CHAPTER VI.

PERSONNEL.

In view of the nature of the Isthmian proposition and its absolute dependence upon right technique, it is in order to examine the engineering judgment in which this eighty-five-foot project at Panama has been established and is fixedly maintained as a closed case. The personal phase is touched upon with regret. The members of both Minority and Commission were affable gentlemen, and social amenities would insure silence. But the Panama Canal, holding the Nation's honor in peace and service in war, is at stake in their engineering, and personal considerations on both sides must give place. Public officials in their public capacities are legitimately weighed and measured. Their technical past belongs by all ethics to history, and the people have an incontestible claim to the official record. This only is reviewed.

There have been in recent years of American Engineering several notable misadventures—the collapse of the Ashtabula Bridge, the breaking of the Johnstown embankment, the failure of the Austin Dam, the irruption of the Colorado River into the Salton Sink (and recently the fall of the Quebec bridge). The greatest of all menaces and the most crucial of professional commitments centered in the Bohio Dam at Panama. The story of it must be prefaced with a little back history.

The selection of an Isthmian route for the Canal had been long and hotly contested. It began three hundred years ago, but it was in the memorable Paris Congress of 1879 that the first great clinching of parties came. Our own American engineers were there—Rear Admiral Ammen, Lieutenant Commander Goringe, Mr. Menocal and others, and Commander Selfridge, invited by M. de Lesseps personally. The Americans were almost all Nicaraguan advocates, and they pressed its advantages with ability. So moved were they at the high-handedness with which its claims seemed to be put down and Panama's put up that they detailed much of the under history of the Congress in their report to the United States Government. It is a valuable, scholarly presentation, but to get a full understanding it must be read in connection with the French official report. Then it becomes one of the most amusing records in technical literature.

The Rear Admiral headed the accredited delegation—Ammen
dignified, careful, solemn and weighty of every professional utter-
ance; an officer impressed with the great import, technical and
financial, of an Interocanetic Canal. He was unfortun-
ately not over agile with "the gift of tongues." Undelegated came Commander Selfridge, debonair, lithe of
mind and glib of French. Selfridge was Nicaragua's most
deadly foil. He was in perpetual rise "for the Atrato-Na-
pipi." Was there any marked merit at Nicaragua, he went
it one better on the Atrato-Napipi. Was there any badness
in any project—it was outdone by the alarming condition of
the harbor at Graytown and the earthquakes at Nicaragua.
So the Rear Admiral felt it incumbent to let it be known
that HE was head of the American delegation, and they were
for Nicaragua, and not for the ubiquitous Atrato-Napipi.
But the assembly was hopelessly mixed, and the members
seem to have become only more mixed as to the American
contingent.

But our delegates were not to be swept away from the
first principles of engineering because of the unpopularity.
In the final session, with its culmination of hero worship,
with its cheering men and its delirious women waving ap-
proval of each accession to the Panama vote they sat immov-
able, and in the last exciting roll call they declined to vote.
"Only able engineers can form an opinion after careful study
of what is actually possible and what is relatively economical
in the construction of a ship canal." "Imaginatory projects
traced on imperfect maps of the Isthmus, some of them the
result of one night's inspiration," such engineering could not
set on the consciences of these American engineers, so the
Panama officials dubbed them "egotistical enigmas."

But the Panama route was in the hands of M. de Lesseps
and "a man of many wiles was great Ulysses." A couple of
Frenchmen had bought out the concession obtained from Co-
lombia by M. Gorgoza. It had seemed of sufficient value to
General Turr and Lieutenant Wyse of the French Navy to
warrant some preliminary surveys. These officers interested
M. de Lesseps, who had just carried Suez to completion.

The report of the American delegates to the Congress,
written in 1879, gives two notes which are of interest. It
summarizes the technical review thus:

"By these proceedings the remarkable condition is pre-
sented of engineers designing and estimating on the cost of
such important work as the one under consideration without
a proper knowledge of the ground on which the works were
to be constructed, which was generally regarded as well as that of cost, to be a matter for after consideration. It is expected that the impracticable scheme proposed for Panama (the Sea Level) will soon be abandoned for want of supporters."

Here, then at the very beginning of the Panama Canal designing, we find an evil genius laying upon it that malign spell, which nothing seems to lift, the blight of the paper location.

Chagres Dam Launched.—A second feature on which the report comments runs thus: "On the 26th of May (1879) the technical sub-committee met to discuss a new plan, based upon making a huge dam at some point across the Chagres River, with the intention of forming a large lake. Ten days before, this dam had not entered the mind of man."

Thus airily, without a shred of information as to the formation, without even a pretense of data, the first great Chagres dam was launched.

The failure of the French company brought us in 1901 an opportunity for a free choice of Isthmian routes, and the question became whether it were best to purchase the French investment and build along their route or to hold to our distinctive field and build at Nicaragua. Congress appointed a Commission to study the situation and report fully and exactly with recommendations. One million dollars were put at their disposal for an investigation. Upon this Board sat three of the engineers recommending to-day the eighty-five foot government project. More than a year was consumed in the examination of the Panama property, its sites, its structures, its hydrology, etc. The million was expended so exactly that not enough was held to publish the report, which was issued in abbreviated form. Three years later a full history was published from other moneys.

Brother of the Gatun Dam.—An eighty-five foot, six-lock canal was advised, whose central feature was the massive masonry-core, Bohio Dam. This dam was the heart, the crux of the whole waterway. It was, like its brother of to-day, a stupendous mass, and it, too, held a Central Lake, eighty-five feet deep, and some thirty-eight miles in area. The cumulation of the Nicaragua opposition had come through the years to center chiefly against the Panama Dam. Their engineers had maintained that, under Isthmian conditions, this huge structure was unsafe and to be deprecated.
But the Commission of 1901 gave to the Nicaragua project instead the coup-de-grace, and they did it by maintaining that the Bohio Dam, as planned, with a Masonry Core, was a safe and a certain engineering proposition. Each member of the recommending commission was examined minutely by the Senate Committee regarding this long-condemned central feature, but every man was ready; the Bohio Dam had no wavering defenders.

Senator Hanna—With reference to this Bohio Dam have you any doubt about the practicability of the construction and operation of that dam?

Mr. Noble—No, sir; I have not.

Senator Hanna—None at all?

Mr. Noble—No, sir; none at all.

They all stood together before the Senate guns in the same cross fire, and the declared safety of the Bohio Dam sealed forever the fate of the Nicaragua enterprise.

Believing the engineering to be competent and trustworthy, and supposing that the technical judgment of these men was a full and valid warrant for action, Congress purchased the French investment for 40 millions and authorized an appropriation of 145 millions for the construction of the Panama Canal. Office and field forces were sent down to begin work. As one of the first proceedings supplementary borings were instituted on the site of the proposed huge dam to corroborate the 1901 Commission's testimony. Then came the revelations. The rock which had been announced and directly attested before the Senate as safe and certain for foundations was found non-existent; nor could right foundations be reached within any distance which made the building of the colossal structure practicable.

The Great Bohio Dam Project Fell in a Night.—The very core of the eighty-five-foot six-locked waterway, on which both the purchase and the appropriation for the Panama Canal had been based, was virtually swept to perdition by the revelations of the first competent borings. The truth was unescapable—the examinations and explorations had been made incompetently, under inadequate or faulty engineering, and the verdict and recommendation in the very pivotal element of the waterway had been disastrously wrong. The idea had to be abandoned and more money expended anew, to hunt and explore another location for the crucial dam. The Senate reminiscence reads as follows:

Senator Kittredge (page 1845)—The reason I ask this
national Board was called, we find a third designing and recommending the most momentous feature of the whole gigantic undertaking—the flights of locks.

The army, whose reward of highest attainment is the Engineer Corps, is not so destitute of minds that it need be represented the second time by the men who had proved unequal to their first task.

This national waterway is a public enterprise, and every man connected with it should be weighed in the scales. The premise was that the Panama Canal was primarily an engineering matter, that the right, technical judgment was the fulcrum, with the whole execution swaying at the other end of the lever; that the value of an expert lay in two elements—the power of rightly diagnosing and the power of rightly prescribing; that as he possessed or did not possess these qualifications he was a success or a failure, the right mind or the wrong mind for the enterprise; and that the loyalty of its friends could be measured in nothing so surely as in their fearless and open elimination of the wrong minds from the destinies of the waterway.

Had the authorities no responsibility for the sequel; the sequel befitting the quality of engineering honored on the Canal? What could the harvest be but Dead Sea fruit?

The records of the remaining engineering sponsors for the eighty-five-foot Panama Canal are happily not set against such a dark background as the Bohio Dam. But the turnings and vaultings in canal designing and recommendations mark an extraordinary trail.

That Isthmian Canal Commission had two members—the chairman and Zone Governor—who are self-confessedly not engineers at all, civil or any other kind, not naval constructors nor navigators, nor seamen. One is a railroad organizer, the other a very competent and successful Governor. Being wholly without training or experience, they are quite unqualified for considering hydraulic questions or plans. It is a sacrifice of all chance for rational solution to have a great world problem like the Panama Canal design decided by the opinion and vote of men, however competent in other fields, thus fundamentally unfit.

A third Commissioner foreshewing his colleague's engineering goes to the sea-level. A fourth stands now with the high level, reversing himself, for he moved to adopt the sea-level scheme in the last Walker Commission. The fifth
and sixth served on the Commission of 1901, whose plans incorporating the Bohio structure were made the basis of the canal purchase, and the authorization of the Spooner Act.

Likewise these two men, together with their colleague of the minority, had condemned as unsafe at the Isthmus any dam which had not a masonry core founded on rock. Now, four years later, they vote to build an even huger dam of earth, on a spot which they themselves previously rejected, and they base it upon openly acknowledged alluvium. As they gave learned opinions of the safety of the Bohio Dam, so now they heap up assurances as to the safety of their high Gatun Dam. This was the personnel of the Isthmian Commission that accepted and recommended the eighty-five-foot project.

Next as to the engineers constituting the minority of the International Board, the fabricators of this high-level, multi-locked canal. The first was the condemned expert of 1901, the engineer who had no doubt as to Bohio. "No, sir, none at all." He designed, drew and estimated the present lock flights, the most momentous and deplored feature of the whole waterway, and he located them, as will be seen on "four borings, or rather three" for data. The second engineer had sat upon a previous Isthmian Commission and had publicly and ardently advocated, as the only right solution for Panama, a project quite different from the one now supported by him. He had within three months published a book setting forth by the strongest arguments and through his deductions from French data of Chagres discharge his conviction that the high-level type was unsafe, the sea-level type anathema, and the four-lock 61.5 foot the only correct solution. In the face of many years' denouncement and condemnation of an 85-foot summit level, he now votes for it, but his long testimony as to its perils compels him to dissent from the location of three locks in flight at Gatun. He begs the compromise of setting one of the locks at Bohio.

A third member of the minority voted four gigantic unexampled earth dams, each despite the great difference in conditions, modeled on his one relatively simple chef-d'œuvre. What data he possessed will be set forth in the coming article on the Gatun Dam. A later chapter will describe the failure of this chef-d'œuvre on April 11, 1907, when one-seventh of the crucial mass of the Wachusett Dam went down into the reservoir.
A fourth followed his leader matching the dams, in massive, stupendous and quite unprecedented flights of locks, with the same "four or rather three borings for data." Both recommenda-
tions were brought by their size into the field of experi-
ment. These massive concretes were more than a mile long.

The fifth step-fathering here a high-level design, is on public record in support of a sea-level tunnel scheme through the mountain of Darien, as the solution for the transisth-
mian canal. He "most unhesitatingly recognized the practi-
cability," etc., and he "believes that I can organize a body of the ablest contractors to be found in the United States who will do the work for these prices." He is opposed to locks, and observes that he "need not take up the manifest advantage of an interoceanic canal without locks, because the obvious need not be dwelt upon." He abandons now the sea level, tunneled, lockless Darien-Mandingo of 1902, and advises a very high level, six-lock canal, not at Darien, but at Panama.

Of the nine men, therefore, of the combined bodies, who, being engineers, might supposedly speak with some author-
ity upon this technical matter, one has gone to the sea-level; six have quite changed their previous public and studied pub-
lished recommendations, while the two new men voted their own specialties in colossal and quite experimental features with an open gamble on foundations.

What can be said of the two bodies posed as experts of the first order, whose opinions and advices in a matter in-
volving in only the purchase and estimate around 250 mil-
lion dollars betray such radical changing, inconsistency and defiance of the first principles of precaution? Can such decisions, convince any one, or pretense long mask the fact that they were and are at sea as to what to advise for the Panama Canal, and have engineered loose-handedly in confusion, and compromise? Not one of the various Com-
missions or Boards, or Chief Engineers responsible for the 85-ft. scheme or the sea-level chimera has in November, 1907, any place or part in the canal enterprise.

When the child is stricken and the doctors diagnosing one thing and another thing and again another thing, dose him to ever-failing strength, it is not amiability then, or in-
fluence then, or friendship then. It is one thing and one thing only, and we call aloud, "Give us skill, give us knowl-
edge, these alone can save!" We left the crucial cutting of
this precious canal body to surgeons not only ignorant of its anatomy, but indifferent to its anatomy, to men who fettered its limbs in massive locks, without even inquiring if its limbs could carry them—men who loaded the crushing mountain upon its back, without even seeking if its back could carry the mountain.

The climax of "engineering by autocracy" came in the locating of the massive masonry lock-ladder at Gatun. Here was the full fruition of Bohio, the inevitable sequel to its methods. The flight of three locks had been by the majority of the International Board uncompromisingly denounced as "the most dangerous feature that has been proposed for any canal." It had been declared "so perilously near impracticability (for navigation) that no scheme involving it should be accepted." This lock fight was the creation of the former Bohio Sponsor. He testified before the Senate Committee:

"I made the plans of the locks myself, Senator; I made the estimates of them. I sketched out the plans of the lock personally, and I personally made the calculations of the quantities."

It was supported by the second new board member—a specialist likewise. These two were responsible at first hand for the flights, as the dam specialist was responsible at first hand for the Gatun Monster. The other members accepted and recommended the features, as did also the Commission (all but one), the Chief Engineer and the Secretary of War.

The first and indispensable requisite for formulating a plan of any kind is data; the greater and more vital the feature, the more comprehensive and detailed must be the data. For an unexampled flight of massive concrete locks and approaches, the need of the right foundations is so glaringly self-evident that complete and exhaustive information was imperative before any valid engineering opinion, even upon the possibility of locating there a flight of locks at all, could be entertained. Manifestly its weight could be ventured only upon adequate and unassailable sub-strata continuous every foot of the way.

Remembering the absence of knowledge in which the French had projected their sea level and had been forced later ignominiously to abandon it, and recalling our own inauspicious beginning in the Bohio foundations, the President had been solicitous and he gave exact and comprehensive commands. He wrote:

"The Isthmian Canal Commission is directed to have all
the proposed plans in such detailed form with maps, surveys and other documents sufficient to enable the consulting engineers to consider and decide the questions presented to them."

The author of one Panama design long before requested the Secretary twice to order certain borings. But why should the President be anxious? Why should he trouble about data? What did data matter? There was no time, and the engineers were not exacting much. They could design whether or not; there was no inconvenient Rear Admiral Ammen among them. The spell, the same old blight, was spoken over it for the third time—the blight of the paper location. The Paris and Bohio circuit was complete.

The board convened on September 1, 1905. On their adjournment this 85-foot design with its stupendous masonry lock flight was adopted by the minority, was supported by the Secretary of War, was announced to the country as safely and certainly accredited, was advised to the President, and was recommended to Congress.

In March the Senate Isthmian Committee that had received and credited the Bohio story, began investigating this second design submitted for the Panama Canal. They found it strangely akin to the first. The same 85-foot level was taken, necessitating again a deep Central Lake and the old stupendous dam. This time it was huger than before. It had abandoned Bohio now, but had only moved down stream ten miles and had established itself at Gatun instead. The locks were more formidable than formerly, they had been huddled into a tier of three and were projected into and overhung the rock of the Gatun Hill. The whole design looked so like a grown-up presentation of the old familiar face that they instinctively began investigation as to foundations. What was the engineering on the canal this time? What were the evidences of caution, of care, of safeguarding, of knowledge, of skill?

The masonry lock flight being of stupendous weight and great extent and holding the passing destiny of every ship that should cross the canal was naturally the greatest concern. The chairman questioned the designer of the lock tier—the same engineer whose Bohio Dam plan had gone to the limbo of the impossible (Senate Testimony, page 1,884).

Senator Kittredge—To what extent had your board and have you in your possession information concerning the char-
acter of the Gatun Hills in the vicinity of the proposed locks?

Mr. Noble—There are some borings in there, but I do not think they extend the full length of the lock. There was no time to get all that information.

Senator Kittredge—Do you not think it was desirable to have that information?

Mr. Noble—Oh, extremely.

Page 1793:

Senator Kittredge—How many borings were made in the Gatun Hill in the vicinity of where the locks are to be placed?

Mr. Parsons—There were nine borings made, I think, Senator, on a different location. This map shows them. There were seventeen borings made altogether, and it was figured at that time that the locks should take that direction, as you can see by those black lines. (Indicating on the map.)

Senator Morgan—The seventeen borings were on the lock site?

Mr. Parsons—On that lock site. Not on the lock site that was finally adopted. The seventeen borings were made on the first lock site as proposed by the committee. Then they found that the hill in that section was too short to accommodate the locks and the location was therefore changed * * * so that these borings down here give no information at all as to the condition of the lock further to the east. Therefore, as a matter of fact, there are four borings or really three that come within the lines of the lock as shown by the minority report.

Senator Hopkins—How far out are they, Mr. Parsons?

Mr. Parsons—That distance is 500 feet. You can see that all these borings down to the west of the canal on the lower part are from 500 to 1,000 feet away.

Senator Hopkins—From the actual location of the locks?

Mr. Parsons—From the actual location of the locks. And if you will refer to the plates showing those borings there given in the report, you will see the indurated clay, for instance, which is the material on which they expect to found the locks, and how it will vary in position between two borings. You see it is liable to fluctuate very widely.

Senator Knox—It is liable to fluctuate widely within what distance?

Mr. Parsons—Oh, in a distance of two or three hundred feet it would fluctuate widely. * * * You can see how close the borings were made there (indicating) and on the site of the locks no borings were made at all.

Page 1981:

Mr. Wallace—in my own examination of these borings—there have only been four or five borings taken throughout the entire site on which it is proposed to build those locks, which, with their approaches and wing walls, extend upward of a mile in length, and my criticism of the lock plan was this. * * * And it would seem the part of prudence
before a lock plan of that magnitude and importance is undertaken that the most thorough borings should be made over that entire area and at least as close together as 100 to 200 feet apart, both laterally and longitudinally.

Senator Dryden—These borings have not yet been made, then?

Mr. Wallace—I understand that they have not.

Senator Kittredge's speech, page 1732, reads:

"They (the minority) propose to construct locks having a usable dimension of 900 feet in length and 95 feet in width, three in flight and the lock structure, the guard walls, approach walls and all the other necessary elements of that design will make a structure more than one mile long. It will be observed, if one examines the map, that with one or two exceptions, not a boring has been made under the site of the proposed locks at Gatun to determine the foundation."

On superficial knowledge of four holes, therefore, the monster experiment of all time was formulated by the minority, supported by the Commission and the Secretary of War, with all the enginery of the government back of them, and announced to the public as safely founded and unassailably entrenched. Then the Commission set about getting data, to ascertain whether or not the lock flight could even be built. So reckless and unprofessional a system of engineering and of directing a public enterprise could not be found in all American annals.

These revelations as to borings brought some consternation to the Senate Committee. Other facts came to light, grave facts, which will be reached duly. The easy complacency of the Secretary and the Chairman were shaken for a moment. The former wired the Chief Engineer:

March 18, 1906.

Would it not be wise for you to examine and measure Gatun Hill with reference to the questions raised by Burr and Parsons? It ought to be done, if done at all, at once.

Taft.

Now certain facts are circumstantially revealed. The 85-foot experting, engineering and supporting were being unmasked. All the government forces had rallied to the defense. Were the data in possession of the Commission established at Washington, they could have been produced on the spot. There would have been no need to wire to the Chief Engineer of the sorely disturbing condition, and bid him "measure at once." The Commission could produce only the maps of the four borings. Further, the Chairman
himself, in addition to the Secretary of War, began wiring for the data. The Senate testimony gives this:

(Confidential.)

March 16, 1906.

Stevens, Panama:
Burr and Parsons testified in favor sea level and strongly against lock, asserting Gatun Hill not large enough to permit construction three locks in series with usable length exceeding 790 feet each and proper foundation dam not attainable. Noble testified in favor of lock canals, but had no figures to refute statements about length Gatun Hill.

Shonts,
This last named expert was the engineer who testified that he had designed the lock flight in person, drawn it in person and estimated it in person. The Commission had supported and accredited it to the country. There is the Chairman's own confession and the date was March 16; five months later "he had no figures about the length of the Gatun Hill."

The reply was dated March 20, 1906: "Have fully developed by one hundred borings 3,800 feet in length and 300 feet wide on exact site of three locks perfect foundations, etc. Stevens."

From the adjournment of the Board, therefore, in November until March 20, the confiding public was happy in the belief that the Gatun lock foundations were reposing unchallegably upon the rock. Meanwhile the chief engineer was engaged in making the belated borings upon which their very existence depended. He relievedly proclaims the saving of the situation and the mercy of Mother Nature to this closely pressed lock-tier. The "ideality" of the Gatun Hill conditions come into the lock analysis; here the data story alone is being considered.

By March 20, then, the Commission, alive to the probings of the coming Senate Committee had marshaled together at the Isthmus, but had not yet got to Washington, one hundred borings under the locks. The testimony of the majority had been that these borings should be very numerous and very close together under a great masonry structure more than a mile long. But the 85-foot project had run through the Senate gauntlet and the general lock type was ordered. The Commission settled back to its laisser faire. There were no more Senate probings in sight and the people had accepted the vouching.
The Investigating Committee had brought out other equally compromising testimony. The section between Mindi and Gatun was under discussion. The revelation here ran (page 1627):

"The majority excavates along the old canal line, digging down to 40 feet below sea level. The minority cuts a new line through a series of hillocks made of hard clay.

The fact has developed that except at the intersection at the mouth of the Mindi the minority had in hand from there to Gatun, a distance of nearly four miles, not a single boring on which to base the estimate to which all their responsibilities are attached. There existed neither a profile of the surface nor one of the indurated clay. Their new line was away to the eastward of all the canal excavations of the French company, and therefore away from all accurate knowledge of actual strata. It is not to be credited that the minority has figured in enough refractory excavation. It is concluded from a careful study that, between Mindi and Gatun especially, the quantities allowed by the minority are far too small. When the line is actually surveyed, if it ever is to be, and bored, it will undoubtedly be found that they will have over double as many cubic yards as they now contemplate of clay refractory from a dredging standpoint."

Through one-tenth of the Canal length, therefore, the minority, the Commission and the Secretary of War located their channel and gave estimates for its cost without one shred of information or one tittle of knowledge. Since the Senate revelations some fifty borings have been made through this four-mile section. The evidence of even these few tests is conclusive that the quantity of indurated clay is double that which they named—a serious increase of cost.

This is set forth by the Commission itself in the "information" sent out to bidders. Engineering and estimating by guess, therefore, is likely to be a luxury indeed for the American treasury.

In December, 1906, came the invitations to contract. The canal technique passed now a different gauntlet. Contractors were not lawyers or senators, but they were engineers, and practical executives. They could gauge and weigh values in professional judgment and could analyze evidences in data which the Senate Committee, with all its good intent, was not technically equipped for estimating. The reception of these invitations was so unequivocal that the Chairman withdrew them, and announced publicly that contractors declined to stand for the government's exprecting. The features of the 85-foot canal were pronounced "too risky" and
the borings—the borings—were not sufficient for any safe or sound business.

The Senate Committee has realized the ominous meaning of a national waterway built of such features and founded on such evidence that experienced men will peril nothing in it. They called again for borings, the borings of the year. Though still another ten months had gone by, few further tests had been ordered or made except in Spillway Hill, as the annual report of 1906 showed.

With the possible lock lengths and the safety devices, burdened with the very brunt of defense to every ship that shall ever pass at Panama, both dependent upon right formation beyond the 3,800-foot belt probed, the remissness in the matter of data is something incomprehensible.

The authorities at Washington have upheld and defended all this. When the engineer or the waterway must be sacrificed they have sacrificed the waterway. They tell us these are great engineers. They are more than great; they are phenomenal; they are extraordinary. They are great past anything yet recorded, anything yet dared. Professional men heretofore have needed the homely bases—data. They have built upon some foundations. They have gathered the facts and truths of Mother Earth—earth, who will not deceive nor be deceived. But these had been beyond the common needs and the common bonds.
PANAMA CANAL, SHOWING OUTER AND INNER HARBORS, LOCK WAAL STATION—BY LINDON W. BATES.
CHAPTER VII.

ATLANTIC HARBOR AND TERMINAL CITY.

There have been many landing places and many routes across the small divide—this fevered Isthmus, this swamp-entrenched, jungle-clad pass across the Cordilleras. Who would have dreamed the day the “Admiral of the Seas of Darkness” cast anchor at Porto Bello, east of Limon Bay, that an Admiral of the far Cipango which he sought would sweep from her coasts the fleets of a white race, four centuries later! Porto Bello, San Lorenzo Castle, Chagrestown, Toro, Peacock Bay, Manzanillo, Aspinwall, Colon, Cristobal, Mindi, they mark the trend of a beautiful, vapored, miasmic, sinister shore.

The paved treasure road of Spain led across the low mountains from Porto Bello to old Panama, the richest town of its size in the world. Porto Bello was a safe harbor for sailing craft which could not hope to escape the “Northers” in Limon Bay and dare not lie off the reef-bound mouth of the Chagres emptying there before the Castle on the black rock.

With the advent of the steamship, Porto Bello was forsaken and the Argonauts of ’49, gold-mad for California, landed at the mouth of the dreaded river, paddled to Gorgona over the precious Reef, crossed the Divide afoot or on muleback and sailed away over the Pacific to their land of the Golden Fleece.

There had been many quests at Panama. It was ever the land of secrets—the Secret of the Unknown Ocean, and the Secret of the Strait, which scores of mariners after “the Admiral” had come seeking; the Secret of El Dorado, the Golden-man; the Secret of the Undiscovered Inca Empire; the Secret of the vanished Treasures of the pirate-sacked cities; the Secret of the Lost Pass.

In 1814 Spain, unreconciled to her decline and seeing her early glories merging into memory and tradition, strove to recall them into living force. Her hold upon the American colonies was loosening and her vestige of power was slipping forever away. She decreed the construction of an Isthmian Canal. But her day had gone; the colonies revolted and fell from her impotent grasp.
Bolivar of New Granada gave to the "King of New Zealand" a franchise for a Panama Canal, and later he commissioned a Swedish and a British engineer to survey the route. The line which these two men mapped was wisely projected, and it became afterwards substantially the route adopted for the Panama railroad.

Granada later gave another concession, and Morel made surveys for a route between Porto Bello and Panama. He reported a low dip in the mountains where the crest was but twelve metres high.

It was to find this, the Lost Pass, that M. Guizot, Minister of France, in response to the importuning of believers in the hazy traditions and tales of the Darien Indians, sent out to Panama, in 1840, Napoleon Garella, an eminent and sensible engineer. The Pass was said to be only about twelve metres, or 40 feet high. Garella was to discover this dip in the mountains and to locate through it an Interoceanic Canal.

He did not find the Lost Pass. Where it was supposed to be, there were several passes, each nearly ten times as high as the one so fervently assured to the Minister and so ardently believed. Of these passes, the one which Garella preferred led from the upper reaches of the Rio Cano, the largest western tributary of the Chagres above Bohio, to the Bay of Caimito, 12 miles west of Panama. The terminal he selected on the Pacific was "Voca de Monte." He got his small lock canal away from the Chagres as soon as he could, and did not essay the route which he well knew around the Culebra Hill and down the Rio Grande to the Bay of Panama. He left the Chagres at the mouth of the Trinidad, above Gatun, and struck around and across the low western hills into the valley of the Benito, a branch of the Cano, thence through the Pass into the valley of the Bernardino and to the Sea. He stood on the hill at Gatun, where so many have stood before and since, and looked seaward across the swamps which he "could not cross." He marked through them on his map a short cut to Limon Bay, around the foot of Jaramillo Hill, to a haven on the West Shore, half way to Toro Point, where he set his proposed terminus.

But Garella's plans and the syndicates' hopes for this early water link were put to sleep when he reported the Pass at its true height. The Divide was too formidable for adventure.
If the French delegate could not cross the morasses, a British hydrographer could—the gifted Peacock. He formally entered Limon Bay in 1834, and with Indian guides walked from the deep bight at its western head to Gatun. He memorialized M. de Lesseps in 1879 and gave a history of his expedition. He made a map showing the terminus for his proposed canal, on Peacock Bay west of Jaramillo Hill. It is a rara avis of an engineer who knows how to make a conclusive reconnaissance in a tropical thicket.

Then came the Panama railroad and its fevered driving against stupendous odds to completion. The California rush was on, and the golden age for this interoceanic link. The railroad engineers discarded the valley of the Chagres below Gatun, flanked as it was on either side by flood-swept banks and lined by steeps of rugged clay-rock, slimy and slippery with weathering in the drowning rains.

The railroad engineers passed over the western shore of Limon, or Navy Bay, and the safer anchorage near Toro Point, and started their constructions from Manzanillo Island.
on the further side, whereon was founded the railroad town of Aspinwall.

The French Empress Eugenie, impressed with the ungenerousness of paying here no tribute to Columbus, sent out the statue which marks the entrance of the French canal. In deference to her memorial, the French changed the name from Aspinwall to Colon.

Chagrestown and Porto Bello have been the nightmares of three and one-half centuries. Colon, the Isthmian Canal and Mount Hope, its dead city, have had the cycle of but fifty years.

The Outlook for September, 1906, had a very laudatory article on the canal work, with approval for nearly everything on the Isthmus. It explains Colon's bad record by its natural handicaps. It writes:

"Briefly the situation is this: Probably no town in the world of its size presents so many difficult problems of sanitation. Swamp-built Colon is a natural hotbed of disease. The filth of years of foul living reeks from its mud. It is peopled almost wholly by ignorant negroes, many of them the rejected and worthless employes of the commission, who in their huddled living disregard every rule of health. The chance that the selected plan for the canal might cut off Colon and allow it to perish from very uselessness has passed. It must still remain the receiving and distributing station for the vast bulk of men and supplies that are pouring into the zone. Thus the health of the whole Isthmus depends upon the health of Colon."

This reviewer thus recognizes the force of the contention that Colon, the focus of Isthmian disease, should be ultimately abandoned, and a new right terminal city be built elsewhere. The Mindi hills, are the natural place for the Atlantic city. Here the heights afford the right environment. If Colon was to be retained, why was not Colon made fundamentally sanitary?

The island's engineering surgeons have been sadly slack. Colon has had nearly two generations of existence, and but 500 acres. Since the year of our canal purchase stricken Galveston has lifted a thousand acres of herself a dozen feet with sweet, clean sea sand. She has kept clear of yellow fever when it was all about her, and has been more healthy during the trying process than ever before. The very first
proposition which the Isthmian Canal Commission had before
it, the day it organized, four years ago, was one to raise
and redeem Colon. But it did little save dig a currentless
trench in midstreet at the level of an all but tideless sea.
When, with its millions of money and the guardianship of
such a stake in health, it paves a narrow trench or two, or
toiling, makes some gutters, the world is called to witness
in dozens of illustrated encomiums the worthy achievement
Colon is not Galveston, the commissions are not like her
grade raising committee. Both had the people's mandate to
do the right and the best. But the latter has had the will
and the wisdom, and they cherished their city supremely.

There were half a dozen ways to raise the Colon site—
the easiest by dredgings from the harbor and canal near Cristobal. But the material removed at conspicuous expense has been wasted at sea—the same sea of waste at Panama!

An Atlantic harbor is wanted for our new canal, a harbor commodious, safe for ship and life, easy of access and departure and fully equipped; a refuge, a defense, a warden of our United States supremacy at this gate of nations. Limon bay affords scope for dozens of harbor designs. Out of all the ruck of cobwebbed plans, Peacock's Garella's, Totten's, the official French, the idealist designs of Sautereau and a dozen compatriots, there emerged last winter two—one that of the majority of the advisory board, the other that of the minority, the commission and the Secretary of War. The official maps, accompanying the board report gave their locations and their text confirmed the maps. Both were of a type in which the breakwater arms run from the shore, northward, converging to an entrance seaward of Colon. They were different from all that had gone before. Every other serious plan had put the breakwaters at right angles to the great wave-making winds. These schemes started a new departure in Atlantic harbor designing.

No explorations or borings were made under the greater part, and that the most expensive sections of these breakwater arms. The east arm was a mile long, the west arm 4½ miles long. No one knew (no one yet knows) where the hard bottom underlies the mud, seaward from Mindi Point for 3½ miles. The formation was unsearched and the mud and sand were unplumbed under one mile of the eastern arm and under 3½ miles of the western arm. No designs were made, no investigations were undertaken, no quantities were estimated, yet the majority, the minority, the chairman of the commission and his colleagues, the chief engineer and the Secretary of War, all set their hands and seals to the solemn conjecture that they would cost $5,300,000.

The harbors recommended by the minority engineers are inclosed by two break-water arms. Both are approximately parallel to the axis of Limon bay, but are toward the east of Colon shore.

The east breakwater is an arm run out to the 40-ft. contour from Manzanillo Point. Immediately off its outer end and only a few hundred feet to the northward is a dangerous
cluster of rocks and reefs carrying but 22½ ft. of water. These in "northers" break heavily and induce a jumble of swift currents and back-wash, hazardous to a steamer seeking haven in dark and stormy weather. The board is united in presenting as a harbor feature this perilous reef right under the lee of wind-lashed vessels. Ships that in storms or blinding rains miss the narrow entrance ought to have sufficient sea room to avoid piling onto such hidden jagged peaks. Safety to navigation should be a keynote in the harmony of the best canal scheme.

Further, the mile-long eastern arm receives the high trade wind waves, driven often by vicious squalls, not at right angles to its axis, but obliquely.

The West Indian "norther" and hurricanes and gales come nearly always not out of the north, but from about the north, northwest. This condition of wave exposure compels, for the breakwater, a large cross section and extra heavy blocks of stone or concrete, else the fiasco of the early Galveston jetties must be repeated.

The Majority indicate a west breakwater 3½ miles long from Mandi Point. The minority one 4½ miles long from Mandi mouth. The sailing course here is almost due north.

A little reminder of the conditions to be dealt with in Limon bay may be pertinent. Here are the accounts of the "norther" of last Christmas week:

"The Advance arrived yesterday, four days behind her schedule. She should have sailed from Colon on the day before Christmas, but on December 23d (1906), a fierce 'norther' tore her from her moorings, and to avoid being dashed upon the shore, Captain Hammond turned his boat for the open sea. Fourteen other vessels at Colon also were compelled to put to sea. The gale lasted four days with hurricane strength, causing many wrecks of small craft along the coast.

"The Advance found shelter in the harbor of Porto Cabello, Venezuela. Twice during the four days of the storm Captain Hammond vainly sought to work his way out of that port and back to the Isthmus. He said yesterday that the wind arose with such rapidity that he had all he could do to get his vessel safely out of the harbor of Colon. So terrific were the head seas that the ship had difficulty in clearing the roadstead. The wind moderated sufficiently December 27 to permit her departure from Porto Cabello. She
made her way back to Colon, finished her loading and sailed on the following day.” The Captain’s account gives other details:

“We were scheduled to sail from Colon on the day before Christmas.” Captain Hammond said, “but while we were still loading that wind sprung up and we were up against it good. I never saw the glass fall like it did that afternoon, and pretty soon it came on to blow from the northward. You see, the harbor is open to the north, and that puts us with the shore to leeward. The gale increased by midnight and we could see that the only thing to do was put to sea for safety.

“We didn’t relish going out in that blow, but there was no other course. It was make for the open or go ashore, and so we decided to save the ship. And we had no easy time, either. It was one thing to head the ship for the open, but it was quite another to keep her head where we pointed it, and before it was all over we thought a good many times that there was something else for us than finally getting the vessel to New York.

“Never saw bigger head seas than we got going out, and if the Advance had been a whit less seaworthy I wouldn’t be here now to tell what happened. They swept clean over us at times.

“Had we stayed inside half an hour longer I hardly think that we could have ever gotten out at all. There were five other steamers in the harbor at the time and they all went along with us. We managed to weather the storm, though we found ourselves in Porto Cabello, Venezuela, before we could start back to Colon.

“Had to lie in at Porto Cabello for nearly four days, all the time hoping to get a chance to go back to Colon. Did make two attempts at it, but the weather was too much for the vessel to go into. But the hurricane blew itself out by the night of December 27, and after that we had good weather.”

The West Indian “norther” nearly always, as was noted, comes not out of the north, but from about the north-north-west. This is why Toro Point, on the west side of Limon bay, partially shelters the safest anchorage. The charts of all nations show this and all Admiralties officially admonish mariners of it. The following are the official instructions to mariners:
"Anchorage—The best anchorage in ordinary weather is abreast the Pacific Mail Company's dock, about 600 yds. off, but in bad weather it is better to anchor on the opposite side to avoid the heavy sea that rolls in around Toro Point; the holding ground is good, but there are many anchors and cables strewn about the bottom."

"Norther—These winds occur in November, December and January; they are seldom violent, but a heavy sea rolls in."

"At Colon a norther is not necessarily a gale of wind. In fact, the wind frequently does not blow home, and is at times quite light; but very heavy ground swells heave into the bay. When the wind does blow home, as happened during the norther of December 19-21, 1890, no vessel can remain at anchor with safety. There is no way of predicting these dangerous northers. The barometer gives no indication; the 'fitful showers of rain in large drops' may or may not be an indication. The gradually increasing swell, supposed to be a forerunner of a norther, frequently proves to mean nothing.

"The norther of December 19-21, 1890, was preceded on the 18th by a heavy swell and threatening weather, but toward evening the swell decreased, the weather cleared, and it looked like a fine night. Later in the night the swell commenced to heave in with great force, so that the steamers were compelled to leave their wharves. It was not until after daylight on the 19th that the full force of the norther began to be felt, and in a very short time it became so rough that all steamers put to sea. The Pacific Mail steamer Newport, cut her lines and steamed across the bay to the anchorage under the lee of Toro Point, but was soon compelled to abandon this anchorage and put to sea. One steamer lying in the harbor with two anchors down dragged nearly one mile before she could get sufficient steam to be able to slip and go to sea.

"During the season of northers, steamers should keep steam up constantly and be ready to move at a moment's notice. This is the custom of steamers of all nations which touch at this port, regardless of the time they may remain. However long the weather may have been threatening, when the norther does break it comes suddenly and leaves no time for preparations. If compelled to get under way, the surest way is to slip the chain and steam out to sea. It would
is 1,000 ft. or more and the writer's Lake Canal provisions arranged for the gradual broadening to this very desirable width.

The Minority of the expert board, after due ponderings, achieved a plan which received eulogistic acceptance from commission, Chief Engineer and all canal authorities. The Atlantic harbor elements have been detailed. The situation was supposedly studied, first by reliable experts; second by combined commission and Chief Engineer. All accepted the described breakwaters, as the harbor solution. The board dissolved. Of the technical men then on the commission three only remain January, 1907. The canal engineering was then in the hands of four professional men. They go at the situation apparently afresh and we have a marvelous new deliverance—
with jealous bigotry a half-baked design to-day and discarding and denying it to-morrow—all this will make its engineering story a conspicuous instance of the great power for harm as well as for good that exists in public office. The place invests the man, and the curule chair is still a symbol for inferred eminence.

A commissioner with the authority of the Secretary of War has announced in a New York paper "they may not be required." There is to be thus saved the immediate expenditure of $5,300,000, while the engineers get time to experiment with bucking "northerners." That is, they are to get by experience the knowledge which they lack.

Well, some progress has been made albeit negative. The breakwaters of unknown quantities, founded in unplumbed depths of unsearched mud (the original boring notes can be presented), of a vouchèd cost, though without any determinate evidence and not drawn at all on the momentous map of December 17, may pave the way for one of those late repentances to which the country is growing used. There may be some day another announcement of again changed alignment and again redesigned breakwaters. This would be wise, indeed, for those adopted and incorporated into the previous maps were merely notional.

Let the hope be recorded that there are seen in this last official map the obsequies of the minority design.

This discussion must now refer to a few dominating harbor factors.

An inspection of the head of Limon bay is convincing that Mindi is the best Canal entrance. It eliminates sharp curves and shortens by several miles the total canal length.

Jaramillo Hill is the best location for the right terminal city, and a course nearly centering the bay is the best approach. This location is well away from the dangerous reefs off Manzanillo Island, which remain the perquisites of the last official alignments. It gives a curveless entrance to a Mindi lock and terminal city. The approach points into the eye of the heaviest winds and wave motions, not somewhat obliquely, as does the Minority or the December 17th approach. Were this terminal city adopted and the first lock set at Mindi entrance, there could be created here a double harbor—one of salt water, one in the fresh water of Lake Chagres. The Mindi lock would bring a lake within 3,000
ft. of Limon bay. This disposition would make possible the most perfect harbor combination in the world.

No one would want to live or do business where the present Colon is located, if he could have highly attractive and sanitary conditions and real commercial activity at a city on the Mindi Hills.

It is folly not to put on the steamer's ocean voyage the distance to the head of Limon bay. The canal headquarters and dispatching station should be at a terminal lock here. It should not be at the infected, saturated, distant site of Old Colon.

On the other hand, the navigator will also know that in any plan which seeks to permanently preserve Colon as the terminal city he would be obliged to have the protection of a very costly outer breakwater.

A merchant captain or a naval commander will not wish to exchange the advantages of fresh and salt water havens at Mindi, straight, safe entries, and all that goes with rightly designed harbors, for the disadvantages attending the government locations.

The official chart shows that the shortest and most direct route from the new canal entrance to the nearest point on the 71/2-fathom contour would lay the entrance line to a place nearly midway between Toro Point and Colon. This fact has a material bearing upon the location of breakwaters.

The cheapest and best breakwater will be wisely set where it is founded in shallow water, not over twenty feet, and yet incloses an ample salt water harbor area. Such breakwaters would extend from Mindi Point westerly. Mindi Point is about a mile north of Mindi mouth on the east side of Limon bay. Breakwaters thus located would receive their wave shocks at right angles, where they can give their full resistance. They do not, therefore, require the heavy construction demanded by a wrong alignment in the deepest water, where, of course, there must be greater volume to resist the sea. They do not extend one and three and a half miles seaward beyond all borings. They are not experimental and are not in unplumbed depths of mud or sand. Their location is in the known and tested section of Limon bay. These breakwaters are the only ones, therefore, which are not through their greatest extent conjecture entirely. The Mindi Point breakwaters are based on known borings and on
known foundations. Their cost would be but a fifth that of the Minority's and their sum, $5,300,000 was itself wholly inadequate for the structures demanded by the wave conditions which the board's construction had to meet.

What should be the dispositions here? Well, if it be regular, rational, normal harbor improvement, it should be somewhat like this: The channel seaward of Mindi Point, a thousand ft. wide, ultimately, has submerged banks below the plane of wave motion. The bay here is deep enough for sea-going hopper dredges to manoeuvre safely, and by such dredges it will be excavated and maintained. Landward from Mindi Point, smooth-water dredges, dipper, clamshell or multiple-bucket machines cannot work without shelter, and sea-going hoppers will find the surges made by the trade winds too high, the bottom too soft and too light and the depths too shallow for safe effective work. So the logic of

![Entrance to Panama Canal, Plan of Lindon W. Bates](image)

the local conditions and the limits of the science of dredging will compel shelter and the employment of smooth-water excavating devices. This shelter will have to take the form afforded by breakwaters at right angles to the side of Limon bay and extending from Mindi Point to the verge of the new channel. The channel width will intervene, and then another section of breakwater will be built to secure smooth
ROCK FORMATION AT MINDI BUTTES.
strangers will have waved "good speed" in the comradeship of the sea. The canal is a waterway, but it is a landway as well between the hemming oceans. Mother Earth will be fair and ground will be pleasant under foot, after the weary leagues of the seas. If the canal features can be made attractive as well as useful, let beauty be allowed. Let the few short hours wherein our Isthmus shall tend her guests be hours to cherish not to dread.

The terminal cities will be the landing places. In them will be mostly centered whatever of life and interest the Isthmus shall offer. For the ship itself and for its human occupants the best conditions must be provided. The terminal cities and the terminal harbors, because they focus the significance of the enterprise, are worthy of the best that can be done for them. Let the waterway have a fitting setting. Let its "hail" and its "farewell" be worthy of a "World's Canal."
CHAPTER VIII.
THE GATUN DAM.

Why in the Isthmian lock canal is a dam set at Gatun? This is a natural question, but the answer is simple and plain. Considering the steady expansion of the world's trade and commerce, the present dimensions and drafts of ships, their inevitable increase and the need of water for making the required number of lockages incident to the Isthmian transit—in short, for the adequate service of navigation, naval and mercantile, the summit level of a lock canal at Panama must begin on the Atlantic side at Gatun or Mindi.

If it begins at Bohio, ten miles further up the Chagres, the lockage supply is wholly inadequate; if it begins yet further up river, as at San Pablo, or Bas Opispo, it is too meager to be worth a moment's consideration, aside from other phases of the matter, technical and financial.

The pregnant truth was not emphasized or even realized by the French, because in the early eighties there was little anticipation of the stupendous strides that modern commerce was to take and the great sizes that ships were destined to attain. The canal projected by M. de Lesseps was 28 feet deep, and in his greatest financial stringency he considered cutting the 28 down to 22 feet. Already to-day ships are in existence 788 feet long and of 88-foot beam, and draft is permitted to over 38 feet, and still larger vessels are projected. Insufficiency of lockage water did not demand from our predecessors, therefore, so concerned a contemplation as it does from us. Our earlier commissions, likewise, quite failed to appreciate the coming commerce and the advancing proportions of vessels. As recently as seven months before the meeting of the International Board, the channel, newly recommended by the technical committee, was but 35 feet deep.

The Bates project before the experts gave a diagram of an existing Cunarder in this advised canal. The ship was shown to project nearly two feet below the bottom. Object lessons help along to necessary changes. The International Board was the first technical body to acknowledge in channel depth and dimensions the demands of the world's shipping and of existing and future ocean carriers. It is one of the merits which must be set to the credit of the majority, and
to the minority also except as to lock lengths. It is recorded here with gratification.

The reason for setting the dam at Gatun was, then, that a dam there insured a lock canal with an extensive enough watershed and large enough water supply for all possible future demands. To build a waterway at huge expense and make it inadequate for coming commerce were folly surely. Ample lockage water was recognized as the very sine quanon to any right Panama Lock Canal. Accepting the principle involved, the Minority and Commission set about applying it. They recognized that for this sufficient reason, as well as for others, the dam must be put no further up stream than Gatun. But they failed to carry the logic to its inevitable culminaton, and they passed without utilizing them the same capacity possibilities inherent in closing the gaps at Mindi and on the Lower Chagres. It has been mathematicaly demonstrated beyond question that to secure an ample supply of lock water for the future the summit level for the Panama Canal must begin, as was said, at either Gatun or Mindi. If locks be not put in flight, but separated, these two places are the only sites on the Atlantic where locks can be located. If the canal be made with two locks, one must be at Mindi or Gatun; if with four, one must be at Mindi, another at Gatun.

The whole lock idea has been linked from the first with this question of feed water and a dam. The problem has been dams—Where? The originator of the Gatun Lake plan, Godin de Lepinay, who conceived it, he tells us, in 1859, had a clearer realization of the true principle involved than any of the long line of engineers who, through more than half a century, succeeded him. His injunction shows the master insight, “the barrage shall be placed as close to the sea as the configuration of the land admits, perhaps at Gatun; if not, then certainly at Bohio-Soldado.” He presented this idea to the Sub-Committee of the Paris Congress, but it was not considered by the General Assembly. Attention has been called to the report of the American delegates, written in 1879 and published in Philadelphia, in which they comment upon de Lepinay’s proposal of this Gatun dam and a lake. These American engineers were present, and they entertained the idea very favorably, though announcing, notwithstanding, that there were no data whatever for passing upon its practicability. The
Advisory Board has vainly and erroneously credited their valuable terminal lake to M. Klietz—Klietz of '79. The French official report and the Sub-Committee Minutes show that M. Klietz was for a sea level, not for a lock canal at all. He presented instead a paper upon the possibility of building a sea level without a tide gate at Panama.

This dam of de Lepinay, projected first, as was seen, for Gatun, began taking on greater and greater proportions. When the 1901 borings gave the coup-de-grace to the Bohio foundations, the dam and locks then located there had to be reconsidered, and the question became where would they be best placed. The world’s commerce having by this time declared its prophecies in no questionabale figures, moving the dam up stream became impossible, so it had to go downstream to Gatun. This lockage principle has come to dominate the whole lock canal at Panama. If there cannot be a dam and lock at Gatun or Mindi, there cannot be at Panama a lock canal adequate to the commercial needs of America and of the world. The oceans are not supplying reservoirs for the lock types. Rainfall is the source, and the watersheds in the territory supply the feed. Locks must be set where the drainage of a sufficient area above them secures an adequate supply. All these facts are emphasized because the immeasurable importance to the 85-foot design of the mammoth Gatun Dam must be clearly and forcibly impressed. It is the very heart of this whole high-level project.

Another natural question is, Why is the Gatun Dam so colossal? It is colossal because the level of the canal has been set at the great height of 85 feet. A dam which is to hold back a lake 85 feet deep must be huge at best, and it must be, at Gatun, extraordinarily huge, because, in the first place, the gap to be closed is wide; and, in the second place, there are not rock foundations. So the structure, being of "earth" type, must be of vast proportions.

Now, if any one asks the further question, Why was the level set at this great height of 85 ft.? It must be confessed frankly that this is the conundrum. Engineers are asking, more and more concernedly, Why? The high level entails so much and hazards so much, and to what good?

The Panama Canal is being built for the service of ships; navigation itself is therefore the best gauge for heights and depths. Ships are to-day permitted a draft of some 38 ft. As vessels go, therefore, a 60-ft. or a 50-ft. lake would meet
the needs of commerce as amply as the 85-ft. lake. The sav-
ing of excavation in the Culebra is not at all sufficient to off-
set its higher dam and its extra locks. The 85-ft. lake com-
pels a dam 135 ft. high. It also has demanded six locks,
three on each slope, to gain the summit. Sites for locks be-
ing limited, three were set together in a flight at Gatun, and
a most dangerous feature was introduced. So the source of
the engineering perplexities and menaces, as well as of the
great money deficits, lies in the fundamental and most de-
plorable selection of an arbitrary 85-ft. level, rather than
one at a low plane of 60 or even 30 ft.

Profiles.—Some surveys and borings on the dam site were
ordered and were made in the summer and fall of 1905. These
are before us in the Report of the Minority, and the Senate
testimony of March, 1906. The map is Plate XI of the re-
port, the profile of borings is Plate XII. The original map
prepared by the engineer who directed the borings and who
signed the profile bears record November 3, 1905. The origi-
nal blue print was subsequently lithographed by order of the
Senate Committee. A comparison of it with that issued by
the Minority and the Commission discloses two facts:

The first, of minor importance and of but suggestive in-
terest, is that the scale was changed so that the two sub-
terranean gorges under the projected Gatun Dam looked less
formidable to the lay mind. The second is that all data re-
leting to the artesian flow from seven out of the only eight
borings, in these two gorges were omitted. The information
is fully given on the profile which is signed by the division
engineer, but it is lacking in the profile which the Minority
causd to be made from this identical blue print, and which
they incorporated in their report. The Senate Committee
finally demanded and got the original. The profile in ques-
tion is verified from the record:

Senator Morgan—“I suggest that it is very necessary to
have copies of this blue print made for the use of the Com-
mittee and the Senate (referring to blue print profile, the
original from which this plate twelve was prepared). It is
the most important document in the whole case.”

The Chairman—“Very well.”

Senator Kittredge—“I agree with you, Senator, about
that.”

The Chairman—“That seems to be the only copy that
they have.”

Senator Kittredge—“They sent us what purported to be a
copy, but it was not.”
Senator Morgan—"It is a very precious thing if that is the only copy that they have got, and it should be done at once. I hope that the Committee will pass an order that the Chairman be requested to apply for permission to have it printed."

The Chairman—"If there is no objection it will be done."

This one and only "blue print," "the most important document in the whole case," is here considered.

The borings shown in the Report Plates XI. and XII., and the additional story disclosed in the borings of the "blue print," with the field records, will be analyzed together.

Part of the facts in the case appear to have been casually considered by two of the "Majority" members. There were meager allusions before the Senate Committee. But these engineers seem to have gotten the impression that, while there were some under strata that were water-bearing, this was the worst that could be said of the situation. It was referred to from this relatively harmless viewpoint alone.

The import and the tremendous, far-reaching bearing of the facts seem to be quite unrealized. The conditions will be reviewed as untechnically as possible and the conclusions adduced. Since all deductions are based upon the data, these must be detailed at some length. The factors and local conditions must be set forth before any conclusions can be drawn.

Contrary to the general belief entertained, few borings under the actual dam site have been made since November 3, 1905, when the Division Engineer's Map was recorded (that is for the fourteen and a half months to January, 1907), except in Spillway Hill, a knoll of some fifteen acres in area, midway between the locks and the west abutment of the dam.

Thirty-seven borings in all were made on a preliminary axis for the dam, of which one, being probably defective, has not been counted. Thirty-six is the number given between the locks and the western hill, in the annual report of 1906. Of these there were but three in the whole area of Spillway Hill. Not one of the thirty-six had been driven on the actual site of the paper location for the vast concrete works of the spillway. These constructions were vital ones, since they were to control the lake level and the whole Chagres flood, and they were speculative entirely.

The Spillway was estimated to cost $2,608,000. Its great concrete works were to contain 189,000 cubic yards of masonry, and the figures were $1,512,000.
THE GATUN DAM.

The borings on which a work to cost over two and a half millions was vouched were located as follows:

One bore is 150 feet north of the north end of the concrete apron. Two are respectively 275 and 300 feet away outside of the north toe of the apron. There were no others reported in the hill, so the Minority and Commission estimates were the sheekest guesswork, as the thirty-odd holes now reported were made long after.

The record of these borings went to the Senate Committee January, 1907, in response to a request for the year's tally of underground explorations.

In Spillway Hill no borings were given between a line connecting stations 40 plus 50 and 47 plus 90 and the south toe of the spillway—a distance of 740 ft.—nor for some 700 ft. south of this line. This was a most crucial area of fourteen acres, which was to be dug out and filled with concrete and mechanism. The Minority conjectured that its excavation involved 1,100,000 cubic yards of earth and 480,000 cubic yards of indurated clay. Self-evidently they had no warrant of ascertained facts. Now the thirty-six bores in Spillway Hill are reported satisfactory.

Gatun Dam Borings.—We turn to the 36 or 37 bores, on the showing of which the mammoth Gatun Dam was located in 1905 by the members of the Minority, was accepted by the Commission, the Chief Engineer and the Secretary of War, and was assured to the public as safe and certain of construction and of stability. All the other holes, save four of the “sixty-three” bores last reported to the Senate Committee, are outside the limits of the main dam shown on Plate XI. Some are over half a mile distant.

It will be recognized readily that in a great construction like the Gatun Dam the mass, volume, weight and pressure are greatest under its highest point—that is, under the crest. This dam is at its crest 135 ft. high. It slopes, first rapidly, then gradually, away down stream for half a mile, where its base merges into the valley. Its most crucial problems therefore are represented in the belt directly under its crest, not in other belts. An examination of the map will show that the tentative axis is distant from the crest line in the center quite 442 ft. The preliminary or tentative axis on which most of the boring has been done is different from the axis of the finally located crest. The relation of this preliminary axis to the axis of the crest is well illustrated by a bow and
its string. The curved bow is the tentative axis and line of borings; the string marks the crest axis.

First, as to where the borings are and where they are not. The total length of the dam structure exclusive of the lock site is 8,640 ft. On the entire dam site east of the locks, a distance of 940 ft., no borings whatever were made. On the first 1,025 ft. west of the locks no borings whatever were made.

The total distance eastward from the locks before a boring is struck on the crest axis is 2,295 feet, or over two-fifths of a mile. On Gatun Island there are five bores, reaching to the bottom of the east geologic Gorge.

At Station 19 plus 15 indurated clay is struck at 205 ft., and at Station 27 plus 30 indurated clay is struck at 187 ft. below sea level. The bottom width of the Gorge is about 815 ft. Four of its holes reached to the indurated clay, one did not.

Station bore 22 plus 40 did not reach indurated clay nor did 26 plus 85. Both of the last two holes are north of the dam crest about 260 feet.

Of the thirty-seven bores presented on Plates XI. and XII. and the Blue Print, there reached clay rock and stopped, 5; reached clay rock and penetrated a few feet, 30; did not find rock, 2.

From Station 23 plus 27 to 77 plus 50, and for about 5,400 ft., or over a mile, along the crest axis, there were no borings.

From hole 77 plus 50 to the west abutment, northwest a distance of 1,000 feet, there was not a single boring. The nearest is at station 80 with indurated clay at 75 ft. above ocean level and 200 feet away from the crest, another is at Station 82 plus 50, which is 300 feet distant. The bores at Stations 85, 87 plus 50; 90, 92 plus 50 and 94 are from 500 to 1,100 ft. distant from the crest—away to the southward. From Stations 61 to 77 plus 40, a distance of 1,650 ft., there are seven holes, on a line about 200 ft. north of the axis of the crest.

There are actually in 8,640 ft. under the located crest of this massive structure only three borings. Two are in one place and one is at another, over a mile away. Next, near the two mentioned above, there are two other borings on the slope of the crest, and there are no further holes anywhere within two hundred feet of the crest axis.

South Foot of Dam.—There is but one boring along the
LOCK CANAL PROJECT, VICINITY OF GATUN, SHOWING LOCATION OF PROPOSED DAM AND LOCKS.