

It was then 800 feet in length and covered an area of about 6 acres. It has since extended until the material involved is about one-half a mile long and covers an area of about 27 acres. Over 700,000 cubic yards are in motion. In 1907 the maximum movement was 14 feet in twenty-four hours. This movement turned over a steam shovel and buried another. One hundred and thirteen thousand cubic yards, with a glacier-like motion, moved into and across the cut, completely filling it up for the time being. The French tried elaborate drainage systems, which proved inadequate. Removal of the material is the only effective remedy. There have been during the past year slides at thirteen different points and 884,000 cubic yards of material have been removed; about 1,000,000 cubic yards are still in motion and will eventually have to be handled. While annoying, and in themselves of some importance, when compared with canal operations as a whole, these slides dwarf into insignificance, and will affect the total amount and cost of the work by less than 1 per cent. All the banks stand up well, and it is the shallow top layer of soft earth and disintegrated rock that is causing the trouble. Undoubtedly before the canal is completed these banks will be so-covered with tropical vegetation as to be permanently held in place.

The various excavating operations are successively as follows: Drilling, blasting, loading, transporting, and dumping.

Tripod drills are used for shallow holes; well or churn drills for the deeper holes; and hand drilling only for a few isolated holes. Compressed air furnishes the power to the drills at 80 pounds pressure. Each shovel is preceded by a battery of from 4 to 12 drills, covering a field from 30 to 40 feet wide, which keeps well ahead of the shovel. Holes are drilled from 15 to 30 feet deep and from 6 to 16 feet apart, depending upon the material and conditions. Each hole is loaded with a charge of from 75 to 200 pounds of dynamite, 45 and 60 per cent dynamite being used principally. One million pounds of dynamite are being used monthly. After being loaded, the holes are connected up in parallel and discharged by electric current. While the greatest care practicable is taken in all operations connected with the handling of dynamite, a number of accidents have occurred and a number of lives have been lost, mostly alien laborers. The most serious explosion occurred at Bas Obispo last December and resulted in 24 deaths,

most of them laborers. It was a premature explosion of 22 tons of dynamite, loaded in 53 holes. The cause of the explosion has remained obscure. One theory was that the water in the holes being slightly acid tended to liberate the nitroglycerine, which being in an extremely unstable condition exploded from some small shock or vibration due possibly to a distant shot or blast. Some of these holes had been loaded several days before the explosion. In order to be on the safe side no holes are loaded now which can not be fired the same day. The large blasts break the rock into fragments small enough to be handled by the steam shovels. Any large pieces are broken into smaller fragments after the main blast by what are called "dobie" blasts, consisting of a small quantity of dynamite laid on the surface of the rock, covered with clay, and discharged by fuse. During the first operations black powder was tried and discarded. During the greater part of the year the holes when loaded are full of water. Power to run the drills is furnished by one of the largest air plants and longest supply mains in the world. A 10-inch air main runs the full length of the cut, $9\frac{1}{2}$ miles, with an extension at the south end to Miraflores. To equalize the pressure, compressors are located at three points, one near each end of the line, at Las Cascadas and Rio Grande, respectively, and one near the center at Empire. Each of these plants has four compressors of a capacity of 2,500 cubic feet to 100 pounds pressure per minute, or 30,000 cubic feet per minute in all. It will be necessary to install two additional compressors on account of the greater proportion of rock that is now encountered.

The smaller size steam shovels weigh 70 tons and have $2\frac{1}{2}$ -yard dippers, and the large size shovels 95 tons and are equipped with 4 and 5 yard dippers. They are self-propelling and are able to make a cut over 20 feet deep. There are 100 in all. In working down from one level to the next lower level it is customary to start shovels at different points to dig the center trench, called the "pilot cut," which is 34 feet wide at the bottom, 50 feet at the top, and from 15 to 20 feet deep. These pilot shovels are followed up by shovels widening the cut on each side, each taking $26\frac{1}{2}$ -foot slices. The great problem is to keep the shovels supplied with cars, so that they can work continuously; under the best of circumstances, owing to

repairs, accidents, and delays due to moving the shovel forward, as well as waiting for cars, etc., it is not possible to keep the shovels working more than two-thirds of the time. During the past two years the average output per shovel has increased over 50 per cent. In March, 1909, the shovels in the Central division averaged nearly 36,000 yards for the month. The largest monthly record for one shovel was made in October, 1908, when a shovel loaded 58,483 cubic yards. The largest day's record was in February, 1909, when during eight hours one shovel excavated 3,941 cubic yards, which is equivalent to the work of over 600 men. There is great rivalry between the shovel engineers to make the best record. The crew of the steam shovel consists of 1 engineer at \$210 per month, a cranesman at \$185, and a fireman at \$83.33; also from 6 to 10 laborers, called "pitmen," who are kept busy moving the track forward on which the shovel runs and on various other operations. The working day for the shovel is eight hours—from 7 to 11 and from 1 to 5. At 5 o'clock the various supply and repair trains start out promptly from the different yards for the "cut," where they spend the night making repairs and getting ready for the next day's work. This consists in supplying each shovel with a ton and a half or so of coal, with oil, and other supplies. Repair gangs are required to make all the necessary adjustments and repairs so that the shovel can begin digging at 7 o'clock the next morning. It is seldom now that shovels have to be taken into the shop for general repairs, as a sufficient supply of extra dippers, booms, dipper sticks, swinging circles, and other main parts of the shovel are kept on hand, and when a breakdown occurs it is only necessary to replace the part in question in the field with one of the spare parts.

The large shops at Empire, where 600 men are employed, are devoted to repairs of steam shovels and steam-shovel parts. Repair parts are purchased in the United States unless they can be manufactured more cheaply on the Isthmus.

The greater part of the excavated material is loaded onto long, flat, wooden cars with one high side, called "Lidgerwood flats." One thousand eight hundred of these cars have been purchased. Originally there were 16 cars to the train. It has since been found practicable to increase the number to 18. Each car has a capacity of from 18 to 20 cubic yards, or about 350 cubic yards to the train, making a load of about 500 tons. Each shovel is able on an average to load

from three to four trains per day. From Empire south, trains move down grade, coming out of the cut on the incline at Pedro Miguel, and thence run down to Miraflores dump, or to Balboa, where they dump into the Pacific to form the breakwater which is being extended to Naos Island. From Empire north, the trains move down grade, coming out on the main line at Las Cascadas or Matachin, or taking to the relocated line on the east side of the canal at Bas Obispo, where the spoil is dumped on the relocated line between Gamboa Bridge and Caimito. At the present time all hard trap rock suitable for use in Gatun dam is being loaded onto trains of from 25 to 30 steel dump cars and hauled from Bas Obispo to Gatun.

A dozen or more dumps were maintained in former days. On account of the deepening of the cut and from considerations of economy, it has been found desirable to concentrate the disposition of spoil in a few large dumps. The dump at East Balboa requires an 11-mile haul. At Miraflores dump nearly 4,000,000 yards have been dumped within an area of about 260 acres. The largest dump is at Tabernilla, where 10,000,000 yards have been spread over an area of little less than 1 square mile. The average haul north is 12 miles to Tabernilla, $5\frac{1}{2}$ miles on the relocated Panama Railroad, and 25 miles to Gatun.

The work requiring the largest number of laborers is in moving and ballasting track. In Culebra cut alone there are 51 miles of track, and in the whole Central division there are 194 miles of track exclusive of Panama Railroad tracks. On an average about 1 mile of track per day is moved in Culebra cut and on the dumps in the ordinary conduct of work.

One thousand one hundred all-steel dump cars have been purchased varying from 12 to 20 yards in capacity. The 12-yard cars are dumped by hand and the large steel cars are dumped by air. Over 650 of the small French dump cars have been used at various times, and by executive order the application of the interstate commerce law to the Isthmus as regards couplers and air brakes, specially excepted French dump cars for one year from July 1, 1909, during which time their use will be required. The wooden flat cars called "Lidgerwoods" are unloaded without hand labor by a 5-ton steel plow, to which is attached a $1\frac{1}{2}$ -inch steel cable. The plow is operated by a Lidgerwood unloader capable of exerting a 60-ton pull,

which in turn is operated by steam furnished from the locomotive to which it is attached, the plow being drawn forward by this cable winding around the drum of the unloader, and the dirt being thus forced over the side of the cars. When working smoothly the train is unloaded in five minutes and starts back immediately to the cut.

On an average, the cars make two round trips per day, and in the Central division over 200 dirt trains, including both steel dump cars and Lidgerwood flats, are loaded and dumped each day. The ridge of rock and earth which is plowed off the cars is leveled by a spreader which operates on the same principle as a snow plow. In moving tracks on the dumps, a labor-saving device called a "track shifter" is employed which performs the work of 500 laborers. It consists of a derrick mounted on a steel flat car with a projecting arm to which hooks are attached, by which a section of the track ahead of the car is raised, after which, by means of a side arm carrying another hook, the suspended track is moved over any distance up to 8 or 9 feet. The usual throw of the track is from 4 to 5 feet.

Locomotives are housed at night in engine houses at various points along the line, the principal ones being at Pedro Miguel and Las Cascadas, where they are coaled and given light running repairs by a night gang. Every morning they begin to leave the engine houses promptly at 6.30, and in five minutes the 30 or 40 locomotives have departed. One hundred and sixty large American locomotives have been purchased by the Commission. In addition, the Panama Railroad has 82 locomotives, and about 130 old French locomotives have been repaired and put into Commission service.

The number of cars in use by the Commission is nearly 4,500, and in addition there are a large number of unloaders, plows, spreaders, track shifters, cranes, pile drivers, and smaller pieces of miscellaneous equipment. Locomotives, cars, and other equipment, except steam shovels are repaired at the Gorgona shops, where a force of 1,000 men is employed. The French company started these shops, which have since been rebuilt and enlarged. An iron foundry and a brass foundry are also located at the Gorgona shops.

GATUN DAM.

Due primarily to its size, Gatun dam has received perhaps more than its share of attention in the United States. There is nothing especially difficult or complicated about this dam, and many dams

have been successfully built in the United States to withstand much larger pressures and greater heads of water than the Gatun dam without being given one-hundredth of the attention. Gatun dam fills the opening between the hills at Gatun, through which the Chagres River flows to the sea. It will consist of a water-tight center or core composed of sand and clay mixed in proper proportion and deposited hydraulically; that is, by being pumped in by dredges. This center core is to be confined by a rock wall on each side. The dam rests on impermeable material of sufficient supporting power. The site and the plans have been examined by the leading specialists in engineering construction of this kind in the United States, and both the foundation and superstructure have been pronounced, without qualification or reservation, to be entirely and absolutely safe. The last special engineering committee accompanied President-elect Taft to the Isthmus in February, 1909, and spent two weeks studying various canal matters. It thoroughly approved and indorsed the project as a whole and in part. A few changes in detail on lines of economy which were suggested are being followed.

The locks and the spillway may be described generally as appurtenances of the dam. The spillway consists of a concrete-lined opening cut through a hill of rock along the line of the dam near the center, supplied with gates of suitable design to allow the lake level to be regulated. The locks are built in an excavation at the east end of the dam, in rock, and afford means for passing vessels in and out of the lake on the Atlantic side. They are operated in the manner usual for such works.

The dam proper is about 7,500 feet long over all, measured on its crest, and for only 500 feet of this length will it be subjected to a pressure of 85 feet of water, as the natural surface on which it is built rises rapidly after passing by the old bed of the Chagres River. For only about half of its length will the head of water on the dam be over 50 feet. Hard rock underlies the dam near the surface of the ground except for about one-quarter of its length, where the rock dips down to a minimum depth below sea level of from 195 feet in the depression east of the spillway to 220 feet in that west of the spillway. These depressions or valleys have during past ages filled up, and, measured from sea level down, the first 80 feet consists of

sand and clay; the next 100 feet or so is stiff blue clay; the last 20 feet is a conglomerate, composed of sand, shells, and stone. This material is all impervious and of sufficient bearing capacity to support the dam, and thus fulfills the essential requirements. The entire area to be covered by the dam and adjacent territory has been probably more carefully examined by borings, test pits, etc., than that for any other similar structure.

The construction of the dam is being carried on by first building two lines of rock, composed of spoil from the canal and lock excavation, about 1,200 feet apart and parallel to the center line of the dam. The south or upstream pile or "toe," as it is called, has a height of about 60 feet and the downstream toe about 30 feet. These rock toes confine the body of the dam between them, which is to be mainly of impervious material pumped in by dredges. At the bottom this impermeable core will have a width of about 860 feet, outside of which the body of the dam will consist of spoil, which can be placed with the least expense. Outside of the toes are the waste piles for the spoil of neighboring excavation. These piles will slope down gradually and extend indefinitely, so far as material is available. The total thickness of the dam at the base between the outer edges of these waste piles will be fully 2,000 feet. The thickness of the dam at the water surface, elevation plus 85, will be 398 feet. The top of the dam will be 30 feet above the water level and have a width of 100 feet. The top and upstream slope will be thoroughly riprapped. At the present time the rock toes east of the spillway have been carried to full height, and three dredges are working twenty-four hours daily in pumping in impervious material to form the core between them. From 300,000 to 400,000 yards of material are handled by these dredges per month. The spillway has a channel 300 feet wide and is designed for a maximum run-off of 140,000 cubic feet per second. The concrete floor has been laid, and the side walls are well under way.

Last November, while the south toe was being constructed where it crossed the old French canal channel, the weight of the superimposed rock on the soft silt and mud, which had been collecting since the French stopped work twenty years ago, squeezed the mud out at the bottom of the French canal, from which the water had just been pumped. The crest of the pile of rock slid down and in for a distance of about 200 feet. The vertical movement was about 20 feet at the

top, but at the bottom of the rock pile was only 8 feet. The bank on the south side of the rock pile was entirely undisturbed. Several other slight movements had previously occurred without anything being thought of it. This local disturbance, happening in conjunction with a flood in the Chagres River, formed the basis of the sensational stories which were published in the United States. This happening caused no anxiety on the Isthmus, and hardly passing interest.

GATUN LOCKS.

The excavation for the locks at Gatun is well under way. Three-quarters of the 5,500,000 yards have been excavated. The excavation for the upper lock is practically completed, and the mixing and placing of concrete begins this month. The general plan of the upper locks may be taken as typical of all the locks. The locks are in pairs each having a width of 110 feet and a usable length of 1,000 feet. Each lock consists of a chamber, with walls and bottom of concrete, and with water-tight gates at the ends. The level of water in the locks is regulated through openings in the bottom, by the operation of valves in the side and center walls, which permit water to flow into and out of the locks by gravity. These locks are the largest that have ever been designed.

The controlling principles which have been followed in the design of the locks have been:

First, to make them safe, and second, to make them adequate in size and arrangement.

To attain the former, attention should be particularly directed to five devices which will be used. The fundamental principle has been followed that in all cases there shall be at any time not less than two barriers separating a high level from that next below. In carrying out this principle there are two gates at the upper end and two gates at the lower end of the upper lock. The double gates will be operated simultaneously. Another safety device is a chain stretched across the lock near the surface of the water and passed around fixed capstans on the walls. This device is so designed that by the application of frictional resistance at the proper varying rate it will arrest a 10,000-ton vessel moving at a speed of 6 miles an hour. When not in use it will lie in a groove in the lock floor. The results of serious mishaps to the gates and locks are guarded against by mov-

able dams above the upper gates. Each dam consists of a swing drawbridge from which wicket girders can be lowered one at a time, the upper ends being supported by the bridge and the lower ends by a sill in the bottom of the entrance. These wicket girders being lowered in horizontal tiers one at a time gradually diminish the area of the waterway. This dam is so designed that the flow of water through the locks, with the gates once opened, could be checked in less than an hour. The safety devices already mentioned, namely, twin locks, duplicate gates, cable protection, and movable emergency dams, have all been successfully tried separately on different locks in this country and abroad. In no case has it ever been deemed necessary to install all of them in the same work.

In addition, a further safeguard will be adopted to minimize the chances of accident. Practically all recorded accidents to locks in recent years have occurred through some mistaking of signals between the pilot house and the engine room while the vessel has been passing through locks under its own steam. To obviate this source of danger, it is proposed to provide on the walls of the locks electric locomotives, which under proper control will tow vessels through the locks, there being one locomotive on each side of the lock forward and astern, or four in all, vessels not being allowed to move their propellers meanwhile.

The gates consist of two leaves and are massive steel structures 7 feet thick, 65 feet long, and from 47 to 82 feet high. They will weigh from 300 to 600 tons each. Eighty-four leaves will be required for the entire canal, the total weighing 43,000 tons. Intermediate gates will be used in the upper locks in order to save water, if desired, in locking small vessels through, the gates being so fixed as to divide the locks into chambers 550 and 350 feet long, respectively. Ninety-five per cent of vessels navigating the high seas are less than 600 feet long.

The adequacy of the water supply for the demands of commerce has never been seriously questioned. Data on this point is available from many years' investigations and study. During three-quarters of the year the rainfall is ample. During the remainder there is practically no rainfall, and therefore enough water must be stored during each rainy season to carry over the succeeding dry season. The advantage of the enormous storage capacity of Gatun Lake for this purpose is thus seen, and it is intended to allow the water

to rise in the lake to elevation +87 at the end of each rainy season, and it can lower $5\frac{1}{2}$ feet from this elevation without reducing the depth through Culebra cut below that in the sea-level approach on the Atlantic side at low water. In other words, Gatun Lake will, during the rainy season, store over 5 feet of water that can be used during the dry season.

According to conservative calculations the canal as designed will have ample water supply for as many lockages per day as can be passed through the canal, which is estimated to be 48 for the twin locks. This will amount to fully 80,000,000 tons per annum, and the canal will not be called upon to take care of tonnage in excess of this amount until a very distant day. Should the day ever come when greater capacity is needed, other locks paralleling the present ones could be built, and the storage of additional water to carry over the dry season could be obtained from a dam at Alhajuela. The tonnage passing through the Suez Canal is about 21,000,000 gross tons per year and through the Sault Canal 40,000,000 gross tons per year.

The main culverts, 18 feet in diameter, through which the lock chambers are filled, are located in the walls and connect with the lock chambers through lateral culverts opening upward through the lock floors, which are controlled by valves of the Stoney type; that is, gate valves moving on rollers in frames to reduce friction. The lateral culverts which cross the floor are 72 feet center to center, with openings 18 feet apart. By thus distributing the water over the entire floor of the lock, currents and eddies are reduced to a minimum when the lock is filled or emptied quickly. The locks can be filled either from the side culverts alone, through the middle culverts alone, or through both together. With both culverts turned on, the time of filling the lock would be a little over eight minutes, or over 3 feet per minute. It is not expected, in the ordinary operation of the locks, to fill or lower same in less than about fifteen minutes, or at a rate of about 2 feet per minute.

Electricity will be used not only to tow vessels through the locks, but also to operate all the gates and valves, power being generated by water turbines from the head created by Gatun Lake. Electric energy is likewise being used to operate the machinery and plant used in constructing the locks. At Gatun and at Miraflores each power plant consists of three 1,500 kilowatt turbine generators,

steam being furnished by six 400-horsepower boilers. Twenty-five cycle alternating current is generated. About 2,300,000 yards of concrete will be placed in the Gatun locks and spillway. The Pedro Miguel locks and dams and the Miraflores locks, dams, and spillway, altogether, will require about the same amount.

Concrete will also be required to line a portion of Culebra cut under water amounting to almost half a million yards, making a total of almost 5,000,000 cubic yards of concrete.

The strata which have been pierced in excavating for Gatun locks consist successively of red clay, argillaceous sandstone, conglomerate, and soft sandstone (which is water bearing); and underneath these strata, tufa and argillaceous sandstone, and finally fine, compact, impervious argillaceous sandstone are to be found. The water carried by the soft sandstone is small in amount and comes from a remote source under pressure from the southeast. The strata dip to the north. The floor of the locks at Gatun rests upon either the sandstone or conglomerate, and there will be a thickness of not less than 20 feet of concrete, or concrete and hard, impermeable rock between the bottom of the locks and the water-bearing sandstone.

Concrete curtain walls 6 feet thick and from 8 to 18 feet below sea level are being built around the upper locks, from the sill of the emergency dam to the lower end of the intermediate gate abutments, to act as a water cut-off where the concrete is less than 20 feet in thickness, and old French rails have been embedded in the underlying rock to act as anchors for the concrete, tying it to the portion of the rock which acts as the floor.

The construction plant is complete and elaborate. Broken stone for concrete is brought from a large quarry and crushing plant at Porto Bello, 18 miles to the east of Cristobal, which has a capacity of 2,400 cubic yards in eight hours, and sand from old Nombre de Dios, beyond. Upward of 2,000 yards of concrete will be laid daily, working in two shifts. Cement will be brought from the United States in two large steamers bought for the purpose, each of which can carry 45,000 barrels. Nearly 5,000,000 barrels will be used.

Pedro Miguel locks and dams.—At Pedro Miguel there is to be a single set of locks with one lift of 30 feet. The locks are similar to the Gatun locks in design. The dams connecting the locks with the near-by hills on each side at Pedro Miguel are not large. To the west

the dam is of earth, 1,400 feet long with top 40 feet wide at elevation +107. The maximum head of water against this dam will be 40 feet. The dam has an impermeable core of solid material 140 feet thick. The east dam will have a concrete core 550 feet long, 4 feet wide at the top and 10 feet wide at the bottom.

Miraflores locks and dams.—At Miraflores there is to be a flight of locks in pairs, with two lifts of $27\frac{1}{2}$ feet each. The dams extend from the upper ends of the locks to the nearest hill on each side. The west dam is 2,300 feet long and runs practically parallel with the locks. It is of earth with a top width of 40 feet at elevation +70. The maximum height of water against this dam is 45 feet. The east dam will be of concrete 500 feet long, and a spillway having a capacity of 39,000 cubic feet per second will be built in this dam. There will be a power plant similar to the plant at Gatun in size.

Sand for making concrete for the Pacific locks will be brought from the peninsula of Chamè, lying to the west of Panama. Rock will be transported by rail from a quarry which has been opened on the west side of Ancon Hill. In handling the material for mixing and placing the concrete, 8 cantilever cranes will be used.

The foregoing constitute some of the salient features of the construction work. The work is being carried on with the greatest speed practicable, with due regard to economy, and everything on the Isthmus is subordinated to the construction work.

Forming a part of the Department of Construction and Engineering on the Isthmus are the Quartermaster's and Subsistence departments, the departments of Examination of Accounts, and Disbursements, and the Mechanical Division, and in the United States is the Purchasing Department. The office of the Chief Engineer is divided into four divisions. All of these departments and divisions have their special functions and duties.

The Disbursing Officer is the pay officer. The Isthmian pay rolls average about \$1,500,000 per month. American employees and European laborers are paid in gold. West Indian laborers are paid in silver. Over 42 tons of silver are paid out monthly. The pay train travels over the Isthmus once a month, from the 12th to the 16th, paying off all employees. From \$400,000 to \$450,000 of the monthly earnings of employees are used to purchase money orders on the United States and elsewhere. The hotel and commissary

receipts from commission employees are not far from \$300,000 per month. Probably \$250,000 or more is spent in Colon and Panama; and an equal amount in the Zone. What becomes of the balance is open to conjecture. Undoubtedly a large part of it is being saved.

The Examiner of Accounts has charge of the general books of the Commission and, with his force of 115 men, classifies all expenditures; handles the accounting for coupon books and meal tickets; examines claims and accounts presented for payment and prepares the proper vouchers; makes a monthly administrative examination of the Disbursing Officer's accounts and counts the cash in the hands of the Disbursing Officer every six months; inspects the books and accounts of all employees handling money and coupon books; checks all payrolls; examines and checks daily, time books of all hourly employees; reports misconduct of employees, misuse of property, and violation of rules and regulations in connection with the efficient and economical application of labor and material; handles employees' injury claims: and audits accounts of all revenue officers.

The Quartermaster's Department performs all duties in connection with the recruiting of laborers, the housing of employees, the construction and repair of buildings, the purchase of material on the Isthmus, the custody and issue of all material from storehouses, and the supplying of animal transportation. Under executive order, at the present time, no one not an American citizen can be employed on the gold roll. The gold employees number about 4,200, and their average period of service on the Isthmus is over two years. They are all furnished suitable quarters. The Commission inherited from the French a number of family quarters, and when it was necessary during the early days of canal construction to offer great inducements to get men down to the Isthmus, the furnishing of family quarters within a reasonable time was made a condition under which they were employed. In addition, a considerable number of new quarters have been built. Accordingly there are accommodations for about 1,500 families of gold employees. The Commission builds no family quarters for men employed after January 1, 1908, when this condition was changed, though, in case any family quarters become vacant, employees appointed after that date are eligible for assignment thereto. At the present time there are about 400 applications on file for family quarters. There is a surplus of bachelor quarters.

bados, Guadeloupe, Martinique, Trinidad, and St. Kitts. In all, 23,000 West Indians have been recruited and brought to the Isthmus. In addition, many thousand Jamaicans and other West Indians have come at their own initiative. At the present time the problem can be said to have been solved, as there are more laborers on the Isthmus than there would be work for if they should want to work steadily.

The West Indian laborer is paid 90 cents for a day of nine hours, and is furnished three meals by the Commission for 30 cents, if desired. The Commission also furnishes him with quarters without charge. The European laborer receives \$1.80 for nine hours' work, and is charged 40 cents per day for three meals. He is likewise furnished with quarters without charge. The standard rate of pay for American mechanics and other hourly gold employees is 65 cents an hour. By act of Congress the eight-hour law applies on the Isthmus, and is rigidly adhered to. In 1906, by a supplemental act of Congress, alien unskilled labor was excluded from the provisions of the eight-hour law. The standard day for these alien laborers is nine hours.

The average compensation received by American employees is not far from \$150 per month. The average monthly compensation received by laborers and other silver employees, based on the number actually working in any one day, is about \$35.

The effects of the climate are especially felt by shop mechanics. The humidity of the atmosphere prevents sunstroke, however, and notwithstanding the heat, sunstroke, even among those working in the open, is unknown.

The life of Americans on the Isthmus has become established in grooves corresponding very closely to life in the United States. The Y. M. C. A. clubhouses in the larger settlements afford recreation, and there are social and other organizations of the same character as are to be found in the United States. There are over 1,500 American women who are sharing alike the comforts and discomforts of Isthmian life with their husbands, and about the same number of American children, not including wives and children of Panama Railroad employees.

Intimately connected with the housing and care of employees is their feeding and furnishing those who keep house with provisions

and supplies. This is done through the medium of the Subsistence Department, which maintains at all settlements where there are gold employees a hotel where meals can be obtained by an employee for 30 cents each. The European laborers are fed in what are called "messes," where for 40 cents a day they are given an ample supply of the food to which they are accustomed. Such of the West Indian laborers as are fed by the Commission eat at so-called kitchens. The West Indians furnish their own mess kit and, after obtaining the supply of food to which they are entitled by their meal ticket, are at liberty to eat it wherever they wish. There are eighteen hotels for gold employees, and forty-two messes and kitchens for silver employees. In 1906 a large hotel, the well-known Tivoli Hotel, was constructed at Ancon. This hotel is a rendezvous for all Americans on the Isthmus. Here various social organizations hold their regular dances, and it is the headquarters for celebrations of various kinds. It is the usual stopping place for American visitors. It is operated by the Subsistence Department so as to be self-supporting, and the charges are in accordance with this requirement. At the commissaries operated by the Panama Railroad not only provisions, including cold-storage articles, are kept, but also clothing and everything to meet the necessities of employees, which are sold at reasonable prices.

The cold-storage plant in Colon is operated by the Commissary Department, and a trip through this plant gives one a very good idea of the scale of operations on the Isthmus. From 75 to 80 tons of ice are made daily, which is sold at the rate of 40 cents a hundred pounds. The cold-storage supply of meats, vegetables, etc., is kept in this plant, and shipments are made daily along the line amounting to nearly 100 tons per day, including ice. Accessory thereto are various manufacturing plants, including the laundry and bakery, with the following daily output:

Bakery:

Loaves of bread.....	13,000
Rolls.....	2,400
Pies.....	290
Pounds of roasted coffee.....	625
Pounds of cake.....	450

Laundry:

Pieces.....	7,500
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There is also a plant which turns out 240 gallons of ice cream each day, which retails for 25 cents per quart.

The general purchasing officer of the Commission is in charge of the Washington office, as chief of office. He makes all purchases and inspections of material in the United States requisitioned by the Quartermaster's Department, and fills all vacancies in the "gold" personnel in accordance with civil-service requirements from lists of eligibles on file in his office or from certifications of the Civil Service Commission.

The foregoing represents, generally, the organization of the Department of Construction and Engineering. In addition there are two other coordinate departments, the office of the Secretary of the Commission and the Panama Railroad and steamship line, all under the Chairman of the Commission, the latter coming under his jurisdiction in his capacity as President of the Panama Railroad.

The Secretary of the Commission edits the "Canal Record," published weekly under the authority of the Canal Commission, handles requests received for information regarding matters in connection with the canal work, and hears and investigates grievances of employees.

DEPARTMENT OF SANITATION.

The importance of the sanitation of Panama, Colon, and the Canal Zone was early recognized and a committee of sanitary experts accompanied the Commission on its first visit to the Isthmus, in April, 1904, which led to the organization of the Department of Sanitation two months afterwards. Besides the care of the sick, the work of this department for the improvement of public health may be classed under two heads, viz: First, the sanitary service, which includes all work to eradicate yellow fever, and to reduce and control malaria and other diseases; and, second, the quarantine service, which prevents the importation by land or sea of bubonic plague, yellow fever, cholera, and smallpox. The work of the Sanitary Department under the member of the Commission who has been its head since it was organized has been phenomenally successful, and by removing the cloud which rested over the Isthmus from its insanitary and extremely unhealthful condition, and thus making it possible for Americans to live and work there in health and happiness, it has performed a service of inestimable value toward the construction of the canal. The

present condition has been reached only by persevering hard work. There have been 134 cases of yellow fever among employees and 34 deaths, but since 1905, nearly four years ago, not a case has been known. Similar success has attended the fight against malaria. In 1904, three-fourths of the Zone population were infected with malaria, and in the early days of canal construction the number of employees treated for malaria in hospitals in a year averaged over 80 per cent of the entire number. It is scarcely one-third of this at present.

In the last three years the total sick rate of employees has been reduced more than one-half, and the death rate more than two-thirds.

When we consider the handicaps in the way of insanitary conditions under which the French worked, we have increased admiration for what they accomplished. Over 1,200 men are carried on the rolls of the Department of Sanitation, and the expenditures amount to \$2,000,000 per annum. It will require constant work and unceasing vigilance to keep health conditions up to the standard which has been established. The total expenses of the Sanitary Department will amount, it is estimated, to about \$20,000,000, or a little over 5 per cent of the total cost of the canal. Of the total expenditures of the French, less than \$2,000,000, or hardly one-half of one per cent was charged up to hospital service, and practically nothing to sanitation.

The main hospitals are at Ancon and Colon. Ancon Hospital takes patients from the territory south of Tabernilla, and Colon north of Tabernilla. Ancon Hospital has about 1,450 beds in 37 wards, including 350 for the insane, and Colon Hospital has 400 beds in 13 wards. Ancon Hospital was established by the old French company in 1883, and from 1883 to 1889 over 5,000 deaths occurred at the hospital, 1,200 of which were from yellow fever. The insane asylum forms a part of Ancon Hospital, and operated in connection with the hospital is a laundry and a dairy. Employees receive medical attention without charge. There is a regular scale of charge for members of their families, private rooms, special nurses, etc. In addition to these main hospitals are dispensaries and sick camps in each settlement, with resident physicians to attend to those whom it is not necessary to take to the hospitals.

On Taboga Island, in Panama Bay, 10 miles from shore, is the sanitarium for convalescent patients, which was established by the

French Canal Company in 1885. It has accommodations for about 100 patients. There is a leper colony at Palo Seco, on the seashore west of Panama, with 31 patients.

The quarantine service is under a chief quarantine officer, with quarantine stations at Colon on the Atlantic side and on Culebra Island, 4 miles from shore, on the Pacific side.

The sanitary work proper in Panama, Colon, and in the Zone consists at present of the cleaning of streets and grounds, the collection and disposal of garbage, the extermination of rats and mosquitoes. The latter work requires draining low ground where water collects, cutting grass and vegetation, etc., which work is done by the forces of the construction divisions and quartermaster's department, under the supervision of the sanitary inspectors.

The Commission has provided for the religious welfare of its employees by the employment of a dozen chaplains of different denominations and by furnishing buildings in which to hold services. In addition, nonsectarian religious meetings are held in commission club houses under the auspices of the Y. M. C. A. The chaplains are carried on the payrolls of the Department of Sanitation. They visit the hospitals daily and perform such duties in connection with their calling as may be required. The Salvation Army has 7 stations and does active work. The headquarters building at Cristobal was erected by the Commission two years ago, and in addition to quarters for the officers has a reading room, dormitory, and restaurant.

The Department of Civil Administration was created to administer civil government within the Canal Zone; that is, it exercises the governmental rights conveyed by Panama to the United States in maintaining and protecting the inhabitants of the Zone in the free enjoyment of their liberty, property, and religion. The Chairman of the Commission, in whom is vested, by the President, the authority of the chief executive of the Canal Zone, has delegated that authority to a member of the Commission, who is known as head of the Department of Civil Administration. The work of this department is divided among the divisions of Posts, Customs and Revenues, Police and Prisons, Schools, Fire Protection, and Public Works; the offices of Prosecuting Attorney, Treasurer, and Auditor of the Canal Zone; and the judiciary. The latter include the supreme, circuit, and district courts of the Zone. The population of the Canal Zone is not

far from 70,000. The cost of government, paid from canal appropriations, is about three-quarters of a million dollars per annum. Taxes, land rentals, and postal receipts amount to a third of a million dollars additional. By authority of Congress, the latter are applied to the maintenance of the postal service, the support of public schools, the construction of Zone roads, etc.

There are 17 post-offices in the Zone. Seventy per cent of the mail matter handled is carried free under government frank. Receipts amount to about \$100,000 per annum. The expenses (including 40 per cent of the value of stamps, which is paid to Panama) are 50 per cent greater.

At the time of American occupation there were 327 saloons in the Zone paying from \$12 to \$60 per annum for retail license. At the present time there are 56 saloons paying \$1,200 per annum. The receipts from these licenses support the schools.

Rentals from agricultural lands and building lots amount to about \$25,000 per annum. Over 150,000 acres are owned by the Government, exclusive of Panama Railroad Company holdings. At the last session of Congress a bill was passed authorizing the leasing of public lands for a term of twenty-five years. Town lots are rented for from 5 to 30 cents per square meter per annum, which is equivalent to about from 46 cents to \$2.77 per 100 square feet. Agricultural land is rented for \$1.20 per acre per annum, not more than 125 acres being leased to one person.

The custom laws of the United States are enforced in the Canal Zone with the exception of the rates of duty which are as prescribed by the Republic of Panama. All commercial importations into the Canal Zone pay a duty to the Republic of Panama. The collector of revenues is administrator of estates and administers without charge on the estates of deceased Americans, who are employees of either the Isthmian Canal Commission or Panama Railroad, when the estate consists of personal property amounting to less than \$1,000. Fifty estates of a value of about \$11,000 were settled during the twelve months ended June 30th, 1909.

The police force numbers 250 officers and men and costs \$250,000 per annum. All are Americans except 96 West Indians, who are useful in maintaining order among their own race. Arrests average 500 per month. The penitentiary, containing 125 convicts, is located at Culebra.

The school system, under a superintendent, is similar to graded public schools in the United States. There are 12 schools for white children and 17 for colored children. High schools for white children are located at Culebra and Cristobal. About 650 white children are enrolled and 1,300 colored.

The fire department consists of 7 paid and 19 volunteer companies under a fire chief and affords protection to over \$20,000,000 worth of property. It costs about \$110,000, equal to about one-half of 1 per cent of the value of the property protected. During the past year there have been 78 alarms, with a total loss of less than \$3,000.

The Division of Public Works has supervision over the eight public markets, the two public slaughterhouses, and the construction and maintenance of roads and trails. Sixty miles of trails have been cleared and partially graded, 12 miles of macadam roads built, and 18 miles of macadam roads are either under construction or will be undertaken as soon as funds are available. Prison labor is used on road work so far as practicable. This Division is also charged with the operation of the waterworks and sewers, and maintenance of pavements, in the cities of Panama and Colon. It passes upon all applications for water and sewer connections, inspects plumbing, and keeps records of water consumed, for which it prepares bills and makes collections thereon. On June 30, 1909, there were 1,292 water connections in Panama and 464 in Colon. The annual collections for the year ended June 30, 1909, were \$66,348.45 in Panama and \$71,275.80 in Colon.

The judicial branch of the Canal Zone government consists of a supreme court, three circuit courts, and four district courts. The chief justice and the two associate justices of the supreme court are also the judges of the three circuit courts. In capital cases trial is by jury.

The Panama Railroad is operated as a corporation and, in connection with it, the Panama steamship line of six steamers, four of which have been purchased by the Commission and chartered to the Panama Railroad Steamship Line. The gross receipts of the company are not far from \$6,000,000 per annum. The stock is owned by the United States. The work of rebuilding the Panama Railroad, made necessary from canal-construction work, which is under the engineering forces of the railroad, is proceeding at a rate which will enable

the stretch between Gatun and Gamboa to be completed by the time the rising waters of Gatun Lake flood the present tracks crossing the bed of the lake. In less than two years the new line will be ready for operation between Colon and Gamboa, a distance of 31 miles. On the Pacific end traffic will be carried on the new line between Paraiso and Panama within a comparatively short time, there being little work remaining. So long as necessary the present tracks between Corozal and Pedro Miguel will be used by dirt trains. To date, on relocation work, over 1,500,000 cubic yards of material have been excavated and 5,000,000 yards placed in embankments. Twenty-two miles of permanent track have been laid. From 2,000 to 2,500 men are employed on this work. The work will cost about \$8,000,000.

Inquiry is often made as to the liability of danger to canal works from earthquakes. So far as records are available no such danger need be apprehended. Masonry structures of unsubstantial construction have been standing in Panama for upwards of two hundred years—ever since the old Spanish days. The Isthmus, in fact, is outside of the zone of earthquake disturbances, which are frequent both north of it and along the coast of South America. A seismograph has been installed in Ancon for the purpose of recording any tremors. The location of Panama with reference to the disturbances in Central America is not clearly appreciated everywhere in the United States. For instance, when Acapulco, in Mexico, was shaken in the latter part of July, some apprehension was felt as to the effects of this earthquake in Panama. Inasmuch as Panama is about as distant from the territory shaken as it is from South Carolina, it would have been more appropriate to have felt solicitude for the safety of the Gulf States. As a matter of fact, it has been proved, especially in the States bordering on the Pacific Ocean, that earth dams and large concrete structures imbedded in the ground are practically immune from injury from earthquake shocks no matter how severe, and such structures will remain unharmed where buildings of all classes would be destroyed. The earthquake bugbear, so far as the Panama Canal is concerned, may be relegated to the background.

As is well known, there is no other place on the globe where the temperature is so constant, day and night, from day to day and from one month to another. The average temperature is about 79° the

year round. The daily variation is seldom as much as 20°; in fact, in the shade, the mercury rarely gets out of the seventies and eighties either night or day, winter or summer. Taking the average monthly temperatures, the variation for the twelve months is only about 3°. Compare this with the variation in average monthly temperature, of Washington, D. C., which is about 43°. Panama owes its relief from the scorching heat of the tropical sun and its nights of even temperature to the belt of aqueous vapor which hangs over it and permeates the atmosphere. This makes the conditions different from what one would expect in the vicinity of the equator. The humidity is always high, usually over 85 per cent, and this is the most disagreeable feature of the Isthmian climate. It is necessary, however, and is preferable to the heat which would otherwise be felt.

Among important matters in connection with canal construction are:

First. Its cost.

Second. How much money has been spent to date.

Third. How much work has been accomplished; and

Fourth. When will it be finished.

The cost of an 85-foot level lock canal as estimated by the Board of Consulting Engineers in 1906 was about \$140,000,000, not including expenses of the Canal Zone government, of the Department of Sanitation, or the \$50,000,000 paid to the French Canal Company and to the Republic of Panama. As estimated in December, 1908, the cost will be about \$298,000,000, with the same items excluded, or about \$158,000,000 in excess of the original estimate. Of this excess, \$100,000,000 is for construction work and is due to the fact that the present plans provide for increased width of channel, increased size of locks, etc., which have resulted in an increase of over 50 per cent in the amount of work to be done as compared with the estimate of 1906. The 1906 estimate was based also on the ten-hour day, while the eight-hour day has been established by act of Congress, which has increased the cost of skilled hourly labor 20 per cent. The increase in cost of "Administration, engineering, and contingencies" is due to the fact that the 20 per cent added to the 1906 estimate to cover same was totally inadequate. It was sufficient for the "General expenses" of the work, but did not in addition make allowance for roads, waterworks, and sewers, which will cost \$12,000,000; for buildings which will cost over \$14,000,000; for

double tracking the Panama Railroad, purchase of additional steamers, docks, and wharves leased to the Panama Railroad, and loans to the Panama Railroad, together amounting to over \$12,000,000, etc. The total estimate of \$140,000,000 in 1906 did not include the expenses of the Department of Sanitation and Zone government, which are estimated to cost about \$27,500,000, and the \$50,000,000 paid the French Canal Company and Panama.

Work is proceeding in accordance with the estimate of 1908, amounting to \$297,766,000 for engineering work, to which should be added \$27,500,000 for sanitation and civil administration and \$50,000,000 paid to the French Canal Company and to the Republic of Panama, making a total of \$375,201,000. Of this amount, 56 per cent, or \$210,000,000, has been appropriated and estimates have been submitted for the action of Congress next December amounting to \$48,000,000, which will be sufficient to carry the work up to June 30, 1911, and when these funds have been expended the canal will be about two-thirds completed. One hundred and sixty-five million dollars is yet to be appropriated, and if the \$48,000,000 asked for is appropriated by the next Congress there will remain \$117,000,000 to be appropriated after the next session of Congress.

A good deal has been said about the issue of Panama Canal bonds in connection with appropriations. The bonds and the appropriations are two entirely separate matters. By paying for the cost of the canal out of current Treasury funds no bonds would be necessary. The bonds are provided—

First. To distribute the cost of the canal over a period of years in the future, to be paid when the bonds fall due, and

Second. To insure sufficient funds being in the Treasury to enable canal construction work to be continued without interruption.

The special act of 1902 authorized a bond issue of \$130,000,000. This was not expected to defray the entire cost of the canal, but only to distribute a portion of the cost of the work over the future years. The only estimate available at that time was that made by the Commission of 1901, which reported on the relative advantage of the Panama and Nicaragua routes, which estimate amounted to about \$144,000,000. This did not include either payments to the French Canal Company and to the Republic of Panama or the expenses of sanitation and civil administration.

Just before adjournment two weeks ago Congress authorized the issue of additional bonds toward the construction of a canal up to the full amount of the estimate for a lock canal, \$375,201,000. This action further confirmed and finally fixed the policy of the country in regard to the completion of the lock canal and removed the only possible obstacle to its progress, viz, lack of funds.

In accordance therewith, appropriations of from \$45,000,000 to \$50,000,000 for the next two years; from \$25,000,000 to \$35,000,000 for the following two years, and \$10,000,000 for the latter half of the calendar year 1914, will enable the canal to be opened and ready for use by January 1, 1915.

The principal items entering into the completed canal are:

First. Excavation;

Second. Concrete for locks and spillways; and

Third. Embankment and fill for dams, breakwaters, etc.

The total excavation required for the completed canal will amount to about 174,500,000 cubic yards, which is equivalent to a cube measuring nearly 1,700 feet on a side.

Concrete amounting to 4,850,000 cubic yards will be required, which is equivalent to a cube measuring over 500 feet on a side.

Embankment and fill required for the dams will amount to about 23,000,000 cubic yards, which is equivalent to a cube measuring over 800 feet on a side. Three and a half million cubic yards of material will be used as back fill for the locks, and 5,700,000 cubic yards for the Atlantic breakwaters.

Of the excavation, about 82,000,000 cubic yards were completed to August 1, 1909, or 47 per cent. Excavation is proceeding at the rate of about 35,000,000 cubic yards per annum.

Concrete has been laid to the amount of about 45,000 cubic yards. The laying of concrete in the Gatun and Pedro Miguel locks starts this month, and will continue during the rest of this fiscal year at an increasing rate that will soon reach 100,000 cubic yards per month.

To August 1, 1909, backfill and embankment had been placed amounting to about 4,400,000 cubic yards. This work will continue at the rate of from 400,000 to 500,000 cubic yards per month.

On July 1, 1909, the cost was, in round figures, as follows:

Department of Construction and Engineering.....	\$95, 100, 000
Department of Sanitation	8, 800, 000
Department of Civil Administration.....	2, 900, 000
Total.....	106, 800, 000

In addition to the above there should be added the \$40,000,000 paid to the French Canal Company, \$10,000,000 paid to the Republic of Panama, \$4,000,000 loaned to the Panama Railroad Company, and \$5,500,000 for material and supplies which have been purchased and are on hand, and for other similar items, which may be considered as assets, not having been yet applied to the work. In other words, cash had been expended from congressional appropriations to July 1, 1909, amounting to \$166,300,000, or nearly 45 per cent of the total estimated cost.

The foregoing is a statement of the present condition of work. An endeavor has been made also to trace the growth of the canal idea and to indicate that it is not a matter in which the United States alone is interested, but is an enterprise from which other nations will benefit and which the whole world demands shall be completed. The United States entered upon it appreciating its interest and responsibilities and its mission among the nations of the world, and in so doing committed itself to a project which time had shown was too large for any individuals or corporation to carry to a successful termination.

There have been some who at various times have thought that the difficulties will be too great, the cost excessive, or the returns insufficient. There need be no fears on these points. The pride of the American people can not be measured by dollars and cents.

Moreover, the time to consider such matters passed when the United States committed itself to a work from which it could not afterwards recede without great loss of prestige.

The facts are plain; the project is feasible; the work is well on toward being half completed; bonds have been authorized to the full amount of the estimate for a lock canal.

It will be finished as quickly as possible, and there should now be no looking backward.

The present plans are the best, the work is well in hand, and within about five years communication between the Mississippi Valley and the Pacific coast by water, via the Isthmus, will be open.

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