

that the work could be done by floating dredges. No novel problems were presented to the engineer, nor are interesting achievements displayed to the tourist until the great dam itself is reached.

The simplest way of reaching the Gatun dam is of course by train from Colon, a ride of perhaps twenty minutes. But a more spectacular one is by launch, either up the Canal, or around by the Chagres River from its mouth. The latter is a difficult trip however and seldom essayed. One advantage of taking the Canal is that it gives a much clearer idea of the construction of the dam than can be derived by approaching it by railroad. The first significant fact forced upon your attention in thus coming upon the dam is that it does not look like a dam at all, but rather like a long and gently sloping hill pierced at one point by a sort of masonry gate which upon closer approach reveals itself as a system of mighty locks.

Not very long ago there was a wide-spread apprehension in the United States, bred of a rather shallow newspaper criticism very widely republished, that the Gatun dam would prove inadequate to the pressure of the waters impounded behind it and might



*Photo by Underwood & Underwood*

SOUTH APPROACH WALL, GATUN LOCKS

collapse, or "topple over". If all who have been impressed by that gruesome prophecy could see the dam itself their apprehensions would be speedily quieted. One might as well talk of toppling over the pyramids, or Murray Hill, New York (not the structures on it, but the hill itself) or the Treasury Building at Washington. Elevations, natural or artificial, the base of which is eight to ten times their height, cannot topple over while the force of gravity continues to operate. Now the height of



GATUN LOCKS OPENING INTO THE LAKE

The skeleton structure on the left is the frame-work of the emergency dam which swings directly athwart the lock

Gatun dam is 105 feet, and from its crest the filling of clay and rock slopes gently away on the landward side for nearly half a mile. There are more abrupt eminences on many of our rolling prairies. The face on the lake side descends somewhat more abruptly, but is still several hundred feet long before its slope ends with the bed of the lake. This face is covered with broken stone down to the "toe"—as they call the walls of rough rock between which the dirt dam was built.

The method of building the dam was simple enough even though it sounds complicated in the telling. When Congress acquiesced in the minority report of the Board of International Engineers, approved by the President and recommending a lock type canal, it meant that instead of simply digging a ditch across the Isthmus we would create a great artificial lake 85 feet above sea level, confined by dams at either ends, with locks and two short canals to give communication with the oceans. To create this lake it was determined to impound the waters of the Chagres, and a site near the village of Gatun, through which the old French canal passed, was selected for this purpose. Conditions of topography of course determined this site. The Chagres valley here is 7,920 feet wide, but the determining fact was that about the center of the valley was a hill of



BIRD'S EYE VIEW OF GATUN DAM

In the foreground the locks, only two of the three steps being fully shown. In the middle distance the spillway, through which surplus water flows into the Chagres and old French Canal

rock which afforded solid foundation for a concrete dam for the spillway. Geologists assert that at one time the floor of the valley was 300 feet higher than now, and that in the ages the Chagres River cut away the shallow gorges on either side of the rocky hill. These, it was determined, could readily be obstructed by a broad earth dam of the type determined upon, but for the spillway with its powerhouse and flood gates a rock foundation was essential and this was furnished by the island.

The first step in the construction of the dam was to dam the Chagres then flowing through its old channel near the site chosen for the



Photo by Thompson

GATUN LAKE SEEN FROM THE DAM



*Photo by Underwood & Underwood*

#### CONSTRUCTION WORK ON GATUN DAM

The space between two rock walls has been filled with mud, which having hardened, supports dirt trains bringing spoil from Culebra Cut to build up the dam to required dimensions

spillway, and through the old French canal. This was accomplished by building parallel walls, or "toes" of broken stone and filling the space between with fluid mud pumped from the old channel of the stream. A new channel of course was provided called the "west diversion". The toes are about a quarter of a mile apart and rise about 30 feet high. They were built by the customary devices of building trestles on which dump trains bearing the material were run. After the core of fluid silt pumped in between the walls had begun to harden, dry earth

jungle on the one side, and a lesser distance on the other, to the waters of the Gatun Lake then less than half filled. When the main body of the dam had

was piled upon it, compressing it and squeezing out the remaining moisture. As this surface became durable the railroad tracks were shifted to it, and when I visited the dam in 1913 the made land of the dam was undistinguishable from the natural ground surrounding it. Over it scores of locomotives were speeding, dragging ponderous trains heavy laden with "spoil" from the Culebra Cut. From the crest on the one hand the dam sloped away in a gentle declivity nearly half a mile long to the original



*Photo by Underwood & Underwood*

#### PUMPING MUD INTO THE CORE OF GATUN DAM



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A NATIVE BAKERY

The Panamanian never does anything indoors that he can do in the open. The village bakery, the village mortar or mill and the village laundry are social meeting places used by all.





GATUN UPPER LOCK

been completed and the spillway was ready to carry off the waters of the Chagres then flowing through the "west diversion" the task of damming the latter was begun. This was the first effort to stem the current of the Chagres, the river dreaded for so many reasons, and the description by Lieutenant Colonel William L. Sibert, the engineer in charge of this division, will be of interest:

"The elevation of the spillway channel is 10 feet above sea level, consequently in any attempt to stop the flow of the Chagres and force it through this channel, a rise of about 14 feet of water had to be encountered. The banks and bottom of the west diversion were soft clay. The plan adopted was to drive trestles across this channel on the 30-foot contour on each face of the dam, and to build, by dumping rock directly into the stream, two dams at the

same time, hoping to distribute on such dams the head formed during construction. An unlimited amount of waste rock was available for this work. The banks of the channels were first made secure by dumping rock at the end of the trestles. After the channel was contracted to some extent, a considerable current developed; rock dumped from the trestles was carried some distance down stream, forming a rock apron in the bed of the stream below the dam. Quite deep holes, however, were dug by the water below this rock apron. When the work on the two dams had progressed so that a channel about 80 feet wide and 6 feet deep was left in the center, it was found impracticable to make any headway. Stone dumped from the trestles would be rolled down stream. The rainy season was then about to commence.



Photo by Underwood and Underwood

CENTER: GATUN CENTER LIGHT; LOWER CORNER: EMERGENCY GATES



*Photo by Underwood & Underwood*

#### SPILLWAY UNDER CONSTRUCTION

Concrete is dumped directly from the railway into the moulds. Pipes to the power house are shown

The lower part of the bents of the trestles being well supported with rock, it was then decided to dump a carload or two of crooked rails above the trestles in such a way that they would form an entanglement and stop the rock, thus insuring either the construction of the dam or the taking out of the trestle. By this means the two dams were finally completed and the Chagres River successfully diverted.

To the unprofessional observer the Gatun dam is a disappointment as a spectacle. It does not look like a dam at all, but merely like a continuation of one of the hills it connects. But as a matter of fact it is the greatest dam in the world—a mile and a half long, 105 feet high, half a mile thick at its base, 398 feet at the surface of the lake and 100

feet wide at the top. It is longer and higher than the Assouan dam which the British built across the Nile though the latter, being all of masonry, is vastly the more picturesque. Into the entire work will go about 21,000,000 cubic yards of material.

One day while the Gatun dam was in the earlier stages of its construction in 1908, a newspaper correspondent was temporarily detained at Gatun while crossing the Isthmus. Idly, to pass the time away, he strolled out on the dam to where he saw a group of men gathered. He found them discussing a small break at the edge of the dam upstream; a break not caused by any pressure of the water, for the water had not reached that point, but by the weight of the heavy superstructure pressing upon the semi-fluid core of the dam which

then had not had sufficient time for drainage and drying. The dispatch which the correspondent sent north as the result of his casual observation of the slide, was seized upon by the advocates of the sea-level canal as a text from which to argue the entire impracticability of the lake-level project. The agitation became so general and so menacing that President Roosevelt was impelled to appoint a commission of seven engineers of high professional standing and technical knowledge of dam building to visit the spot and report upon the menace. Their verdict was that the Canal engineers had gone far beyond the necessary point in making the dam ponderous and safe. Secretary of War Taft, who happened to be on the Isthmus when the break occurred, declared that it was "insignificant when one takes into consideration the whole size of the dam".

When the tricky Chagres gets on one of its rainy season rages the spillway by which the dam is pierced at about its center will be one of the spectacular points on the Canal line. That river drains a basin covering 1,320 square miles, and upon which

the rains in their season fall with a persistence and continuity known in hardly any other corner of the earth. The Chagres has been known to rise as much as 40 feet in 24 hours, and though even this great flood will be measurably lowered by being distributed over the 164 square miles in Gatun Lake, yet some system of controlling it by outlets and flood gates was of course essential to the working and the safety of the Canal. The spillway is the center of this system, the point at which is the machinery by which the surface of Gatun Lake can be at all times kept within two feet of its normal level, which is 85 feet above the level of the sea.

Fundamentally the spillway is a channel 1,200 feet long and 285 feet wide cut through the solid rock of the island which at this point bisects the now obliterated Chagres Valley. Though cut through rock it is smoothly lined and floored with cement; closed at its upper end by a dam, shaped like the arc of a circle so that, while it bars an opening of only 285 feet, its length is 808 feet. For the benefit of the unprofessional observer it may be noted that by thus curving a dam in the direction



PARTLY COMPLETED SPILLWAY, 1913

The river was low when this picture was taken. At high water it will flow over the completed structure shown at the right.



of the force employed against it, its resisting power is increased. It resists force exerted horizontally precisely as an arch resists force, or weight, exerted from above. The dam at the spillway extends solidly across the opening to a height of 69 feet. But this is 16 feet below the normal level of the Lake. From the top of the solid dam rise thirteen concrete

piers to a height as planned, of 115 feet above sea level, that is the piers will rise 46 feet above the top of the dam. Between each two of these piers will be mounted regulating gates of steel sheathing, made water tight and movable up or



*Photo by Underwood & Underwood*

THE GIANT PENSTOCKS OF THE SPILLWAY

down as the state of the Chagres level requires a free or a restricted passage for the water. Nor will those operating the gates await the visual appearance of the flood before throwing wide the passage for its onrush. At divers points along the Chagres, and throughout its water shed are little stations whence observers telephone at regular intervals

throughout the day to the office at the spillway the result of their observations of the river's height. With these figures at hand the controller of the gates can foresee the coming of a flood hours before it begins to beat against the gates.



THE SPILLWAY AT HIGH WATER

A comparison with the picture on page 179 will show the varying stages of the river



*Photo by Underwood & Underwood*

LOCK GATES APPROACHING COMPLETION

The spillway further serves a useful and an essential purpose in that it harnesses the water power of the useful Chagres, and turns it into electric power to open and shut the colossal gates of the various locks; to propel the electric locomotives that tow the great ships through the concrete channels; to light the canal towns and villages, and the lighthouses on the line; to run the great cranes at Balboa and Cristobal; to run the machinery in the shops at Balboa; to furnish motive power, if so determined for the Panama Railroad, and to swing the great guns at Toro Point and Naos Island until their muzzles bear with calm yet frightful menace upon any enemy approaching from either the Caribbean or the Pacific. There will be power for all these functions, and power too to light Panama and Colon, to run the Panama tramway and perform other useful functions if the present

grip of private Panama monopoly upon these public services shall be relinquished. The water drops 75 feet through huge penstocks to great turbines in the spillway hydro-electric station with a capacity of 6,000 kilowatts, but the amount of water power is sufficient for double that current, and turbines to supply the addition can be installed whenever the need for the power develops.

The Gatun locks are built at the very eastern end of Gatun dam, at the point where it joins the mainland bordering the Chagres valley. Of their superficial dimensions I have already spoken, and have described their appearance as seen from the deck of a ship in passage. It will be hard however for one who has not stood on the concrete floor of one of these massive chambers and looked upward to their crest, or walking out on one of the massive gates peered down into their depths, to appreciate



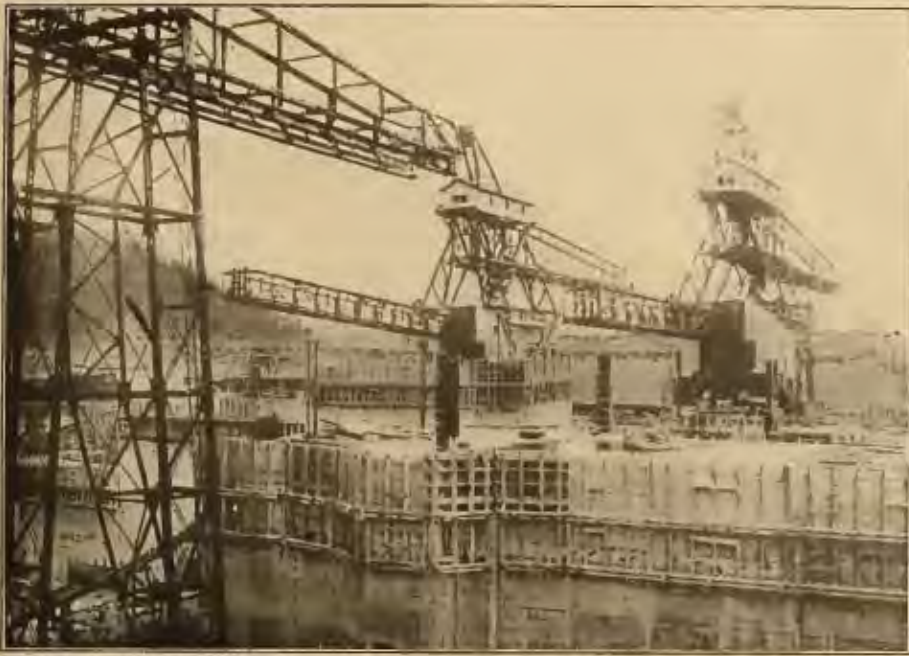
THE WATER KNOCKING AT GATUN GATES

their full size. It is all very well to say that the *Imperator*, the greatest of ships now afloat, could find room in one of these locks with five feet at each side, and fifty feet at each end to spare, but then few of us have seen the *Imperator* and nobody has seen her in the lock. It is all very well to figure that a six story house would not rise above the coping of one of these locks, but imagination does not visualize the house there, and moreover there are stories and stories in height. Yet as one stood on the floor of one of these great monolithic tanks as they were being rushed to completion in 1913, and saw locomotives dwarfed by the ponderous walls betwixt which

they plied, and whole trains of loaded dump cars swallowed up in a single lock chamber, one got some idea of the magnitude of the work. A track for a travelling crane extended down the center of the chamber and the monster rumbled back and forth carrying loads of material to their appointed destinations. Across the whole width of the Canal below the locks stretched cable carriers upheld by skeleton devices of steel mounted on rails so that the pair of them, though separated by 500 feet of space, spanned by the sagging cables, could be moved in unison. Out on the swinging cables ran the loaded cars or buckets, filled with concrete and dumped with a crash and a roar at the chosen place. Giant mixers ground up rock from Porto Bello, sand from Nombre de Dios, and cement from divers states of our union into a sort of Brobdignagian porridge with which the hungry maws of the moulds were ceaselessly fed. Men wig-wagged signals with flags across gaping chasms.



WALL OF GATUN LOCK SHOWING ARCHED CONSTRUCTION



*Photo by Underwood & Underwood*

#### TRAVELLING CRANES AT WORK

Mounted on rails these cranes carry the heaviest burdens. Those shown are placed for delivering concrete to the forms. One crane will cost \$60,000

Steam whistles blew shrill warnings and cryptic orders. Wheels rumbled. Pulleys creaked. It seemed that everything a man could do was being done by machine, yet there was an army of men directing, correcting and supplementing the mechanical labor.

Into the locks at Gatun will go 2,000,000 cubic yards of concrete if the original estimate is adhered to. A statistician estimates that it would build a wall 8 feet wide and 12 feet high and 133 miles long—which would just about wall off the state of Delaware from the rest of the Union.

The side walls of each of the locks are practically monoliths, constructed of concrete poured into great steel frames or moulds where it hardens into a solid mass. They are based in the main on bed rock, though it was found on making tests that the bed rock was not of sufficient extent to support the guide walls as well, so one of these is therefore made cellular to lighten

its weight, which rests on piles of 60 feet long capped and surrounded with concrete. This wall was built by slow stages and allowed to stand in order that its settlement might be uniform. An examination of the picture below will make clear the method of constructing the lock walls, for in it are shown the completed monoliths and a steel form half completed with men preparing it for the concrete therein. Col. Sibert describes the details of the work thus:

"The locks proper are founded on rock and the heavy masonry is completed. This rock foundation was not of sufficient extent, however, at available elevations, for supporting the guide walls. Under that guide wall extending

into the lake the underlying rock at the south end is about 150 feet below sea level, and the overlying material is soft. This wall is cellular in construction. It is composed of four longitudinal walls about 2 feet thick with cross walls about 17 feet apart, all built of reinforced concrete.

"The natural ground underlying the wall was about



*Photo by Underwood & Underwood*

#### BUILDING A MONOLITH



A CULVERT IN THE LOCK WALL

8 feet above sea level. On this ground a wide fill with a very flat slope was constructed to elevation plus 35, and through this piles about 60 feet long, 4-foot centers, were driven and a heavy reinforced concrete slab built around the heads of the piles, on which was erected the cellular structure. There was a continual slow settlement of this wall as its construction progressed. It was brought to a height of 61 feet above sea level through its entire length in order that the settlement might extend over the whole base before any part was brought to full height.

"The north guide and flare walls are yet to be built. It will be necessary to go to a depth of about 70 feet below sea level through very soft material in order to uncover the rock on which to build the flare walls. Under the guide wall itself the rock is at a still lower elevation, and a pile foundation will probably be constructed, the piling going to rock. The material in this space was too soft to hold up steam shovels, and it was decided to do the general excavation by suction dredges. These dredges cut their way into the space where the walls in question are to be built, making a channel just wide and deep enough for their passage. They then widened out the cut and deepened it to 41 feet below sea level. An earthen dam was then built across the narrow entrance cut,

shutting off the connection with the sea, and as the dredges worked they were lowered. They are now floating at an elevation of 32 feet below sea level and can remove the material to the depth required. After the excavation is completed it is proposed to have the dredges excavate a sump 65 feet below sea level and lower the water to 50 feet below sea level in order to test the stability of the sides of the cut. If there is no sliding the pit will be filled with water; the dredges floated out; the dam across the entrance channel replaced and the excavation unwatered for the construction of the walls first referred to.

"The masonry of the Gatun locks was largely placed by cableways, having a span of 800 feet, covering the entire space to be occupied by the

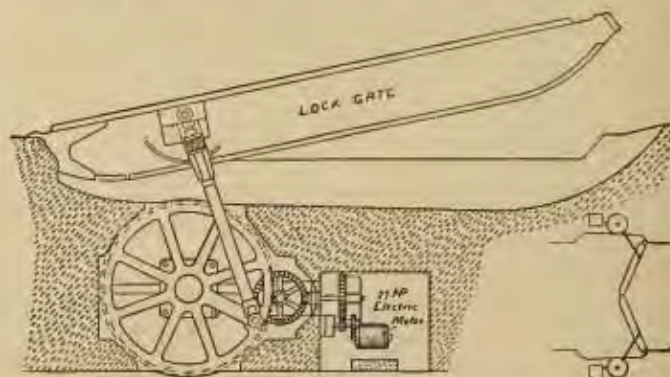


DIAGRAM OF LOCK-GATE MACHINERY

locks. The stone and sand for the concrete were obtained, respectively, 20 and 40 miles down the Caribbean coast, and were brought in barges up the old French Canal as closely as possible to the lock



TOWING LOCOMOTIVE CLIMBING TO UPPER LOCK

site, and were unloaded by cableways into large stock piles near the bank. The material, however, was still 3,500 feet away and 60 feet below the center of lock construction. This situation caused the adoption of a central mixing plant near the central portion of the locks, consisting of eight 2-yard mixers. An automatic, electric, loop-line railroad, each car carrying the material for a batch of concrete, was installed, passing under the cement shed, under the sand and stone piles; and over the mixers. The mixed concrete was delivered to the cableways requiring it by an electric line, the flat cars of which were handled by electric locomotives. Steel forms were used in constructing the walls of the locks''.

A vital feature of the locks is, of course, getting the water into and out of them, and the method of operating the gigantic gates. The former is simple enough of explanation, though the *modus operandi* will be entirely concealed when the locks are in operation. Through each of the side walls, and through the center walls which divide the pairs of locks, runs a tunnel 18 feet in diameter. To put it more graphically a tunnel large enough to take a mogul locomotive of the highest type. From this main tunnel smaller ones branch off to the floors of the locks that are to be served, and these smaller chutes are big enough for the passage of a farmer's wagon with a span of horses. These smaller chutes extend under the floor of the lock and connect with it by valved openings, the valves being operated by electricity. There is no pumping of the water. Each lock is filled by the natural descent of the water from the lock above or from the lake. By the use

of the great culvert in the central wall the water can be transferred from a lock on the west side of the flight to one on the east, or vice versa. Though it hardly seems necessary, every possible device for the conservation of the water supply has been provided.

We will suppose a vessel from the Atlantic reaches Gatun and begins to climb to the lake above. The electric locomotives tow her into the first lock, which is filled just to the level of the Canal. The great gates close behind her.

How do they close? What unseen power forces those huge gates of steel, shut against the dogged resistance of the water? They are 7 feet thick, 65 feet long and from 47 to 82 feet high. They weigh from 390 to 730 tons each. Add to this weight the resistance of the water and it becomes evident that large power is needed to operate them. At Gatun in the passing of a large ship through the locks, it will be necessary to lower four fender chains, operate six pairs of miter gates and force them to miter, open and close eight pairs of rising stem gate valves for the main supply culverts, and thirty cylindrical valves. In all, no less than 98 motors will be set



THE HEAVY WHEEL SHOWN IS THE "BULL WHEEL"

By its revolution it thrusts or withdraws the arm at the right which moves the gate



THE TANGLED MAZE OF STEEL SKELETONS THAT ARE A LOCK IN THE MAKING

in motion twice during each lockage of a single ship, and this number may be increased to 143, dependent upon the previous position of the gates, valves and other devices. Down under the surface of the lock wall, packed into a little crypt which seems barely to afford room for its revolving, is a great cogwheel 5 feet in diameter, revolving slowly and operating a ponderous steel arm which thrusts out or pulls back the gate as desired. The bull wheel, they call it, is driven by a 27 horse power motor, while a smaller motor of  $7\frac{1}{2}$  horse power locks the gates tight after they are once in position. Two of these bull wheels, and two each of the motors are needed for each pair of gates.

The ship then is in the lowest lock, one pair of gates closed tightly behind her. Another pair confronts her holding back the water in the lock above, which if filled, will be just  $28\frac{1}{2}$  feet above the surface of that on which she floats. But the water about her is now slowly rising. Another set of electric motors concealed in the concrete wall have set in motion the valves in the floor of the lock,

and the water is flowing in from the tunnels, raising the ship and at the same time lowering the water in the lock above. When the vessel's keel is higher than the sill of the lock above the upper gates swing slowly back and fold in flat with the wall. The ship is now in a chamber 2000 feet long filled to a level. The locomotives pull her forward a thousand feet or so. Again great gates close behind her. Again the water rises slowly about her lifting her with it. The first process is repeated and she enters the third lock. By the time she has been drawn out into the lake and the locomotives have cast her off, more than 100 electric motors with a horse power ranging from  $7\frac{1}{2}$  to 50 each will have contributed to her progress. Altogether over 1000 individual motors will be required for the different locks. Indeed the whole interior of those massive lock walls is penetrated by lighted galleries strung with insulated wires bearing a death-dealing current. Men will be stationed at the various machinery rooms, but the whole line of machinery can be operated from a central operating tower on the lock above.

## CHAPTER XI

### GATUN LAKE AND THE CHAGRES RIVER

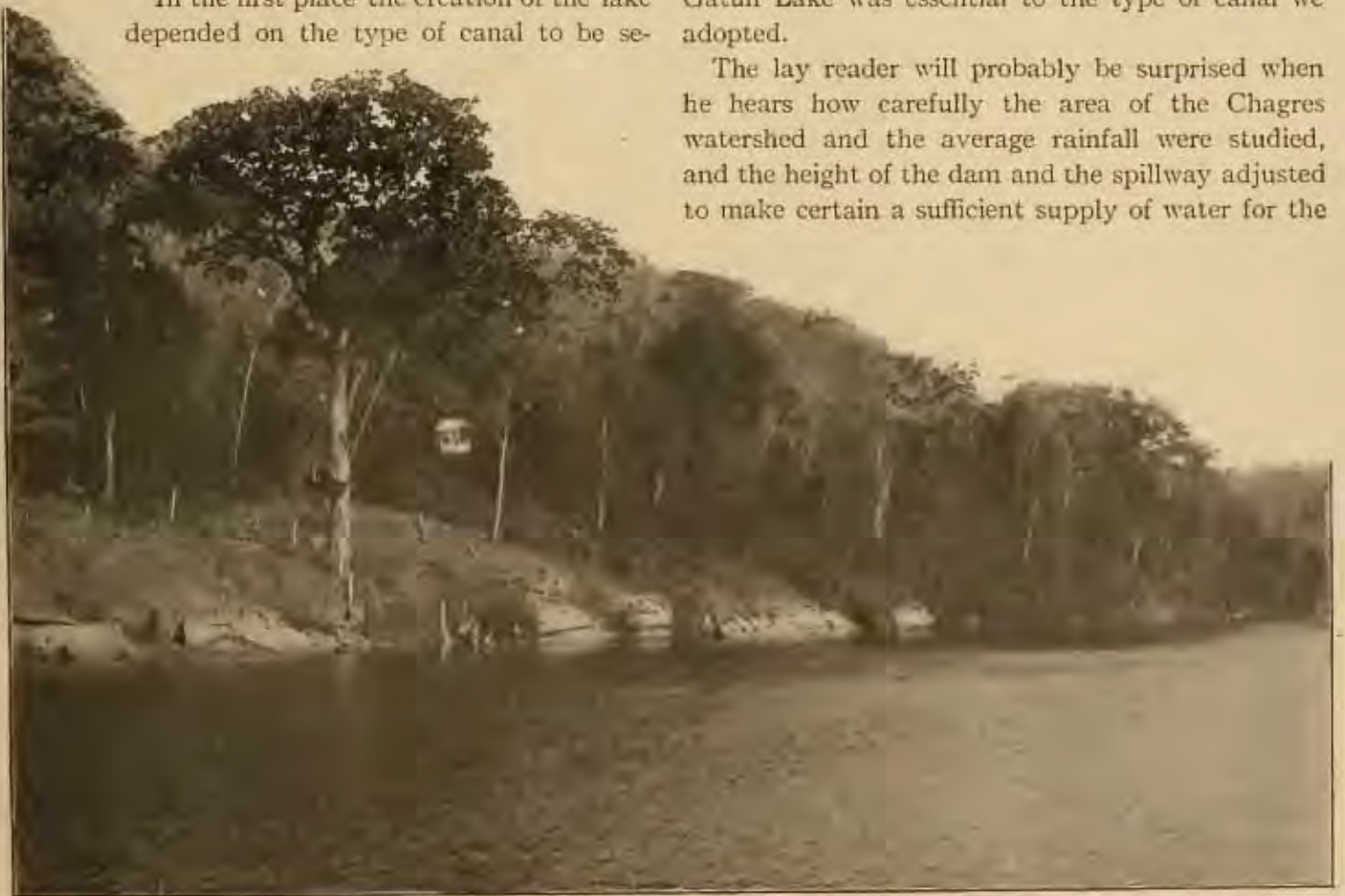


THAT section of the Canal, which for the convenience of engineering records and directions is known as the Central Division, comprises within its boundaries two of the great spectacular features of the Isthmus—Gatun Lake and the Culebra Cut. I have already described the scenic characteristics of this lake, but some discussion of the part it plays in the economy of the Canal will not be out of place.

In the first place the creation of the lake depended on the type of canal to be se-

lected. A sea-level canal could not exist with the lake; a lock canal could not have been built without it. The meanderings of the Chagres, crossing and recrossing the only practicable line for the Canal, and its passionate outbursts in the rainy season made it an impossible obstacle to a sea-level canal, and all the plans for a canal of that type contemplated damming the stream at some point above Gatun—at Bohio, Gamboa or Alhajuela—and diverting its outflow into the Pacific. On the other hand the lock canal could not be built without some great reservoir of water to repeatedly fill its locks, and to supply the waterpower whereby to operate them. Hence Gatun Lake was essential to the type of canal we adopted.

The lay reader will probably be surprised when he hears how carefully the area of the Chagres watershed and the average rainfall were studied, and the height of the dam and the spillway adjusted to make certain a sufficient supply of water for the



THE CHAGRES, SHOWING OBSERVER'S CAR

From the swinging car the observer measures the crest of the flood and rapidity of the current





FLUVIOGRAPH AT BOHIO, NOW SURMERGED

locks. The only locks with which these could be compared are those at the "Soo", or outlet of Lake Superior. That canal, the busiest one in the world for eight months in the year, averaged 39 lockages a day during that period on the American side and a smaller number through the Canadian locks. The water in Gatun Lake will be sufficient for 41 passages, if the full length of the locks is used or 58 if only the partial length is used, which will be the case with steamships of less than 15,000 tons—and in ships of this class the bulk of the world's trade is conducted. If the limit of 41 lockages seems low, it must be remembered that time is quite as much a factor in the case as is the water supply. It will take an hour and a half to put a ship through the locks. That time therefore technically constitutes a "passage". In the 24 hours there would be 36 passages possible, and under the circumstances that would draw most heavily on the lake there will be water enough for 41.

For the creation of this lake our engineers found the Chagres River available. It had dug the valley in which would be stored the vast volume of water needed, and the unfailing flow from its broad watershed could be relied upon at all seasons—though indeed in the rainy season its contribution is sometimes embarrassingly lavish.

Every land comes to be judged largely by its rivers. Speak of Egypt and you think of the Nile, India suggests the Ganges; England the Thames; and France the Seine. The Chagres is as truly

Panamanian as the Rhine is German and there have been watches on the Chagres, too, when buccaneers and revolutionists urged their cayucas along its tortuous highway. It was the highway by which the despoilers of Peru carried their loot to the Atlantic on the way to Spain, and along its tide drifted the later argonauts who sought the golden fleece in California in the days of '49. The poet too has sung it, but not in words of praise. Listen to its most famous lyric from the pen of James Henry Gilbert.

Panama's most famous bard and most cruel critic.



AUTOMATIC FLUVIOGRAPH ON GATUN LAKE



*Photo by Underwood & Underwood*

THE VILLAGE OF BOHIO, NOW SUBMERGED

"Beyond the Chagres River  
 Are the paths that lead to death—  
 To the fever's deadly breezes,  
 To malaria's poisonous breath!  
 Beyond the tropic foliage,  
 Where the alligator waits,  
 Are the mansions of the Devil—  
 His original estates.

"Beyond the Chagres River  
 Are the paths fore'er unknown,  
 With a spider 'neath each pebble  
 A scorpion 'neath each stone.  
 'Tis here the boa-constrictor  
 His fatal banquet holds,  
 And to his slimy bosom  
 His hapless guest enfolds!

"Beyond the Chagres River  
 'Tis said—the story's old—  
 Are paths that lead to mountains  
 Of purest virgin gold;  
 But 'tis my firm conviction,  
 Whatever tales they tell,  
 That beyond the Chagres River  
 All paths lead straight to Hell!"

A much maligned stream is the River Chagres. Pioneers, pirates, prospectors and poets have vied with each other in applying the vocabulary of contumely and abuse to it, and the practitioners of medicine have attached its name to a peculiarly depressing and virulent type of tropical fever. But the humble native loves it dearly and his homes, either villages of from ten to forty family huts, or mere isolated cabins cling to its shores all the way from Fort Lorenzo to the head waters far beyond the boundary of the Canal Zone. The native too has something of an eye for the picturesque. Always his huts are erected on a bluff of from 15 to 40 feet rise from the river, with the ground cleared before them to give an unblocked view of the stream. Whether by accident or because of a real art instinct he is very apt to choose a point at a bend in the river with a view both up and down the stream. Possibly however art had less to do with his choice than an instinct of self-defense, for in the days of Isthmian turbulence, or for that matter today, the rivers were the chief highways and it was well to



STEPS LEADING TO FLUVIOGRAPH STATION AT ALHAJUELA

This is one of the more distant stations, being ten or more miles outside the Canal Zone

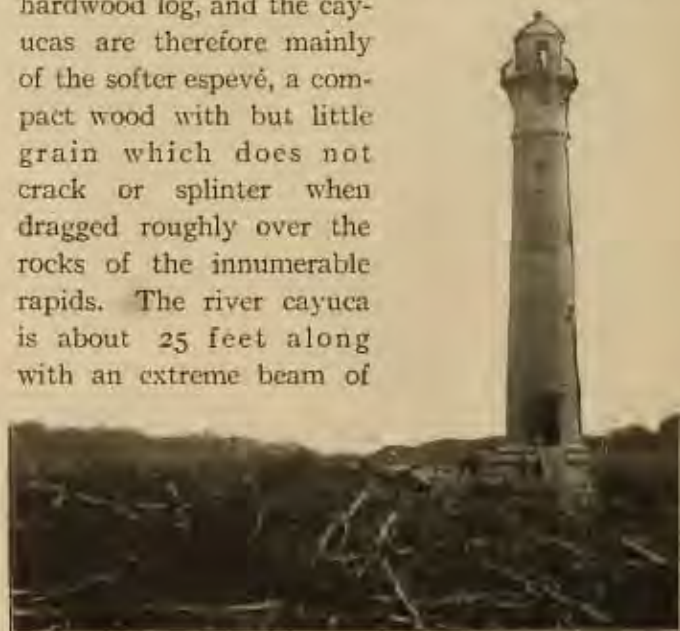
be on guard for hostile forces coming from either direction.

I saw the upper Chagres in the last days of its existence as a swirling stream full of rapids, rushing along a narrow channel between banks sometimes rising in limestone cliffs 60 feet high and capped by dense tropical foliage ascending perhaps as much higher into the blue tropical sky. The river was at its best and most picturesque as at the opening of the dry season we poled our way up from Matachin towards its source. Then Matachin was a hamlet of canal workers, and a weekly market for the natives who brought thither boat loads of oranges, bananas, yams and plantains. Sometimes they carried stranger cargoes. I heard a commission given one native to fetch down a young tiger for somebody who wanted to emulate Sarah Bernhardt in the choice of pets. Iguanas, the great edible lizard of Panama, young deer, and cages of parrots or paroquets occasionally appear. But as a market Matachin is doomed, for it is to be submerged. With it will go an interesting discussion of the etymology of its name, one party holding that it signifies "dead Chinamen" as being the spot where imported Chinese coolies died in throngs of homesickness during the construction of the Panama Railroad. But the word also means "butcher" in Spanish and some think it commemorates some massacre of the early days. However sanguinary

its origin there will presently be water enough to wash out all the stains of blood. In 1913 the place was one of the principal zone villages, with large machine shops and a labor colony exceeding 1500 in number. All vanishes before the rising lake, which will be here a mile wide.

The native craft by which alone the Chagres could be navigated prior to the creation of the lake are long, slender canoes

fashioned usually from the trunks of the espevê tree, hollowed out by fire and shaped within and without with the indispensable machete. It is said that occasionally one is hewn from a mahogany log, for the native has little idea of the comparative value of the different kinds of timber. Mahogany and rosewood logs worth thousands of dollars in New York are doing humble service in native huts in Panama. But the native has a very clear understanding of the comparative labor involved in hewing out a hardwood log, and the cayucas are therefore mainly of the softer espevê, a compact wood with but little grain which does not crack or splinter when dragged roughly over the rocks of the innumerable rapids. The river cayuca is about 25 feet along with an extreme beam of



A LIGHT HOUSE IN THE JUNGLE

about  $2\frac{1}{2}$  feet and a draft of 6 to 10 inches. Naturally it is crank and can tip a white man into the stream with singular celerity, usually righting itself and speeding swiftly away with the rushing current. But the natives tread it as confidently as though it were a scow. For upstream propulsion long poles are used, there being usually two men to a boat, though one man standing in the stern of a 30-foot loaded cayuca and thrusting it merrily up stream, through rocky rapids and swirling whirlpools is no uncommon sight.

Our craft was longer—35 feet in all, and in the official service of the Canal commission had risen to the dignity of a coat of green paint besides having a captain and a crew of two men. Our captain, though but in his nineteenth year, was a person of some dignity, conveying his orders

to the crew in tones of command, though not averse to joining in the lively badinage with which they greeted passing boatmen, or rallied maidens, washing

linen in the streams, upon their slightly concealed charms. The corrupt Spanish they spoke made it



Photo by Underwood & Underwood

THE RIVERSIDE MARKET AT MATACHIN

difficult to do more than catch the general import of these playful interchanges. Curiously enough the native peasant has no desire to learn English, and

frequently conceals that accomplishment, if he has attained it, as though it were a thing of which to be ashamed. This attitude is the more perplexing in view of the fact that the commission pays more to English speaking natives.

"This boy Manuel", said my host to me in low tones, "understands English and can speak it after a fashion, but rarely does so. I entrapped him once in a brief conversation and said to him, 'Manuel, why don't you speak English and get on the roll of English speaking employees? You are getting \$62.50 gold a month now; then you'd get \$75 at least'.

"Manuel dropped his English at once. 'No quiero aprender a hablar ingles', said he, 'Para mi basta el espanol'". (I don't care. Spanish good enough for me.)

Manuel indeed was the son of the alcalde of his

village, and the alcalde is a person of much power and of grandeur proportionate to the number of thatched huts in his domain. The son bore himself as one of high lineage and his face indeed, Caucasian in all save color, showed that Spanish blood predominated over the universal admixture of negro. He saved his money, spending less than \$10 a month and investing the rest in horses.

From Matachin up to Cruces the river is comparatively common-place, spanned at one point by the Gamboa bridge up at which the voyager looks reflectively from below as he hears that

when the spillway is closed and the lake filled up there will be but 15 feet headway above the river's crest, where at the moment there is more than 60. Higher up are the towers, housing the machinery for recording the river's rise, one of them a relic of the French régime, while a slender wire spanning the stream carries the pendulous car in which observers will go out at flood time to measure the height of the tide's crest and the speed of the current. A stream of many moods is the Chagres, sometimes rising 40 feet in 24 hours. Accordingly along its banks and those of its principal tributaries are fluviographic stations whence watchers may telephone to the keepers of the flood gates of the dam warnings of the coming of any sudden freshet.

In the matter of conserving the waters of the Chagres, estimating the total capacity of the watershed and in providing for swift forwarding of in-



A QUIET BEACH ON THE CHAGRES



RAILROAD BRIDGE OVER THE CHAGRES AT GAMBOA  
River is at low water. For picture showing it at flood, see page 141



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THE RIVER AND VILLAGE OF CHAGRES

The little hamlet of rude thatched huts with a frame Catholic church in the middle has seen history in its time. The Spanish fortress of San Lorenzo on the hill was taken by Sir Henry Morgan's buccaneers and later by the British under Admiral Vernon after hard fighting.



formation concerning sudden rises we shall always be under great obligations to the French. Their hydrographic observations and records are invaluable, and their stations established before we assumed control are still used, with much of their machinery. Stations are maintained far up the valleys of the Chagres and tributary rivulets, and all are connected with the central control at Gatun dam by telephone. Some of the stations are equipped with automatic machinery which, in the event of a rise during the night summons the keeper by ringing an alarm bell. The life of the keeper of a fluviograph station, miles perhaps of jungle isolating him from the nearest human habitation, is lonesome enough. Yet its monotony is sometimes relieved by lively incident. The irascible Chagres, for example, once caught the keeper at Alhajucla with a sudden rise, and compelled him to camp out a night and day in a tree top and see his house, pigs and poultry swept



POLING UP THE RAPIDS

away on the rushing tide. There was a fair chance that the tree would follow. On our way up the river to visit some of the fluviographs we landed at Cruces, went a brief space into the jungle and cleared away with machetes the tangled vegetation until the old trail, or Royal Road to Panama, was laid bare. Three to four feet wide or thereabouts it was, and

at points rudely paved with cobble stones. The nature and dimensions of the trail show that it was not intended for wheeled carriages, and indeed a native vehicle is a rarity on the Isthmus today, except in the towns. Time came when with the growing power and cruelty of the Spaniards this Camina Reale, or King's Highway, was watered with the blood of Indian slaves, bearing often their own possessions stolen from them by the Spaniard who plied on their bent backs his bloody lash. It may have been over this trail that Balboa carried, with incredible labor, the frames of three ships or caravels, which he after-



Photo by S. H. Elliott

CONSTRUCTION WORK ON THE SPILLWAY