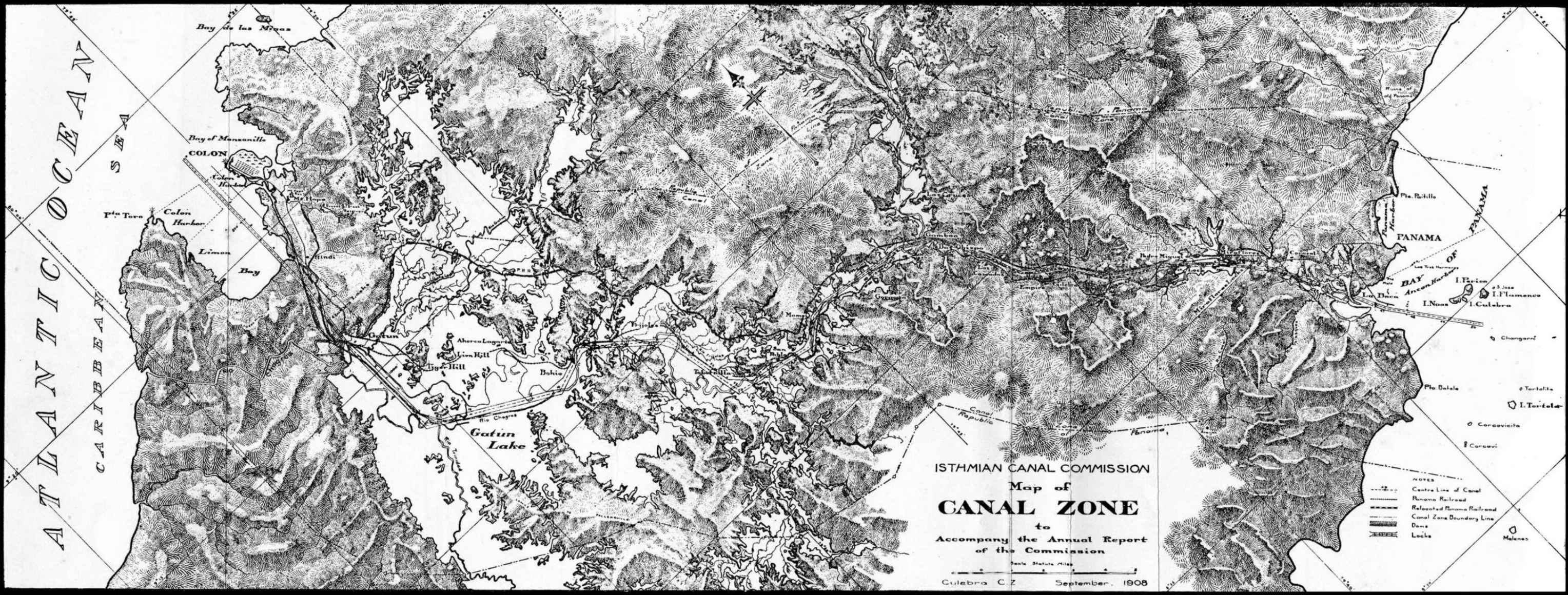
By ALDERMAN SIR BOSDIN T. LEECH, J.P.

(Addressed to the Society in the Geographical Hall on Tuesday,
December 13th, 1910.)

THE eyes of the world have been drawn, for nearly thirty years, to this great work, which has passed through vicissitudes of no ordinary character. The question is asked on all sides, "Will it ever be completed? and, if made, will the advantages derived be commensurate with the vast expenditure of life and money which must be incurred?"

I have made a point of inspecting the chief ship canals that have been constructed, and when, last February, a party consisting of Alderman Plummer, Councillor Harrop, Mr. C. H. Scott and myself (the three latter Ship Canal directors) decided to visit the West Indies, we arranged to make the Panama Canal part of our programme.

Colon was reached in the ss. "Tagus" on the 13th of March, and on our arrival we were waited upon by Col. Goethals, Chairman and Chief Engineer of the American Isthmian Canal Commission, a most courteous gentleman, who said he had had several letters about our coming (one being from the War Office at Washington), with instructions to pay us special attention. Certainly no one could have been more kind and helpful than was Colonel Goethals. On the first day he took us in his private railway carriage the whole way to Panama, nearly fifty miles. We stopped at all the principal points on the works, and listened to his personal explanations; and he then entertained us to lunch at his own house at Culebra. He had engaged rooms for us at the "Tivoli Hotel," Panama, a fine and commodious house built by the Government. Next day we left by the 6-30 train to re-join him and his assistant, Colonel Hodges, at Culebra. Our hosts again gave us every opportunity of critically examining the Culebra cutting, the construction of the various



ATLANTIC OCEAN

CARIBBEAN SEA

Bay de las Minas

Bay of Mansanillo

COLON

Colon Harbor

Colon Harbor

Limon Bay

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Limón

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Gatun Lake

ISTHMIAN CANAL COMMISSION
Map of
CANAL ZONE
to
Accompany the Annual Report
of the Commission

Scale: Statute Miles
Culebra C.Z. September, 1908

- NOTES
- Centre Line of Canal
 - Panama Railroad
 - Relocated Panama Railroad
 - Canal Zone Boundary Line
 - Dams
 - Locks

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locks and dams, and the remainder of the works. When we had seen everything Colonel Goethals franked us, by railway, to Colon, where we re-joined our steamer. No one could have seen the Panama Canal under better auspices, and we owe a deep debt of gratitude to our conductors for their kindness and attention.

HISTORY OF THE CANAL.

The intrepid Balboa, in 1513, was the first man to scale the Culebra Mountains and get a view of the Pacific, and ever since then there have been visions of constructing a waterway to connect the Atlantic and Pacific Oceans. So far back as 1520 the King of Spain had a survey made for that purpose, but nothing was done. A railway across the Isthmus was made in 1855, at a cost of £1,650,000, by an American syndicate, who handsomely repaid themselves by making passengers pay 25 dollars (or £5. 4s. 2d.) for the fifty miles travel; they carried their monopoly so far that a man who walked had to pay 10 dollars (over £2) for even passing over the line. This was reduced, but even now the 3rd class fare is 5 cents a mile, and goods pay 1 dollar to 3½ dollars per ton, according to classification.

In 1866 the United States Government recommended a Commission of Enquiry, and in 1869 President Grant had one formed, which reported in 1876 in favour of a Nicaraguan Canal; the matter, however, dropped. Flushed by the success of the Suez Canal, De Lesseps, in 1879, held a Congress of Engineers at Paris, and in 1881 formed an Inter-Oceanic Company for constructing a canal by the Panama route, expecting the already constructed railway would be of service to him. In November, 1883, De Lesseps visited Manchester, and I had a long talk with him about his Panama project, about which he was very sanguine. Every one knows under what good auspices he started the work, but De Lesseps was not a practical engineer, and the physical difficulties he had to encounter and the frightful loss of life that occurred, together with scarcity of funds, brought his adventure to grief. There can be no doubt that De Lesseps did good work; in eight years he spent £12,000,000. The whole concern came into liquidation in 1889, and was taken over by the new Panama Company, who struggled with it for a further twelve years, till, in turn, their working funds were exhausted.

All the time the United States had been watching the course of events. She proposed to make a canal by the Nicaraguan route and adopt the lock system, which, it was said, would save time and money. This alarmed the French company, and they sought a conference and tried to come to terms and sell their concern. President McKinley took the advice of a Commission of Engineers, who advised a high level canal and preferred the Panama to the Nicaraguan route. They recommended the purchase of the partly-constructed works if they could be bought for £8,000,000, but scouted the much higher price that had been asked for them. Eventually America bought the works and also the railway for £8,000,000. When the Americans took possession, in 1904, the French excavations had paved the way for either a high or low level canal; no unnecessary labour had been done, except some extra excavation in the Gatun Valley. In case of a sea level canal the Chagres River would have had a lock at Bohio. For a high level canal the dam must be placed at Gatun. Then came negotiations with the Republic of Colombia, who had sovereign rights over the soil, and with whom De Lesseps had treated for the privilege of crossing. Also with Great Britain, who, in 1850, had come to terms with U.S.A. for a joint protectorate of any passage across the Isthmus. The rights of Great Britain were waived by the Hay-Pauncefote Treaty of 1901. The United States offered Colombia £2,000,000 down and £20,000 per annum after nine years for a strip of land ten miles broad, on which to make the Canal. To the surprise of everybody, Colombia, after holding out hopes of acceptance, rejected this offer. Panama, as one of the Colombian provinces, had been in favour of the Canal, and had not been on good terms with the Mother Republic. She immediately declared herself independent, and was recognised by the United States as the Republic of Panama. A fortnight after, a treaty was made between Panama and the United States, whereby the former ceded a belt ten miles wide for the Canal, and agreed to take £2,000,000 for the ownership and control of it, with an annual payment after nine years of £50,000. The Isthmian Commission govern the canal zone on American lines, receiving £2,000 per year from the American Government towards sanitary expenditure in the city of Panama, the Panama Republic paying half the annual cost of Colon sanitation. The towns of Colon and Panama, though within the ten mile limit, did not pass to America, but the United

States virtually govern them, and entirely so in regard to sanitary matters. She has also undertaken the water supply both to Panama and Colon. Cristobel, adjoining Colon, belongs to the United States, and here are the chief works.

The pressure brought to bear on the Colombian Republic by the U.S.A. for purposes of her own has been a subject of much comment. Colombia was powerless; she had no army fit to cope with the American forces, and, though furious, she was compelled to submit and relinquish Panama.

By the Panama Treaty the Canal in time of peace is to be free and open to all nations on terms of equality as to use and charges, but the United States have the sole right to erect fortifications to protect her interests on the Canal.

Having secured the necessary rights, President Roosevelt, in 1905, called together a board of eight American and five European consulting engineers—one of whom was Mr. W. H. Hunter of the Manchester Ship Canal—to decide if the French idea of a sea level canal should be proceeded with, or if a cheaper and more expeditious high level canal with locks should be constructed. The majority, consisting of five foreign and three American engineers, recommended a sea level canal, whilst five American engineers favoured a lock canal. Nevertheless, the American Government decided on the latter. Before finally doing so they had called together an Isthmian or Local Committee of Engineers, who, by a majority of six to one, recommended a lock canal. Further, the Senate appointed an Inter-Oceanic Canal Committee, who reported in favour (by a majority) of a sea level canal, but their report was upset when the matter came to be debated in the open Senate. Finally, the Government adopted the minority report, which was ratified in the House of Representatives, and decided to place the carrying out of the works in the hands of their Army Engineering Department.

GEOGRAPHY AND DESCRIPTION.

A mistaken idea prevails, viz., that the Canal runs from east to west to connect the Atlantic and Pacific. Owing to the swan-neck band of the Isthmus it actually runs direct north and south—Colon being north of Panama. As the crow flies the Isthmus at Panama is 36 miles across; the bends in the channel and the estuarial work, added to this, make the total length 50 miles. From the crest of the Culebra Range to the Pacific Coast is six miles.

On the Atlantic side a channel is dredged for $4\frac{1}{2}$ miles through Limon Bay to the mainland. The entrance from the ocean will be protected by breakwaters. The old French channel ran inland, and did not pass through the estuary. From the coast to the Gatun Locks is about $3\frac{1}{2}$ miles. At Gatun, three locks and a dam raise the Canal 85 feet, and help to form a lake of 168 square miles, into which the river Chagres will deliver itself, and through which a canal channel will run for about $23\frac{1}{2}$ miles, practically to Gamboa. Between this place and Gatun the Chagres river crosses the line of the Canal 23 times. Soon after leaving Gamboa the mountainous district of Culebra is encountered, which runs almost to Pedro-Miguel, the site of single locks and also a dam. Below this lock runs the Rio Grande, and this river is impounded and formed into a lake by a dam and a double set of locks at Miraflores. The Canal is conducted in a trained channel through the lake. Outside the mainland a dredged channel is carried for $4\frac{1}{2}$ miles close to the island of Naos, and to protect it a breakwater is being formed with the material excavated from Culebra, which is being dumped into the sea by means of a trestle bridge. The changes that will be wrought by the Canal can only be realised on the spot; it is difficult from a map to get a true conception of the work being done. In this tropical country vegetation grows so fast that in a few weeks it is scarcely possible to trace even where deep cuttings have been made. Where we walked on dry land in the Gatun Basin, will, in time, have 45 feet of water over it, more or less burying all the hills.

In a few places the Canal is completed, and the river Chagres turned into its new course; this is the case between Matachin and Gorgona. At the Pacific end there is also a complete length of five miles.

One of the most interesting places on the Canal is Gorgona. There are many minor workshops, but here is centred the great workshop of the Isthmus. It is filled with the best labour-saving machinery, and stands on 21 acres of land. In it are seven miles of railway track. Oil is the fuel used. The various workshops make their own electricity, and at the one at Empire is an installation of 8,857 lights. On the whole there is a production of 3,703,407 kilowatts, at a cost of two-thirds of a penny.

As a supply of water sufficient for a Canal and its locks is necessary for success, the Commission have taken steps to

ascertain all particulars as to rainfall and evaporation. To test the latter they have had exposed tanks, which show that the greatest evaporation occurs in February, March and April, and the least in October and November. The rainfall gauges show the least fall to be in February and March, and the greatest in October, November, and December. In December, 1906, 10·48 inches fell at Gatun in one day, and in November, 1909, at Gamboa 28·41 inches of rain fell during the month.

The Canal has a minimum depth of 40 feet and the normal water level is 85 feet above the sea level. It has a minimum bottom width of 300 ft. when passing through the Culebra cutting, and widens out to 1,000 ft. Near this cutting the speed of ships will be limited to $4\frac{1}{2}$ miles per hour. It is anticipated that it will take ten hours for a ship to pass through the Canal. The highest point at Culebra that has had to be cut through is 210 feet above sea level. On the Pacific the range of tide is 20 ft.; on the Atlantic side there is very little rise or fall.

THE MANAGEMENT OF THE WORKS.

What strikes one at first is the difference between the European and American systems of carrying out large public works. In England we have engineers for electricity, water-works, gas, hydraulics, sanitation, etc., whilst in America military engineers conduct public works, and are expected to be all-round men, capable of turning their hands to all kinds of engineering.

It follows that the works are carried out under a military system and with military precision—a soldier being at the head of most of the departments. Colonel Goethals is the pivot round which everybody works. Colonel Hodges, his second in command, takes charge of locks, dams, and all civil engineering. Then come the Atlantic, central, Pacific, mechanical and sanitary divisions, each with a head and a subordinate staff. Following are the quartermasters, the subsistence, the cost, and the hydrographic departments. At the end of the year each official gives a report, accompanied by plans, to Colonel Goethals, and these form the bases of a huge report; this is annually submitted to the American Government, and I have had the advantage of perusing and making extracts from it.

The working staff on the canal works in April, 1909, numbered 33,699; and in addition to these there was a railway

staff of 7,648 men, who were engaged in laying the new line, and a further 5,000 engaged in miscellaneous work, and running the old one. At the commencement, practically no American labour was forthcoming. The largest body of labourers come from Barbadoes and other West Indian islands; next in number are the Spaniards and the Italians. They are divided into two classes—the silver roll and the gold roll; the former are mostly coloured men and labourers; the latter are white men and chiefly artisans; the silver roll men earn 5d. per hour—on an average 25/- per week; whilst the gold men earn from £4 to £10 per week. A joiner whom I questioned said he got 7 dollars a day, or £7. 11s. per week, and a superintendent on the railway was earning over £600 a year.

At one time white men could not be induced to face the terrible epidemics that existed, but since the sanitation has been rectified Americans are tempted by the wages, and now no foreigners can get berths on the gold roll.

In addition to good wages, the Commission holds out other inducements to their employees; they supply them with houses, light, fuel and distilled water without charge, and they provide daily food for 7,700 men, in kitchens, where Europeans can get good meals for 15 cents. We were also given to understand that the negroes can get a fair meal for 10 cents. They provide ample school accommodation, viz., 12 schools for white and 17 for black children; also two higher grade schools; they have established four mutual improvement and recreation clubs, placed under the management of the Young Men's Christian Association. The influence for good of this institution has been enormous. It has found rational instruction and amusement for men in their spare time, and nothing marks this more strongly than the fact that, whilst at one time there were 175 gambling saloons, there are now only 33 on the Isthmus. To crown all, the Commission allows their employees six weeks holidays, during which time they may visit their homes, and they are paid wages during their absence.

THE MODE OF CARRYING OUT THE WORK.

Having decided on a lock canal, a complete reconstruction of the old French Panama Railway became necessary. The old line passed through the Gatun Valley, destined in future to be converted into a large lake, with the Canal running through it. Preparatory to the conversion, over two thousand acres of forest trees on and outside the Gatun Basin had to be cleared away.

The old line is still used during construction, but in time it will give place to an entirely new line built about two miles to the east and nearer the boundary line. The new railway will be 46.2 miles in length. In addition to the main lines, and branching from them, are scores of miles of subsidiary track lines laid in a zigzag course for the conveyance of material to the works and for removing excavated soil and rock which are placed in the waggons by powerful steam excavators. It was a novelty to see a train of 18 waggons unloaded, each of which had an open end and side, with a hinged flap to fall over the buffers; when let down a continuous pathway was made the whole length of the train. On being hauled to the tipping ground a plough was fixed to the last truck connected by a wire rope to a powerful winding apparatus at the engine end. Directly power was applied the plough, with a rotary motion, forced all the material over the truck side, and in $7\frac{1}{2}$ minutes the whole train load (about 320 cubic yards) was on the tip. Then came a distributing machine worked from the truck edges, and this made the heap perfectly level. Had I not seen this expeditious work with my own eyes, I could not have believed that a machine and plough worked by a wire rope could have the power to empty a whole train. Each day an average of 5,868 waggon loads of dirt are removed, and these placed in a continuous train would cover 34 miles. A waggon is loaded in five seconds. A track-laying machine, the invention of an employee, also attracted my attention, and the clever labour-saving appliances on the canal works were a revelation to me.

At Gatun is a cement shed that holds 100,000 barrels. From here an electric railway conveys the cement, sand, and broken stone through a tunnel to eight automatic mixers that turn out two yard batches of concrete. This is then taken by an electric locomotive to four duplex cableways, 800 feet across, which span the locks, and these deliver where desired. I was told the concrete used is 9 to 1, viz., 3 sand, 6 broken stone and 1 of cement. On the three lock systems, Gatun, Pedro Miguel and Miraflores, the concrete used would build 22,242 two storey houses of eight rooms each.

At Culebra lies the chief excavation work. A mountainous range has to be cut through, the highest elevation being 312 feet above the level of the sea, and here great difficulties have been met with, owing to the sides of the mountain slipping down into the canal bed. At Cucarracha first six acres were on the move,

and finally the area of the slide extended to 27 acres, and about 1,400,000 cubic yards have had to be removed. Large slides have also taken place at new and old Culebra, and many other places. At Miraflores in 1908 a slip of 200,000 cubic yards crashed into the railway cutting and stopped the work.

CONSTRUCTION WORKS.

The success of the Canal depends on the works at Gatun, Pedro Miguel and Miraflores. If the locks and dams there are capable of withstanding the immense pressure of water that will bear upon them, and if the stability of the sides of the Culebra Cutting can be assured, there can be no reasonable doubt of the Canal being completed, and working well.

But it is the Gatun locks and dam which give the chief cause for anxiety; unfortunately they have not a sound rock foundation. Prior to the mixed Commission of 1906, borings had been taken to a depth of 250 feet at the Gatun dam site, which, it was stated, showed a foundation of 200 feet of material impervious to water and incompressible. Instead of the anticipated loose sand and gravel, there was a conglomeration of sand, clay and gravel, that a pick would scarcely separate. On this point, however, engineers are not agreed, and it is admitted on all sides that the river Chagres, whose waters have to be withstood, is one of the most fitful and capricious in the world.

At Gatun the locks are in pairs, side by side; there are three sets of them, one above the other; the division wall between each pair is 60 ft. thick, and this is extended in the shape of a guide pier up and down stream, so that vessels can moor to it, and be warped or electrically towed through the locks. Each lock is 110 ft. wide and 1,000 ft. long. (The Manchester Ship Canal locks are 60 ft. wide and 600 ft. long.) There are longitudinal culverts in the side walls, worked by Stoney's valves, and these fill the locks through apertures, 6 ft. wide, in the side and bottom. The locks have a 32 ft. lift. The gates are of steel, double leaf and double sheaf, and are made to mitre. For safety there is a rolling gate at the bottom Gatun lock. The locks themselves have intermediate gates protected by chain barriers. This leaves available two locks, respectively 550 and 350 feet long. For further protection, and to cut off the flow in case of accident at the summit level of all

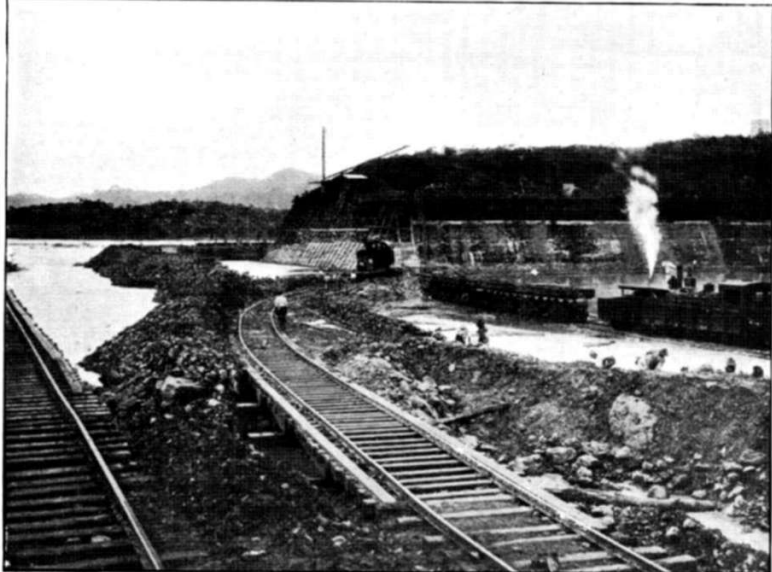


Fig. 2. Panama Canal. Gatun Spillway. Approach channel showing construction of concrete cover on Rock Slope, 1910.



Fig. 3. Panama Canal. Upper Gatun Lock, looking South from East Wall, 1910.

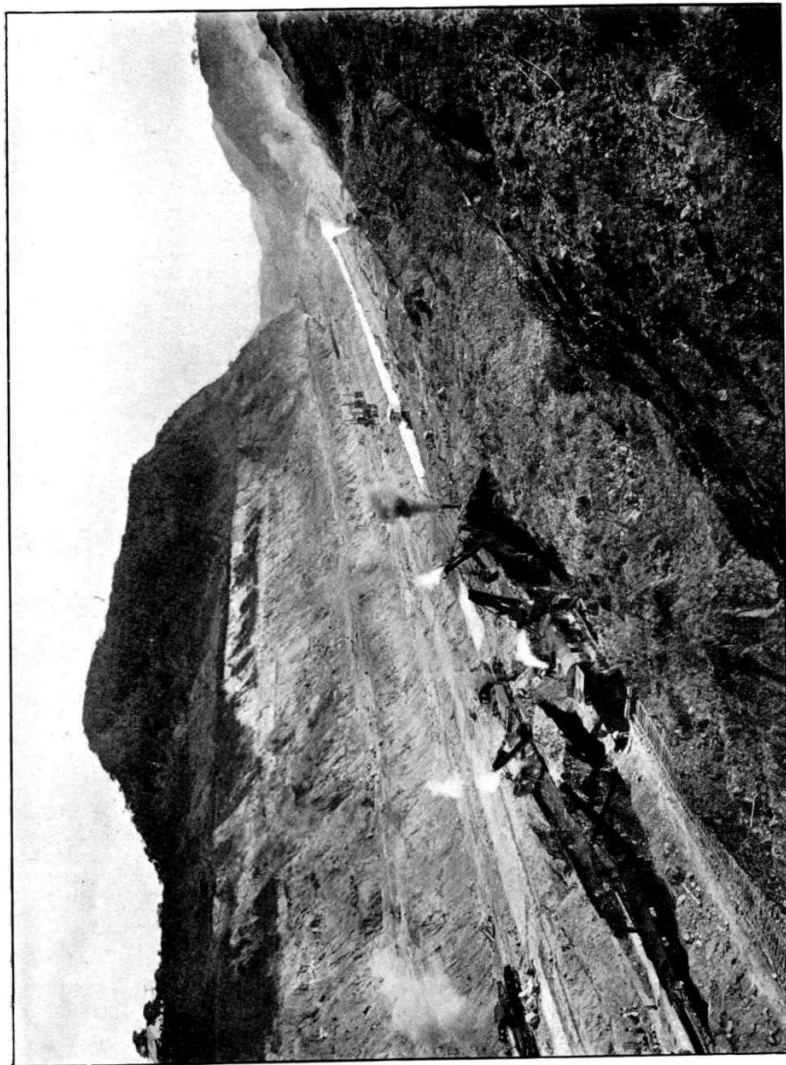


Fig 4. Panama Canal. Culebra Cutting. West Bank looking South, 1909.

the top locks, there is a swingbridge with a sill at the bottom into which girders can be lowered to check the rush of water in case of accident. The average height of the upper gates is 54·8 feet, and of the lower 78 feet, but they vary in size. Each leaf of the largest gate is 82 feet high and 65 feet long, and weighs 640 tons. The total weight of all the lock gates on the Canal, not including fixed parts, is 50,000 tons. If they were all piled up into one tower they would be $1\frac{1}{4}$ miles high. It is expected that a ship will pass through the three locks at Gatun in fifty minutes.

The Gatun dam is of crescent shape, situated between two ranges of hills over 2,000 yards apart, and is located close to the locks. In the centre of the dam, on the best foundation that could be found, is a concrete sluice or spillway 285 feet broad and 960 feet long. Here will be placed Stoney's sluices to deal with the overflow and surplus waters of the Chagres river. Through the east side of the dam ran the course of the old French canal, which has had to be filled up. The top of the dam will be 115 feet above sea level, and is at the base 600 feet thick. The outside casing consists of rock brought from the Culebra Cutting. A deep trench has been cut inside, and in the bottom sheet piling has been driven. The trench and the interior then had hydraulic fill poured in, to form a hearting. The filling, I was told, consisted of clay and sand obtained by hydraulic dredging and then carried by pipes to form the interior of the dam. The heavy matter desposits, and the water drains away.

On questioning Colonel Goethals about the quality of the hearting, he said it had been thoroughly tested and was perfectly watertight; on this will mainly depend the stability of the dam. On November 20th, 1908, a slip took place, and President Roosevelt was so alarmed that he sent down his successor, Mr. Taft, and a commission of engineers to inspect. They reported that the filling was watertight; they did not even think that piling was necessary, and they reduced the height of the dam by 20 feet.

Prior to the Commission there had been a newspaper war in the American papers. It was said the Gatun dam had given way, indeed was sinking out of sight, and that the estimated cost would be doubled. Even the reassuring report of the Commission was attacked. It was said they were a packed jury, several of them being pledged supporters of a lock

canal, and the assurance of Colonel Goethals and his subordinate engineers that the dam could be made and maintained was seriously doubted.

At Pedro Miguel, also at Miraflores, the locks and dams are on the same principle as at Gatun. They have the advantage, however, of being on solid rock, some of which is left to form part of the division walls. The hearting of the dam walls at Pedro Miguel is of puddled clay, with a minimum thickness of 140 feet. Here are adopted the Lidgerwood cables, single and duplex; these lift the sand, stone, and cement to an elevated chamber, where it is mixed into concrete and then conveyed by aerial cable ways, and dropped on the spot where it has to be used.

The costs of the various kinds of excavation and dredging are so mixed up with those for administration and sanitation that it is difficult to give them correctly; but, so far as I can make out, the minimum cost of dredging is $6\frac{1}{2}$ d. per cubic yard, whilst the average cost of dry excavation runs about $2\frac{1}{6}$ per cubic yard. A comparison figure shows that, year by year, a constant reduction is being effected in the cost of the various kinds of work; in 1909 the unit cost was 21 per cent. less than in the previous year.

SANITATION.

To my mind the most wonderful work performed by the American Commission has been practically stamping out yellow fever, cholera, and all other infectious diseases in five years. Previously the loss of life had been frightful, even among the West Indian natives. The whole isthmus, from Colon to Panama, during the French occupation was a white man's grave. It reeked with filth and pollution, and was a breeding place for mosquitoes and all kinds of vermin and flies. Even this year some nervous friends of mine had visions that I should never return, and tried to persuade me not to visit the plague-infected canal zone. But they were mistaken, and I can bear testimony that the Isthmus is now as healthy, and healthier, than any other part of South America. When the Americans got possession they realised that life was money, and it was no use importing men to die off like rotten sheep. They created a chief sanitary officer with a "carte blanche" as regarded assistance and expenditure. Every house was inspected, cleansed, renovated and made sanitary, and the whole district was drained.

Every swamp and unnecessary ditch was filled up, and those left had a coating of oil, so that they might not become breeding places for mosquitoes, flies, etc. An oil pipe was carried through the works so that all stagnant waters might be dealt with at once. The result has been marvellous; whilst, during the French occupation, thousands died from yellow fever, not one case has been recorded on the Isthmus for the last two years.

The head of this beneficent work is W. C. Gorgas, Colonel in the Medical Department of the U.S. Army, and he deserves the highest praise for his skilful and scientific treatment of the scourge. At the start he had an army of over 3,000 men at work, and his present sanitary staff numbers 1,328; these men are always on the alert, and even cut the grass round the cantonments that it may not harbour filth. The cost of sanitation and keeping the houses in order is £4,000 per month. Whilst we were in Colon and Panama we saw fewer flies than we should see at home in hot weather, and no trace of mosquitoes. This is a marked contrast to a neighbouring Colombian town which we visited, when, in the market, all articles of food were thickly covered with flies, and putridity abounded.

The Death Rate on the Panama Works.

	1908.	1909.
Silver Roll (Blacks)	19.48 ...	11.98
Gold Roll (Whites)	15.34 ...	11.95
Including the towns of Colon and Panama	27.67 ...	22.04

This is a death rate less than that of many of our large towns in England, and speaks volumes in showing how disease will succumb to scientific treatment.

THE ADVANTAGES OF THE CANAL.

One has only to study a map to see that the Panama Canal will revolutionise the commerce of the world by preventing the necessity for ships to round Cape Horn in passing from the Atlantic to the Pacific. Of course the United States will take off the cream; the benefit to her, both in times of peace and war, can hardly be estimated. The voyage from New York to San Francisco alone will be shortened by 8,450 miles—a saving of time of 28 days by a cargo steamer. When war was declared with Spain the U.S. warship “Oregon” was in the Pacific, and she had to sail 13,000 miles before she could reach Cuba.

Had the Canal been available, she could have been on the spot many weeks earlier. England, too, will gain largely; it will bring San Francisco nearer to Liverpool by 6,000 miles; and it will shorten the distance to the average South American Pacific ports from New York by 4,709 miles, and from Liverpool by 2,600 miles.

By the new Canal Melbourne will be 2,739 miles nearer to New York than to Liverpool, and there is no question that America will become a formidable competitor with England for the trade of the world. She is the great producer of cotton which comes to Europe, and is now sent to China and India *viâ* the Suez Canal in a raw or manufactured state. Her iron and steel manufactures for the Eastern markets, too, will only have to travel half the distance, and the freight charge will be materially reduced. At present on cheap and heavy goods the freight is sometimes more than the cost of production. Few people can realise the momentous changes that will come about when the Canal is opened.

COMPLETION AND COST.

The questions usually asked by sceptics are: “Do you think the Canal will ever be made?” “What time do you give for its completion?” and “What will it cost?” My reply to the last question is: “Nobody can tell.” Every canal so far has nearly doubled the original estimate. It was so with the Kiel Canal, the Manchester Canal, and the Suez Canal. We know that up to June, 1908, America has expended £26,000,000, and the same year Colonel Goethals declined to tie himself, and said the Canal would cost 50 to 100 millions. I quite believe that if the money spent by the French and Americans was added together, and interest charged for, during construction, this Canal from its inception will have cost £150,000,000.

As regards completion, some interesting figures were attached to the official report, issued on June 30th, 1909, in which it was calculated that 34 per cent. of the work was in a finished state.

President Taft maintains it would have taken five years longer and have cost £40,000,000 more to construct a narrow sea level canal than it will to complete the present lock canal.

Colonel Goethals ventured the opinion that the locks would be completed in three years, and the remainder of the work in two years more, but as was in the case of the Manchester Ship Canal, there may yet be many slips between the cup and lip.

Both Canals had very fair sailing for the first four years. Then the Ship Canal had two years of continual flood and misfortune, which entailed heavy cost and months of delay. So on the Panama Canal, the Chagres river is a continual menace; its rise is so rapid and unexpected. On the 29th January, 1909, it rose 66·7 inches at Gamboa, filling a small cutting to the depth of 23·3 inches, and flooding the plant; and in 1879 it stood at 825 feet above sea level. One year the maximum flow varied from 4·005 feet per second in April to 24·200 in November.

To prevent loss of life, stations have been erected in the mountains so as to give eight hours' notice of probable danger.

The catastrophe at Jamaica made me feel nervous about the effect an earthquake might have on the locks and dams at Panama. I was assured, however, that the Canal was outside the earthquake zone, that constant observations were being taken at the Ancon Observatory, and that so far there had been no more tremors than at Washington or Harvard. Yet within two months of my return an awful earthquake has destroyed Cartago, a town in Costa Rica, not far from the Canal, and killed or injured 1,500 people. This shows how the unexpected may happen.

CONCLUSION.

I have been repeatedly asked: "What is your view as to the way the works are being carried out?" and, "Do you prefer a sea level or a lock canal?" I feel that, as an amateur, I am not competent to give an opinion that is either valuable or reliable, especially when I remember that the most skilled engineers have differed so widely. When De Lesseps started to saw his way through the Isthmus he had no conception of the difficulties before him,—that his men would die like rats—and that his resources would be so soon frittered away. The Americans, despite the verdict of their engineers, have adopted a lock canal, believing that it can be made more quickly and at less cost than a sea level canal. Their policy is to go full speed ahead regardless of expense; to-day their expenditure in labour is at the rate of £26 per minute. All their men are vying with each other to turn off work in quantity, and, with the danger of flood, storm and tempest, this after all may be good policy; at any rate I should not like to condemn it. President Roosevelt was certainly a bold man when he set at nought the opinions of most experienced engineers, and went in for a lock canal, and I

can only hope that his judgment was sound. Under an almost military despotism as to management, with no interference from trade unions as regards piecework and the hours of labour, and with the best labour-saving machinery, the work is going on at a rate I have never seen equalled. The Gatun locks and dam, built on foundations none too good, are the crucial points of the whole Canal. The quality of the hydraulic-clay filling for the dam, and concrete for the spillway and the locks, can only have been adopted after due consideration. I trust it will turn out satisfactorily; but we in England have been used to quite another class of work. I cannot forget the slip that took place at our own Bridgewater locks, and how the walls slipped down through a vein of sand in the foundations, causing the whole lock side to move into the canal bed. Till water gets into the excavated bed I see a fertile source of danger and delay from slips, especially in the Culebra Cutting, and I feel sure the banks will yet have to be further flattened.

Since the sanitary operations scarcity of labour no longer exists. Good wages and good treatment, the American policy, is working well, and many of the coloured men are pictures of health and strength. There can be no doubt that providing good food at cheap prices pays well. The whole line, with its 27 villages, is a truck shop well administered.

A pleasing feature was the large quantity of money sent by the roll men to their relatives in all parts of the world. Considering the class of men, we found the great bulk of the labourers capable, willing and sober men, of a much better type than one could have expected.

Though at a much greater expenditure of time and money than was originally expected, there can be no doubt that the Panama Canal will be completed, and in a way that will do credit to the American Government. It will be a blessing to mariners, and certainly in time to come be ranked as one of the wonders of the world.