PDHonline Course C637 (8 PDH)

The Panama Canal: A Land Divided, A World United

Instructor: Jeffrey Syken

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
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The Panama Canal

A Land Divided, A World United

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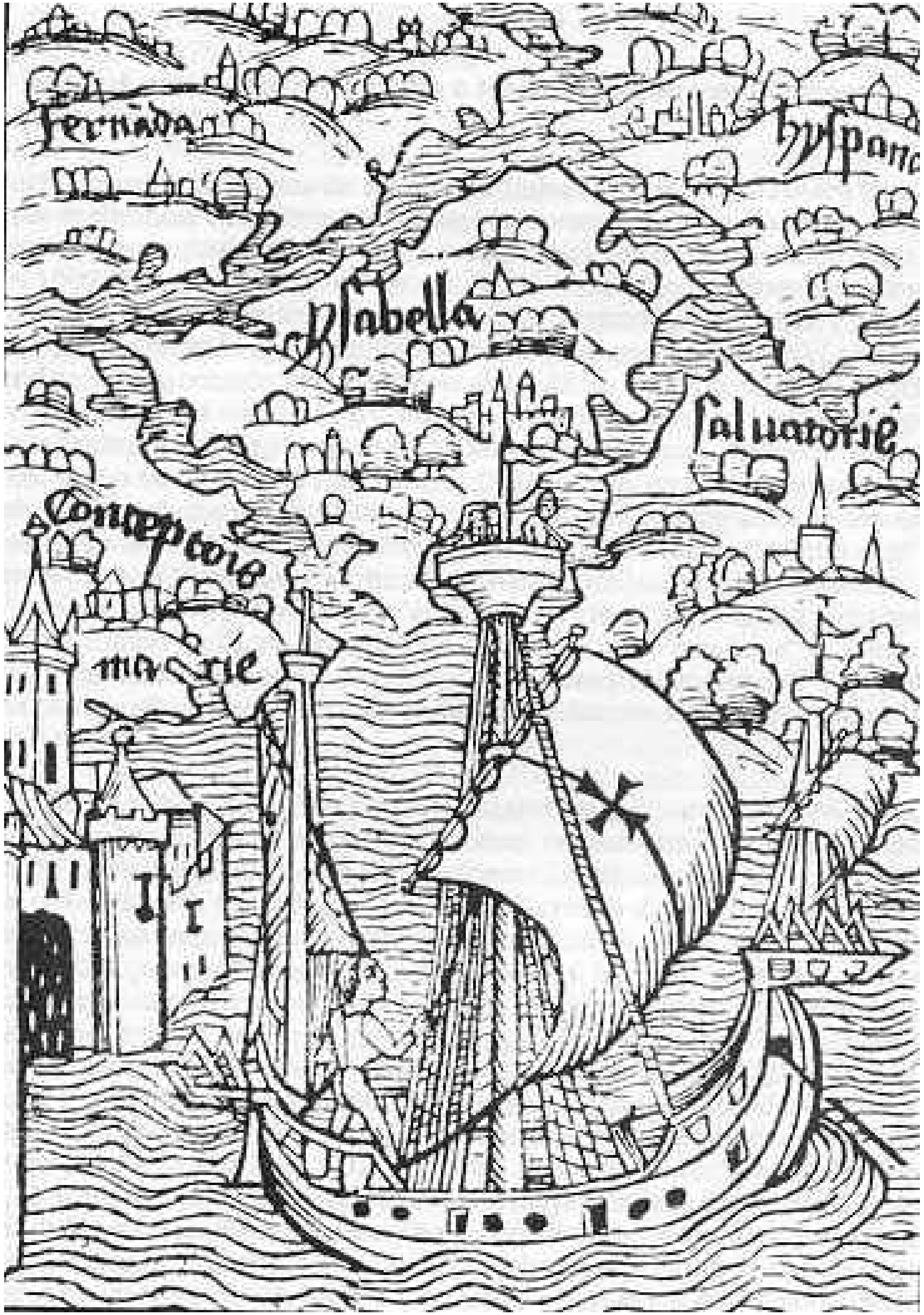
Part 1

A Place of Many Fishes



In 1494 – two years after he set out for the *East-Indies* by sailing westward, master mariner and navigator *Cristobol Colon* (a.k.a. *Christopher Columbus*), in service to the Spanish crown, announced his discovery of a "New World." His four voyages (1492–1493, 1493–1496, 1498–1500 and 1502–1504) would open the way for European exploration, exploitation, and colonization.

"…On September 25, 1513, Vasco Nunez de Balboa climbed the peaks of the Continental Divide and discovered the Pacific Ocean, which he named 'The South Sea…'"

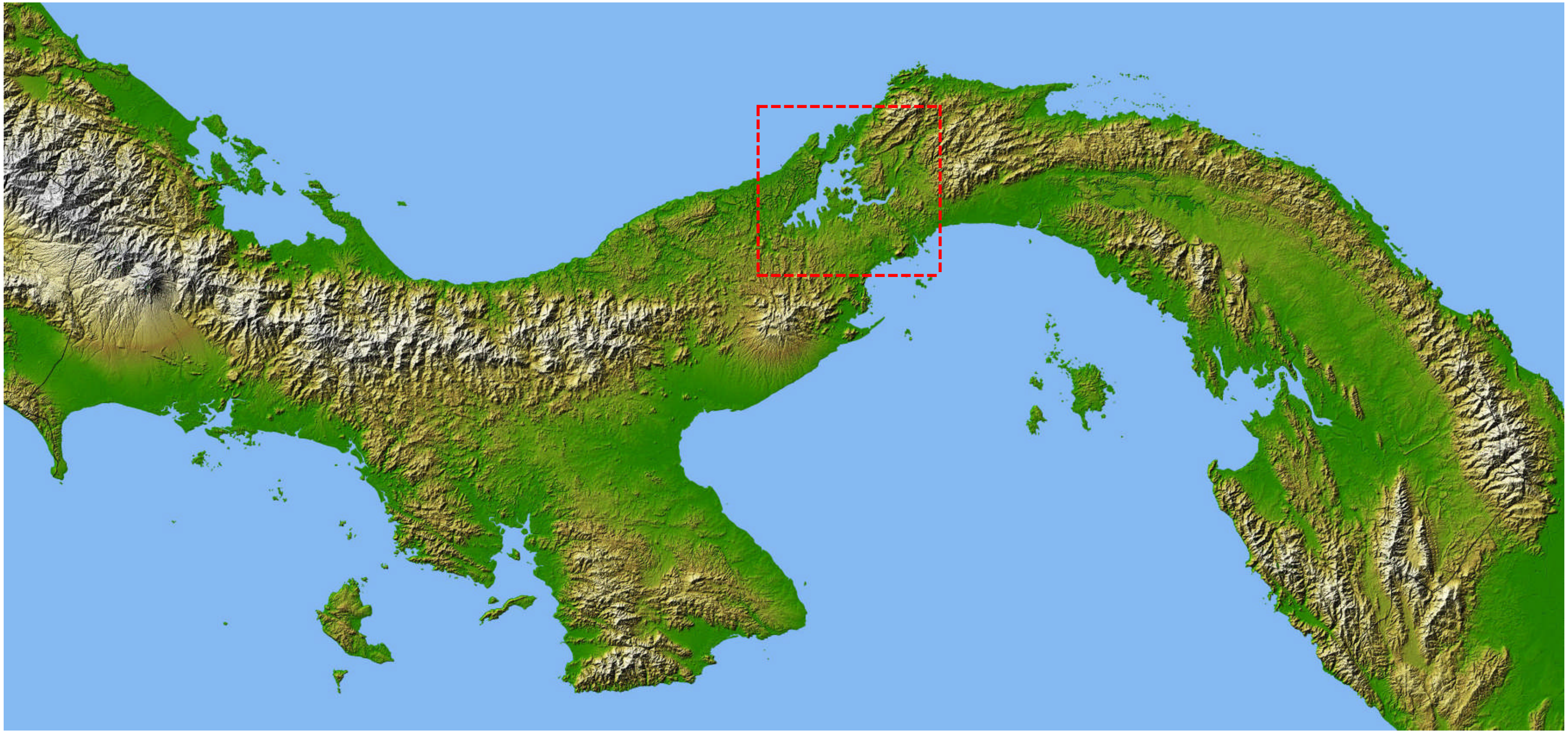
Popular Mechanics, **Dec. 1913**

RE: the idea of digging a water passage across the *Isthmus of Panama* to connect the *Atlantic* and *Pacific Ocean/s* emerged in the early 16th century, when *Vasco Nunez de Balboa* crossed the Isthmus in 1513. Balboa discovered that only a narrow strip of land separated the two oceans. The *Emperor Charles V* of the *Holy Roman Empire* (who was also *Carlos I of Spain*), began a movement to build a passage through the Isthmus.

Left: Vasco Nunez de Balboa

“…From where Balboa stood his new ocean lay directly south, because of the S-shaped twist of the Isthmus…When Balboa’s report of his discovery reached Spain, it was accompanied by the recommendation that a canal be immediately dug across the Isthmus. What the explorer had in mind was a sea-level canal, for although Leonardo Da Vinci, the great Italian painter-engineer, had recently invented the hydraulic lock now generally used for lifting vessels over elevations, it had not become widely known. However, alluring as it seemed, the canal project was dismissed. According to some historians its rejection was due mainly to the influence of the church. To the simple faith of that day it appeared clear that if God had intended the waters to flow across the Isthmus, he would have created a channel there…”

Popular Mechanics, **December 1913**

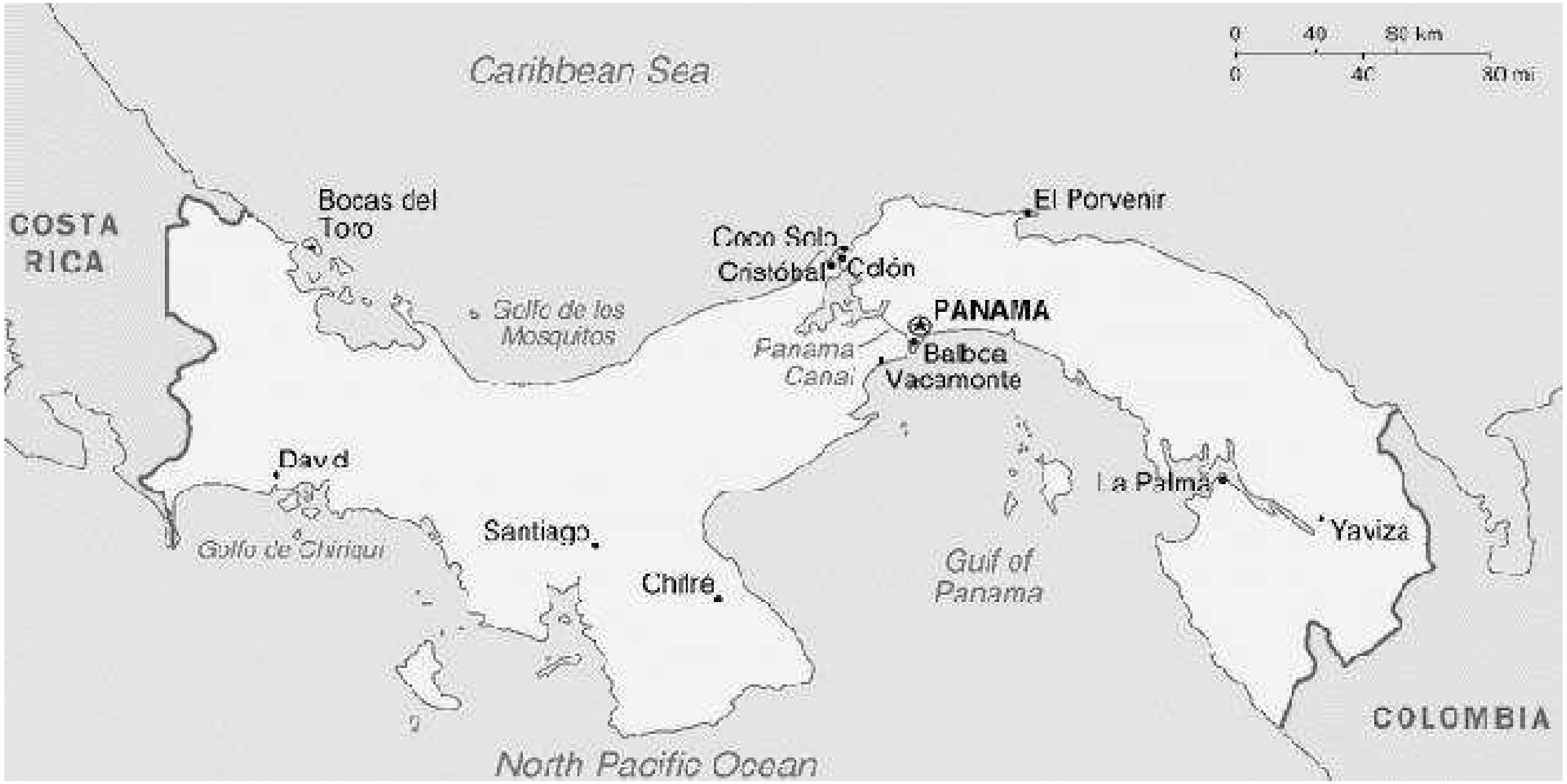


<u>Above</u>: the *Isthmus of Panama*. Only fifty-miles wide at its narrowest point, it's characterized by its mountains, impenetrable jungle, deep swamps, torrential rain, hot sun, debilitating humidity, pestilence and some of the world's most complex geological formations. Most of this was apparent to early explorers and surveyors. What wasn't obvious was the geology of the earth itself which even today remains a constant challenge. The eastern portion of the land is dense tropical jungle while the western part is mountainous and consists of coastal plateaus, very similar to the kind of terrain found in northwestern *Spain* from where the early settlers to *Panama* came from. The word "Panama" means "a place of many fishes" in the native Indian language.

The Istmus' low green mountains rising up behind coral shores look benign and inviting. However, unlike most mountain ranges, instead of being formed by folding due to lateral pressure, these mountains were formed by the upward thrust of individual volcanic actions. Independent formations of different types of hard rock are interspersed and layered between softer rocks and materials in a disorderly and unpredictable patchwork of strata and angles. The Isthmus has also been subjected to several periods of submersion beneath the sea, thus adding cavities of marine materials to the geological mix. This, in addition to there being six major faults and five major volcanic cores in just the short distance between *Colon* and *Panama City,* adds to the area's geological challenges.

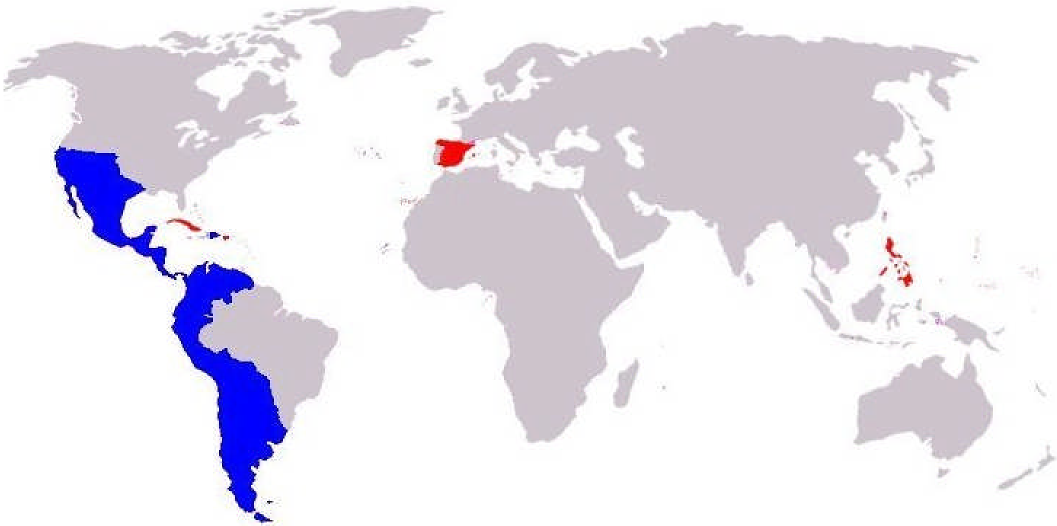
“Although nearly the entire country, from its headwaters to Alhajuela, is clothed with vegetation, much of which is dense, the slopes are so precipitous, and the rock lies so near to the surface, that severe tropical rain storms convert the precipitous banks of the Chagres into a series of small torrents and cascades, causing the river to rise suddenly and discharge almost inconceivable volumes of water.”

RE: excerpt from: “Climatology and Hydrology of the Panama Canal.” Panama’s tropical climate, with a temperature averaging eighty degrees and an annual rainfall of 105 inches, creates ideal conditions for jungle growth similar to that of Brazil's *Amazon* jungle. In fact, the *Panama* jungle was used as a training ground for U.S. troops during the *Vietnam War* as well as survival training for astronauts. Flooding, especially of the *Chagres River*, was another very serious problem. Because of the terrain’s precipitous slopes, the heavy rainfall gathers quickly into streamlets that flow quickly into the river, causing it to swell at a rapid rate, thus creating floods.



Above: Map of Panama
Location: Central (Middle) America, bordering both the Caribbean Sea and the North Pacific Ocean, between Colombia and Costa Rica
Area:
total: 78,200 sq km
land: 75,990 sq km
water: 2,210 sq km
Area - comparative: slightly smaller than South Carolina
Geography - note: strategic location on eastern end of isthmus forming land bridge connecting North and South America; controls Panama Canal that links North Atlantic Ocean via Caribbean Sea with North Pacific Ocean

El Camino Real



When the Spanish *Conquistadors* looted the *Incan Empire* in the 1500s, the fastest way to get their gold from *Peru* (on the *Pacific*-side) back to *Spain* was across *Panama* using the *Chagres River* part of the way. First, the Incan gold was shipped 1K-miles from Peru to Panama's Pacific coast. From there, it was transported by mules fifteen-miles across the *Continental Divide* using *El Camino Real* – "The King's Highway." At that point, the gold was then loaded onto boats which used the *Rio Chagres* to cover the remaining forty-miles to reach the *Caribbean*-side.

Left: map of the 16th Century *Spanish Empire*

Right: early Spanish bird's-eye map of the *Isthmus of Panama*

“…The Isthmus of Panama became, almost at once after its discovery, the great trade route between the oceans. The gold of Peru, brought up the west coast by vessels, was transported by mule trains north across the Isthmus to Limon Bay, where it was loaded into waiting galleons for transportation to Spain. Out of this traffic grew the first European settlement on the mainland of America, the old city of Panama founded in 1519. For more than 150 years Panama remained the chief city on the Pacific coast until its destruction in 1671 by Sir Henry Morgan, the English Buccaneer. But throughout all this period, the canal project continually came up, as traffic across the Isthmus grew…”

***Popular Mechanics,* December 1913**

Replica of the *Nao Victoria* in the *Miraflores Locks* of the *Panama Canal*. The ship recalls the first around-the-world journey by *Juan Sebastian Elcano*. The ship left the port of *Seville, Spain* in 1519 under the command of *Ferdinand Magellan* with four other ships. In 1522, only the Nao Victoria (captained by Elcano) returned with eighteen crew members.

"…It was, indeed, extremely difficult for Europeans to believe that there was not some natural channel across the Isthmus, if it could only be found. Some of the early maps of America, published in Europe, showed an imaginary 'Strait of Panama'…"

***Popular Mechanics*, December 1913**

<u>Above</u>: map of the *Pacific Ocean* and *Caribbean Sea* (ca. 1590)

The Fever Coast

“When the trade winds die out, and the hot sultry air of the Isthmus ceases to move, a white mist will sometimes rise out of the swelling ocean and hover like a fog over land and sea. The white mist is the precursor of fever and sickness, and those of the Isthmus who know remain within doors, unwilling to meet the ghost of the ocean half way. In the early days the white mist that rose from the disturbed soil of the Isthmus was far more disastrous in its killing effects than the mists of the ocean. It rose from the soil like incense from a brazier. It carried with it from its underground prison all the poison of putrefaction, and wherever it enclosed its victims, there fever and death followed...”

RE: both *Malaria* and *Yellow Fever* were endemic to the *Isthmus of Panama*. For several hundred years, outsiders who came to “The Fever Coast” - especially seamen passing through, died from diseases purportedly caused by “miasmal mists,” supposedly emanating from swamps and marshes.

By a decree issued in 1534, *Carlos* (*Charles*) *V* of *Spain* (left) ordered the regional governor of *Panama* to make plans to build a route to the *Pacific Ocean* following the *Chagres River*. This was the first study to build a canal that would allow ships to cross from one ocean to the other via Panama and its course was more or less the same as the current *Panama Canal*. By the time the survey map was finished, the governor said it would be impossible for anyone to accomplish such a feat.

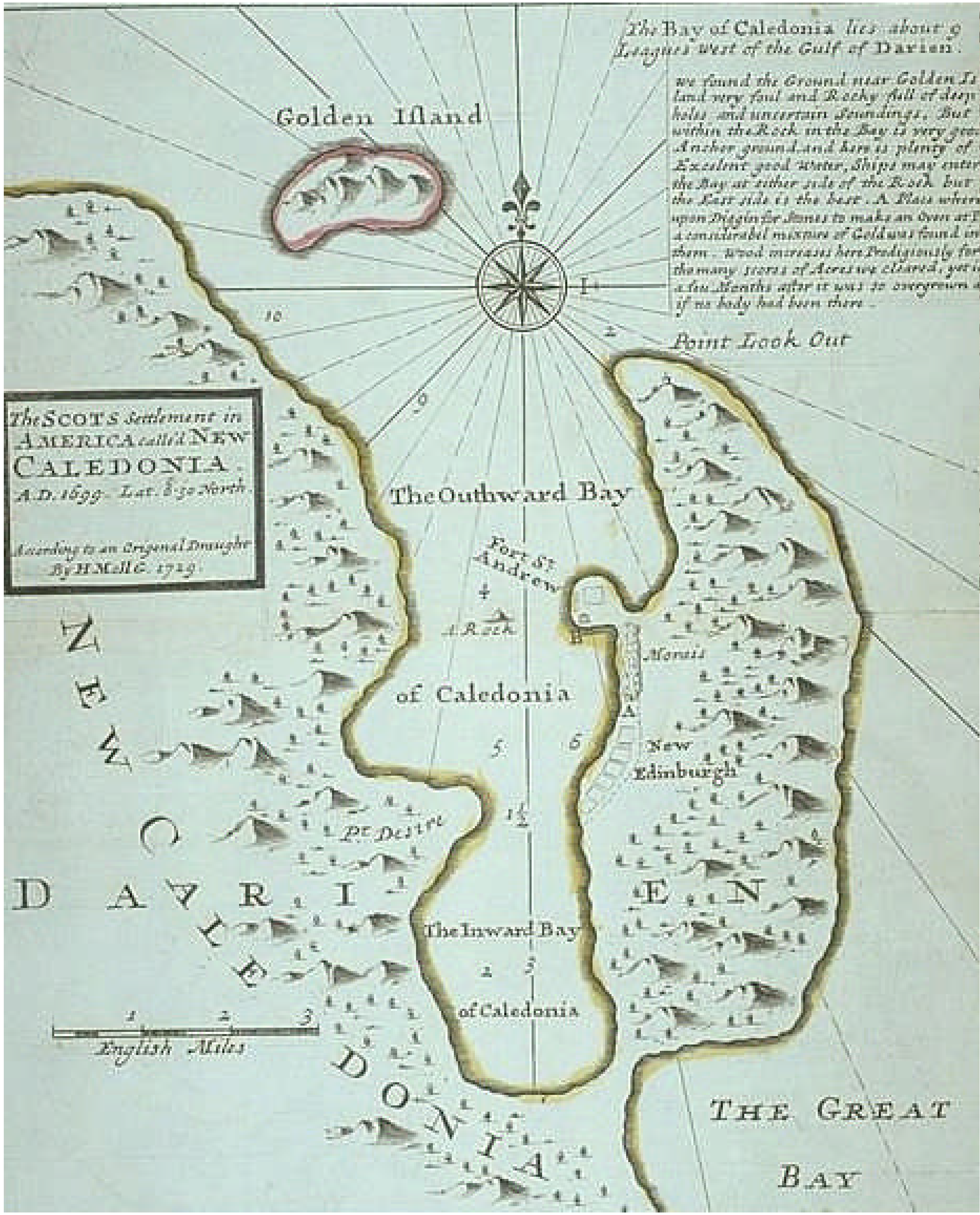
"…In 1551, the Spanish historian F.L. de Gomara, again forcibly urged the canal project in a memorial to Philip II. By this time, however, the Spanish government had concluded to devote all its energies to maintain a monopoly of communication between Europe and the New World, and the improvements of communications by land was discouraged. To seek or make known any better route from Porto Bello to Panama was forbidden under penalty of death. This served effectively to put a quietus on Panama Canal projects for nearly 150 years…"

***Popular Mechanics,* December 1913**

The Key of the Commerce of the World

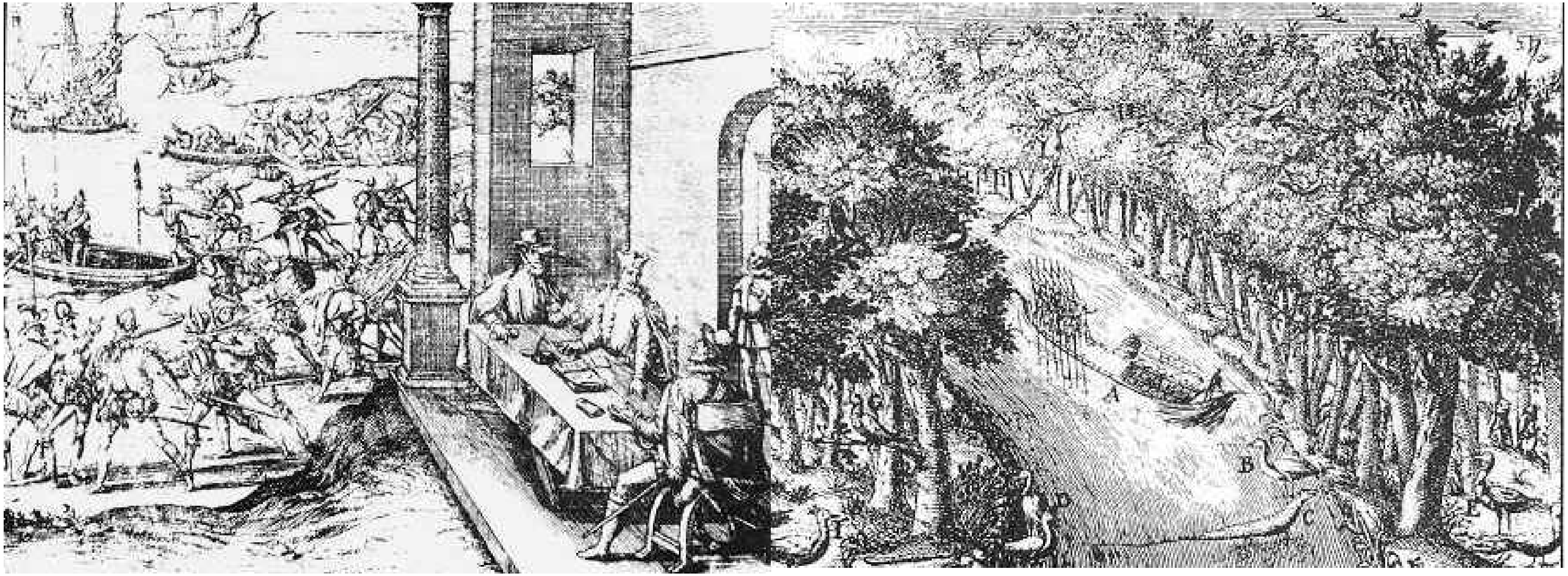
"…In 1698, William Paterson, the famous Scotchman who founded the bank of England organized 'The Company of Scotland Trading to Africa and the Indies,' for which he obtained a charter from the Scottish parliament. Paterson's project was to establish a settlement on the Isthmus of Darien, cut a canal across the Isthmus and 'thus hold the key of the commerce of the world'…On July 26, 1698, the pioneer set sail from Leith…On the fourth of November they reached Darien. Here they laid out the sites for two cities, New Edinburgh and New St. Andrews, while to the country they gave the name of New Caledonia. In less than a year, lack of provisions, illness, and anarchy had reduced the settlers to a miserable condition, and in June 1699, they re-embarked, to sail wherever the winds might take them…A year later, the Spanish expelled the last remaining handful of the Scottish settlers…"

***Popular Mechanics,* December 1913**



Above: **caption: "'A New Map of the Isthmus of Darien in America, The Bay of Panama, The Gulph of Vallona or St. Michael, with its Islands and Countries Adjacent. In a letter giving a description of the *Isthmus of Darian*, Edinburgh: 1699."**

Left: **caption: "The Bay of Caledonia, west of the Gulf of Darien"**



"…In 1771, more than 250 years after the discovery of the Isthmus, the Spanish government again changed its policy and ordered a survey for a canal at Tehuantepec. This route was reported as impractical and, in 1779, other surveys were made at Nicaragua, but political disturbances in Europe prevented further action…"

***Popular Mechanics,* December 1913**

RE: many expeditions were sent out from the maritime countries of *Europe* with many inter-oceanic plans projected, but up to the close of the *18th Century* no actual progress had been made towards the establishment of a sea-level canal between the *Atlantic* and *Pacific*. In the early *19th Century*, Prussian geographer, naturalist and explorer *Alexander von Humboldt*, who spent several years in *Central America*, suggested no fewer than nine routes for an inter-oceanic ship canal. This drew the attention of the civilized world.

Left: signing of the *Panama Contract* (1513) / Right: navigating the *Chagres River* (1735)

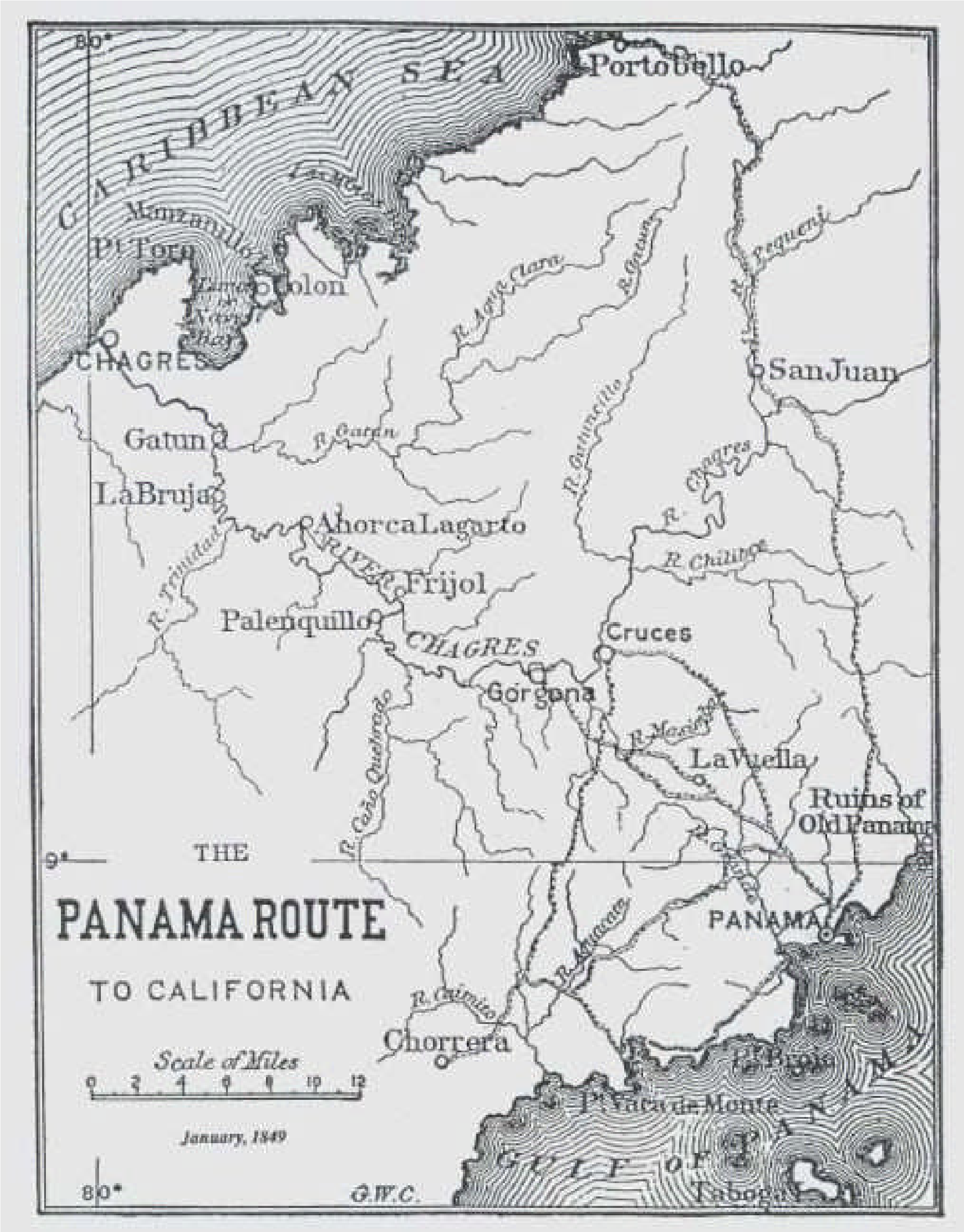
Hands Off

On December 2nd 1823, the *Monroe Doctrine* - a U.S. policy that warned any further efforts by *European* countries to colonize land or interfere with states in the *Americas* would be viewed as acts of aggression, was introduced. POTUS *James Monroe* (left) was enraged at the actions of various European countries taking place in the *Caribbean* and *Latin America*. The Monroe Doctrine asserted that the Americas were not to be further colonized by European countries. In turn, the *United States* promised it would neither interfere with existing European colonies nor meddle in the internal concerns of European countries. The Doctrine was issued at a time when many Latin American countries were on the verge of becoming independent from the *Spanish Empire*. The United *States*, reflecting concerns raised by *Great Britain*, ultimately hoped to avoid having any European power take over Spain's new world colonies. The British worked hand-in-hand with the United States in upholding the doctrine and it was the start of the "special relationship" between the two countries. The Monroe Doctrine became a defining moment in the foreign policy of the United States. It basically told the European powers that the U.S. was now in control of the waters on this side of the Atlantic, whether they liked it or not.

In 1835, the *United States* first became interested in an inter-oceanic canal, though not necessarily at *Panama*. *Henry Clay* introduced a resolution in the *U.S. Senate*, but the financial panic of 1837 effectively stopped any action being taken. In 1838, a concession was granted to a French company for the construction of highways, railroads or a canal across the Isthmus, but the concession lapsed for lack of capital. The first reliable survey of a route for a waterway in Isthmian territory was made at *Nicaragua* in the 1840s by Colonel Childs of the *Atlantic & Pacific Company*. Enterprising Americans and Europeans had long fixed their eyes upon the possibilities of a canal across the Isthmus and soon after Colonel Childs' survey was completed, the governments of *Great Britain*, *France* and the *United States* grew interested in the active explorations made by private individuals and companies. The discovery of gold in *California* (1848) created a tremendous volume of trans-Isthmian business thus heightening American interest in a canal.

Gold Fever

In the early days of the *Gold Rush*, when word of the wealth to be found in the ground reached the *East Coast*, thousands of men dreamed of striking it rich. The fastest way to the gold fields was through *Panama*. Ships dropped the fortune-seekers off in *Colon* on the *Caribbean*-side. Then, they took small boats via the *Chagres River* all the way to the *Continental Divide*. They then walked a mule path the final ten miles to *Panama City* to await the next ship to *San Francisco*. There was one problem; there were no ships waiting for them on the *Pacific*-side. It turned out that many crewmen deserted their ships as soon as they reached San Francisco; no one in San Francisco wanted to man the ships. Just like everyone else, they wanted to strike it rich in the gold fields of *California*. As a result, one ship after another entered the harbor, but didn't leave. At one point, the San Francisco harbor was seven deep in abandoned ships. Until a ships' captain could find sailors to work for him, they would remain there like ghost ships. Many of the prospectors discovered it wasn't going to be as easy as they had believed and, full of disappointment, they returned to San Francisco and men began to hire on ships. The heyday of the *Chagres River* ended when the *Panama Railroad* was completed in 1855. Then, the first *Transcontinental Railroad* was completed in 1869. Henceforth, trains would carry both passengers and/or gold.



<u>Above</u>: caption: "The old Las Cruces Panama Trail, 1914"
<u>Left</u>: "The Panama Route to California"


CANAL ZONE
Up the Chagres River
to Las Cruces
6
CENTS
POSTAGE
1849 GOLD RUSH CENTENNIAL 1949

The Panama Railroad

"…The discovery of gold in California, in 1848, was followed by a tremendous volume of traffic between the Atlantic and Pacific coasts and for 15 years practically all of this traffic was by way of the Isthmus, over the Panama Railroad, opened in 1855 by Americans under a concession from the republic of New Granada, now known as Columbia. The explorations and surveys for the railroad, a work that is said to have cost the life of a man for every tie, led to a much more accurate knowledge of the topography and geology of the Isthmus than had previously been available…"

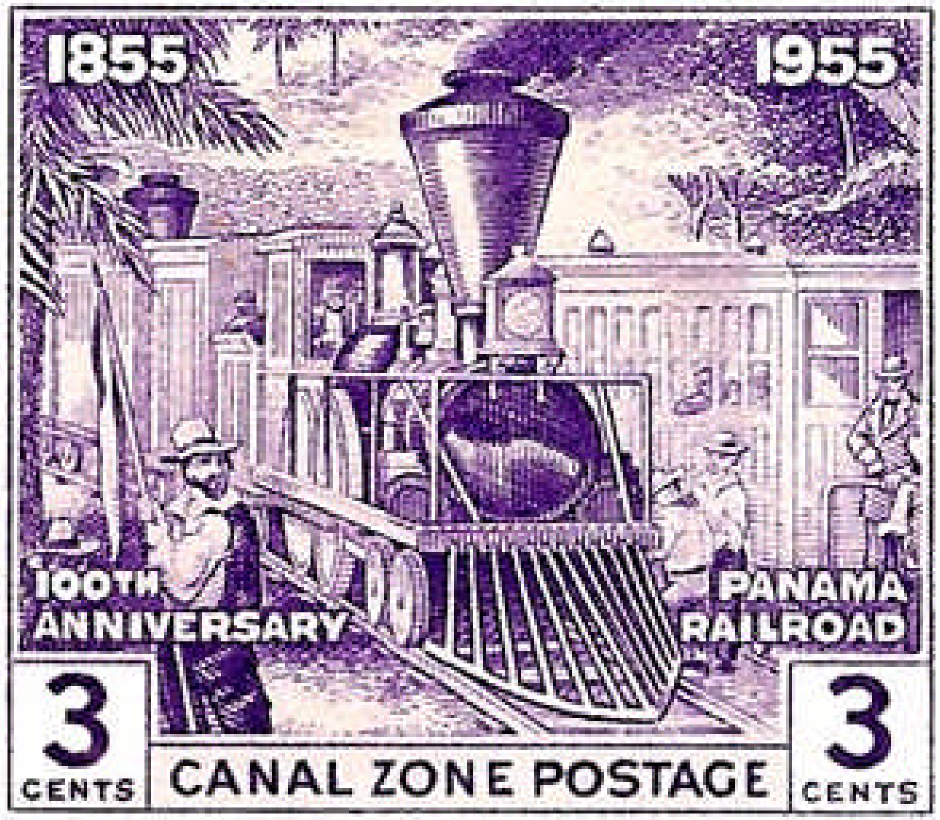
Popular Mechanics, **December 1913**

With the railroad connection between oceans firmly established and financially successful, the idea of canal construction was relegated to the background. Besides, the French company's concession gave it control of the *Panama* route for a canal. In the meantime, a small army of promoters suggested nineteen different routes for a canal, of which the *Nicaragua* canal route remained Panama's greatest rival.

“The horrors of the road in the rainy season are beyond description”

Ulysses S. Grant

RE: in 1869, *Ulysses S. Grant* was inaugurated as the eighteenth POTUS. This brought new impetus to U.S. canal policy. Grant’s personal interest went back to July 1852 when, as a *U.S. Army* captain, he led the *Fourth Infantry* across the *Isthmus of Panama* en-route to garrison duty in *California*. The military detachment of several hundred men, together with their dependents, became victims of a raging *Cholera* epidemic in *Panama* that claimed the lives of one-hundred and fifty men, women and children.


1855
1955
100TH ANNIVERSARY
PANAMA RAILROAD
3 CENTS
CANAL ZONE POSTAGE
3 CENTS

The Interoceanic Canal Commission

In 1869, President Grant ordered survey expeditions to *Central America*. The expeditions were organized by *Navigation Bureau* Chief Commodore *Daniel Ammen* and were under the command of the *Secretary of the Navy*. Surveys were conducted in *Tehuantepec* (*Mexico*), in the *Darien-Atrato* (Mexico), in *Nicaragua* and in *Panama* (along the railroad line). The fine quality of these surveys is still recognized today. Interestingly, the route of the current *Panama Canal* is nearly identical to that proposed by the 1869 Panama survey. An *Interoceanic Canal Commission* was appointed by President Grant to evaluate the findings resulting from these Navy expeditions that took place between 1870 and 1875. A report was prepared by the commission and, following due consideration, in 1876 the commission came out in favor of the Nicaragua route.

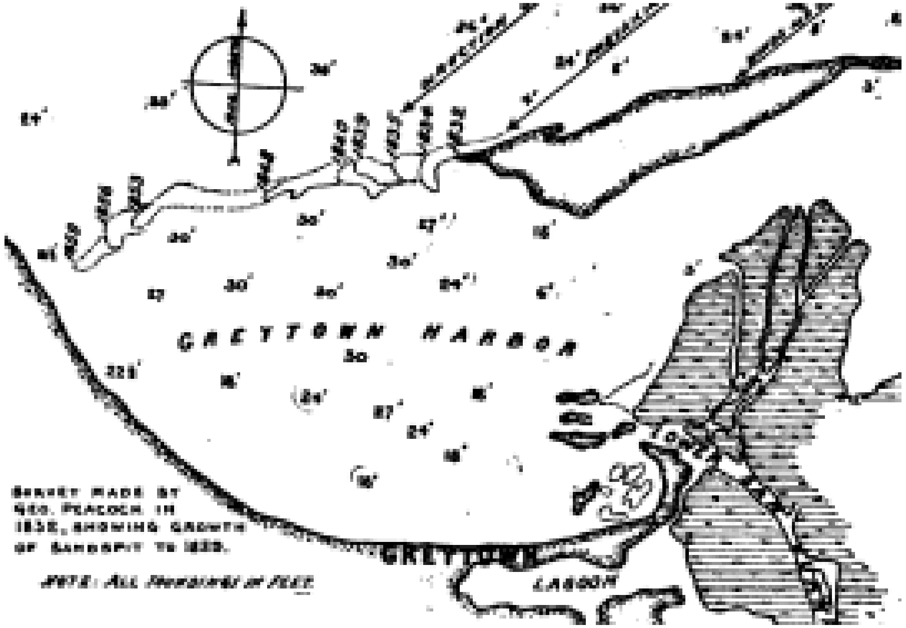
"…in May 1876, the Republic of Columbia granted a concession for the construction of a canal from Colon to Panama, the terminals of the Panama Railroad, to Lieut. Lucien Napoleon Bonaparte Wyse, an officer of the French army…"

***Popular Mechanics,* December 1913**

The Nicaragua Route

"…The Nicaragua route attracted the attention of explorers in the early days of inter-oceanic canal discussion, and was regarded by many as a most favorable one. Water communication by means of a large river and lake from the Atlantic to within a short distance of the Pacific accentuates the natural advantages of this route and at the same time tends to exaggerate them and to obscure the attendant difficulties. Lake Nicaragua is about 103 miles long. It has a maximum width of about 45 miles and an area of about 3,600 square miles. It is fairly regular in outline, with its longer axis nearly parallel to the Pacific coast., which in this vicinity has a northwesterly direction. It resembles Lake Erie somewhat in shape…the bottom of the lake is about sea-level over the greater part of its area, a comparatively small depression being below that level. The maximum depth is about 200 feet…The surface of Lake Nicaragua is generally a little more than 100 feet above sea level…"

Scientific American Supplement, **January 18th 1902**



"The San Juan River, through which the river discharges at Fort San Carlos, follows a torturous course in a southeasterly direction and empties through several mouths into the Caribbean Sea at Greytown. The distance from the lake outlet to the mouth of the river is about 80 miles in an air line, but about 120 miles following the windings of the river…The Indio, which empties into the Caribbean Sea some six miles northwest of Greytown, runs generally parallel to the San Juan…The largest and most important tributary to the San Juan is the San Carlos. It rises in the mountains of Costa Rica, flows northeasterly and empties into the San Juan about 57 miles from the lake…"

Scientific American Supplement, **January 18th 1902**

Left: caption: "Greytown Harbor in 1832"

Right: caption: "The confluence of the San Carlos (left) and San Juan (right) Rivers"

Part 2

The French Era

The Wyse Concession

In 1876, The *Geographical Society of Paris* organized a committee to seek international cooperation for studies to fill in gaps in the geographical knowledge of the Central American area for the purpose of building an inter-oceanic canal. The committee, a limited company; *La Societe Civile Internationale du Canal Interoceanique de Darien*, was headed by *Ferdinand de Lesseps*. Exploration of the Isthmus was assigned to French Navy Lieutenant *Lucien N. B. Wyse*, a grandson of *Lucien Bonaparte*. After exploring several routes in the *Darien-Atrato* regions, Wyse returned to *Paris* in April 1877. De Lesseps rejected all of these plans because they contained the construction of tunnels and/or locks. On a second Isthmian exploratory visit beginning December 6th 1877, Wyse explored two routes in *Panama*; the *San Blas* route and a route from *Limon Bay* to *Panama City,* the current canal route. In selecting the latter, his plan was to construct a sea-level canal. The route would closely parallel the *Panama Railroad* and require a 7,720-meter long tunnel through the *Continental Divide* at *Culebra*. With this canal plan, Wyse traveled to *Bogota* where, in the name of the society, he negotiated a treaty with the Colombian government. The treaty, signed on March 20th 1878, became known as the *Wyse Concession*. It granted exclusive right to the Societe Civile to build an inter-oceanic canal through Panama. As a provision of the treaty, the waterway would revert to the Colombian government after 99 years without compensation.

The Year of the French

A congress: the *Congres International d'Etudes du Canal Interoceanique* ("International Congress for Study of an Interoceanic Canal") was planned to take place in *Paris* on May 15th 1879, with invitations sent out by the *Societe de Geographie* (Geographical Society) of Paris. Critics claimed that a principal purpose of the Congress was to give needed legitimacy to the *Wyse Concession*, legitimacy greatly needed (as recognized by de Lesseps) to bring in financial backing. The purpose of the Congress was not to approve a route or a plan - that decision had already been made by de Lesseps, but to give that decision and the already negotiated Wyse Concession a public introduction and ceremonial sendoff. It also served to provide the appearance of impartial international scientific approval. Fourteen proposals for sea-level canals at *Panama* were presented before the Congress, including the de Lesseps plan. A subcommittee reduced the choices to two; *Nicaragua* and Panama.

Left: memorial to *Lucien Bonaparte Wyse*

At the Congress, engineers and others offered differing opinions concerning the various plans. One such engineer was Baron *Godin de Lepinay*, Chief engineer for the French *Department of Bridges and Highways*. Lepinay was well known for his intelligence and he was the only one among the French delegation with any construction experience in the tropics (1862 construction in *Mexico* of a railroad between *Cordoba* and *Veracruz*). At the Congress, he made a forceful presentation in favor of a lock canal. The de Lépinay plan included building dams; one across the *Chagres River* near its mouth on the *Atlantic* and another on the *Rio Grande,* near the *Pacific*. The approximately eighty-foot height of the artificial lake thus created would be accessed by locks. The principal advantages of the plan would be the reduction in the amount of digging that would have to be done and the elimination of flood danger from the Chagres. Estimated construction time was six years. Since this plan required less digging, there would be, according to prevailing theories that tropical diseases were caused by some sort of toxic emanations coming from freshly dug earth being exposed to the air, fewer problems. Propheticlly, the de Lepinay design contained all of the basic elements ultimately designed into the current *Panama Canal*. The French company would use these concepts as a basis for the lock canal they would eventually adopt in 1887 following the failure of their sea-level attempt. Had this plan been originally approved, *France* might well have prevailed in their canal construction effort. Had it been adopted at the beginning - in 1879, the Panama Canal might well have been completed by the French instead of by the *United States*. As it was, the de Lepinay design received no serious attention at the *Paris* Congress.

The American delegation's *Nicaragua* plan was introduced by *Aniceto Garcia Menocal*. Cuban by birth, Menocal was a civilian engineer assigned to the Grant surveys in *Nicaragua* and *Panama* by Admiral Ammen. The well organized and persuasive presentation by the Americans very nearly upset de Lesseps' carefully orchestrated plans. De Lesseps thought a week enough time to gain consensus and wrap up the details. With things now threatening to get out of hand, on Friday, May 23rd 1879, de Lesseps convened a general session. Striding confidently in front of a large map, a relaxed de Lesseps addressed the Congress for the first time. The hero of *Suez* spoke spontaneously in simple, direct language and with great conviction making everything sound right and reasonable. The map, which he referred to with easy familiarity, clearly showed that the one best route was through Panama. It was the route that had already been selected to develop Panama's trans-Isthmus railroad. There was no question that a sea-level canal was the correct type of canal to build and no question at all that Panama was the best and only place to build it. Any problems – and, of course, there would be some - would resolve themselves, as they had at Suez. His audience was enthralled.

“The Congress believes that the excavation of an inter-oceanic canal at sea-level, so desirable in the interests of commerce and navigation, is feasible; and that, in order to take advantage of the indispensable facilities for access and operation which a channel of this kind must offer above all, this canal should extend from the Gulf of Limon to the Bay of Panama.”

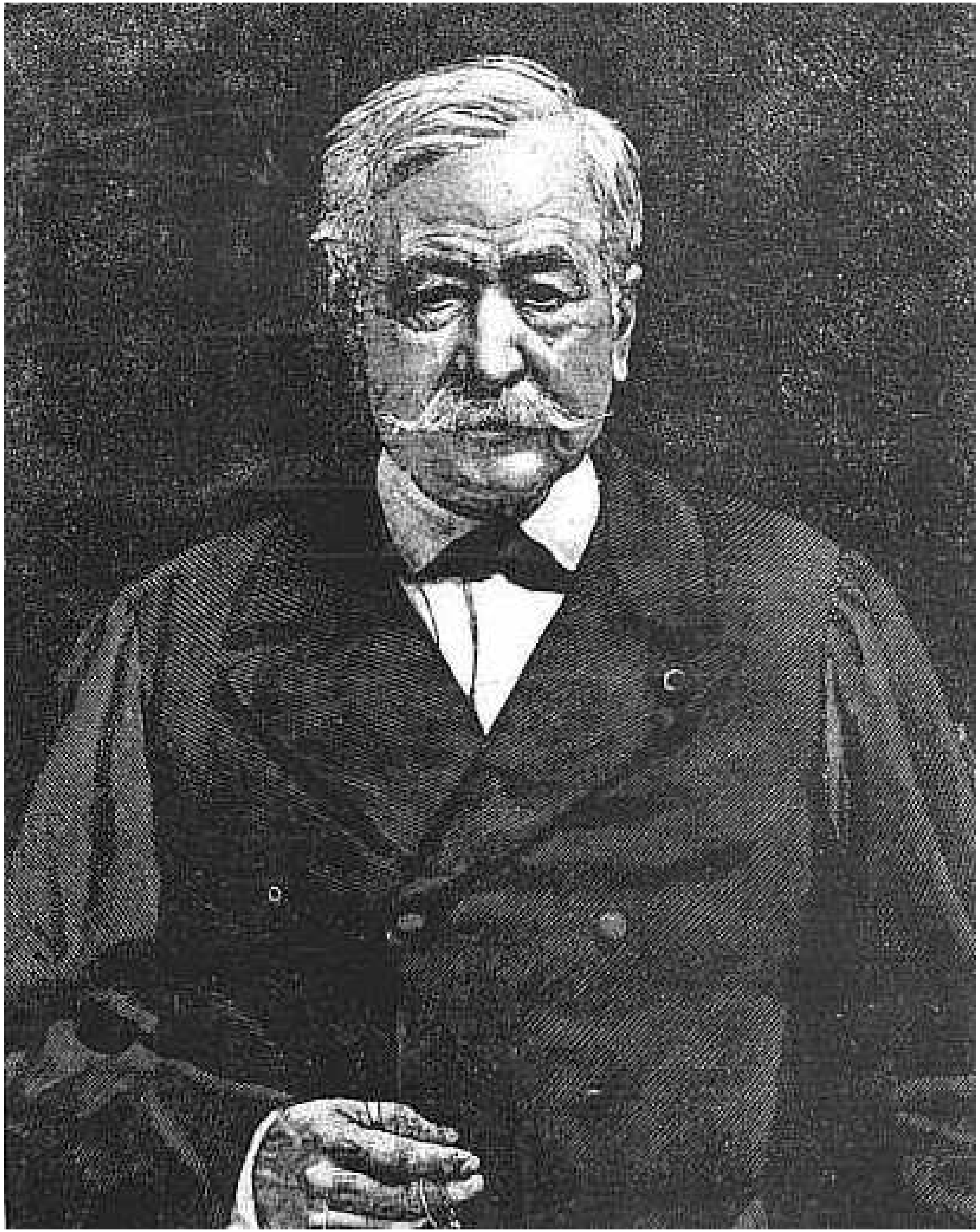
Congres International d’Etudes du Canal Interoceanique **(Technical Committee resolution)**

RE: following de Lesseps’ speech, everything fell into place for the de Lesseps camp and the building of a sea-level canal through *Panama* was the recommendation of the *Technical Committee*. The resolution passed with seventy-four in favor and eight opposed. The “no” votes included de Lepinay and *Alexandre Gustave Eiffel*. Thirty-eight committee members were absent and sixteen, including Ammen and Menocal, abstained. The predominantly French “yea” votes did not include any of the five delegates from the *French Society of Engineers*. Of the seventy-four voting in favor, only nineteen were engineers and of those, only one; *Pedro Sosa* of Panama, had ever been in *Central America*.

The Canal Builder

“Vicomte Ferdinand De Lesseps is certainly the personification of indomitable energy and perseverance. Not content with having successfully canalized one Isthmus in the face of every possible obstacle, geographical, political, and financial, he has now, in his seventy-sixth year, undertaken to execute a similar work across the Atlantic, which is perhaps arousing a fiercer opposition than did his scheme to pierce the Isthmus of Suez…M. de Lesseps, when, more than a half century since, he was Consul in Central America, conceived the idea of uniting the Atlantic and Pacific Oceans through the Isthmus of Panama, more especially as at that time Humboldt was warmly advocating such an undertaking. It was curious also that when subsequently, in 1831, M. de Lesseps went to Alexandria as Consul General, he should find the idea of a canal across the Isthmus of Suez a fertile topic of discussion. As Egypt was nearer home than Panama, he turned his attention to the Old World first; but it was not until 1834 that his enterprise received the official sanction of Mehemet Said, with whom he was on intimate terms…”

***Scientific American Supplement,* March 5th 1881**

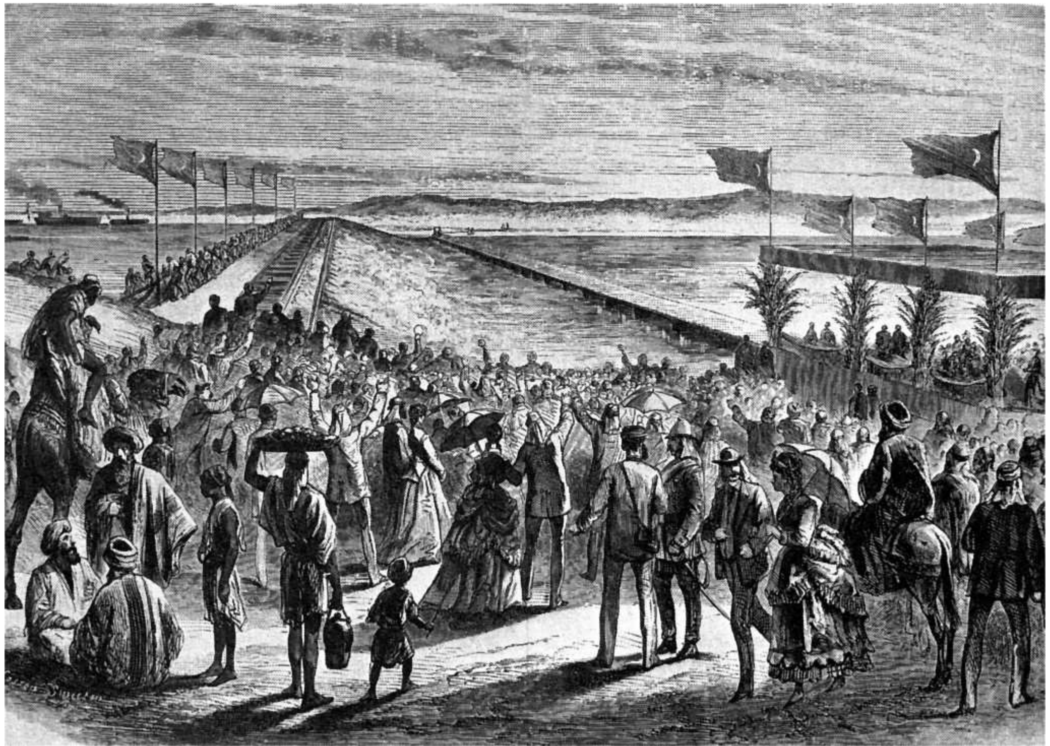


Ferdinand de Lesseps **was born on November 19th 1805 in** ***Versailles, France*****. His Family was long distinguished in the French diplomatic service and at age nineteen, having studied law, he was appointed counsel to his uncle in** ***Lisbon*** **who was then the French ambassador to** ***Portugal*****. He served in** ***Tunis, Tunisia*** **with his father until 1832, the year of his fathers death. Then came seven years in** ***Egypt*****, later** ***Rotterdam*****,** ***Malaga, Barcelona*** **and** ***Madrid*****. With the new** ***Viceroy Mohammed Said*** **in Egypt, whom de Lesseps had befriended years earlier during his Egyptian service, he returned to** ***Cairo*** **and soon the construction of the** ***Suez Canal*** **- under his command, would begin in earnest. The Suez took ten years to build and cost about $100 million, or a million dollars a mile. This low cost was due in large part to the fact that the cut was made through a stretch of level sand.**

Left: Count Ferdinand de Lesseps from the ***Daily Graphic, New York*** **(1880)**

On November 17^{th} 1869, the grand opening of the sea-level *Suez Canal* was held with luxurious ceremonies (above). A *Cairo Opera House* had been built for the occasion and *Verdi* was commissioned to write *Aida*. *Ferdinand de Lesseps* became a national hero in *France* and was presented with many awards and decorations.

<u>Left</u>: de Lesseps and family on the cover of *Scientific American Supplement* (March 5^{th} 1881)

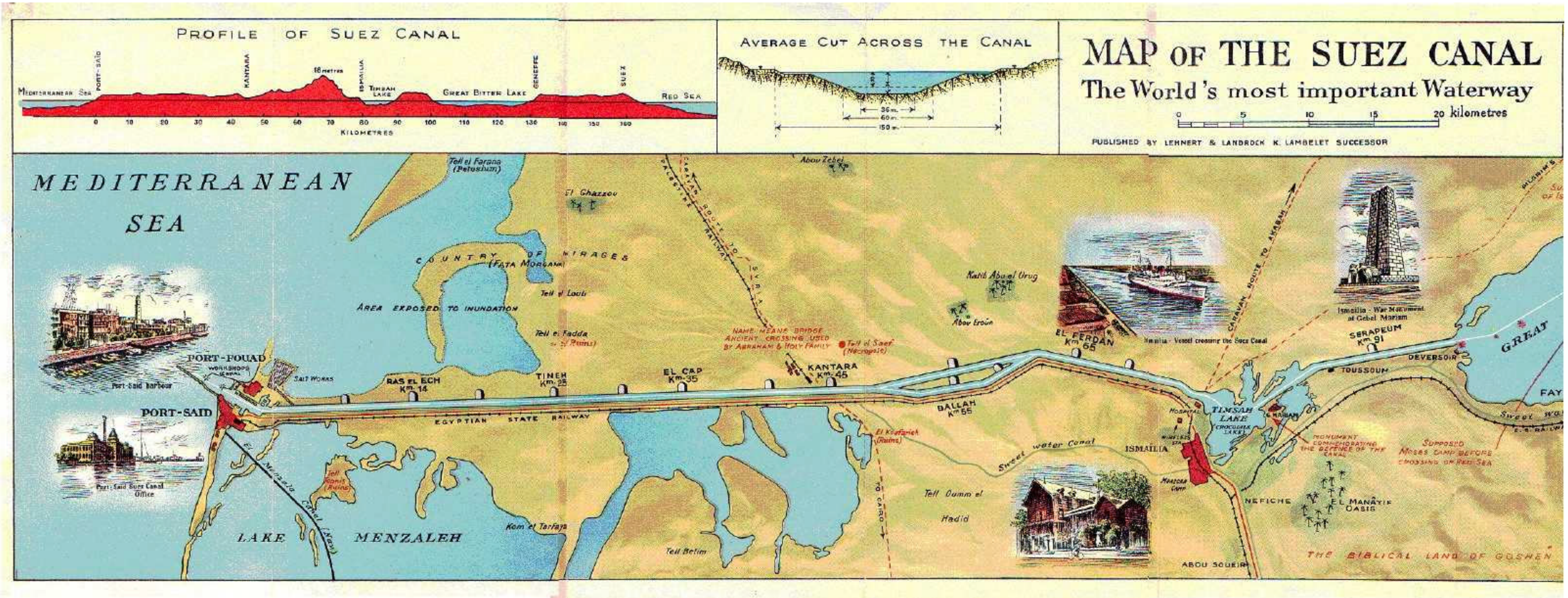


"…Count Ferdinand de Lesseps. In 1869, had completed the greatest canal ever dug up to that time, across the Isthmus of Suez, connecting the Red Sea with the Mediterranean and thus giving the ships of Europe the direct route to Asia for which the explorers of 500 years had been seeking…"

Popular Mechanics, Dec. 1913

“…The Suez Canal had presented no great engineering difficulties. It was a simple problem of a sea-level excavation through flat, sandy country. Yet the commercial and military importance of its accomplishment had raised de Lesseps, in the popular imagination, to the rank of the world’s greatest engineer, while the French people, with patriotic enthusiasm, were as ready to pour their treasure into any new enterprise to which he might lend his name…”

Popular Mechanics, **December 1913**


PROFILE OF SUEZ CANAL
MEDITERRANEAN SEA
PORT-SAID
KANTARA
ISMAILIA
TIMSAH LAKE
GREAT BITTER LAKE
GENEFFE
SUEZ
RED SEA
KILOMETRES
AVERAGE CUT ACROSS THE CANAL
MAP OF THE SUEZ CANAL
The World's most important Waterway
20 kilometres
PUBLISHED BY LEHNERT & LANDROCK K. LAMBELET SUCCESSOR
MEDITERRANEAN
SEA
COUNTRY OF MIRAGES
(FATA MORGANA)
AREA EXPOSED TO INUNDATION
PORT-FOUAD
PORT-SAID
RAS EL ECH Km 14
TINEH Km 25
EL CAP Km 35
KANTARA Km 45
BALLAH Km 55
EL FERDAN Km 65
EGYPTIAN STATE RAILWAY
Sweet water Canal
TIMSAH LAKE
ISMAILIA
SERAPEUM Km 91
TOUSSOUM
DEVERSOIR
GREAT
NEFICHE
EL MANAYIR OASIS
ABOU SOUEIR
LAKE
MENZALEH
THE BIBLICAL LAND OF GOSHEN


PORT SAID
PORT FOUAD
PALESTINE RAILWAY
EL KANTARA
ARABIAN DESERT
ISMAILIA
TIMSAH LAKE
CAIRO
GREAT BITTER LAKE
GEBEL ATAKA
TO CAIRO
SUEZ
PORT TEWFIK
RED SEA

"The British government does not own it, but is merely a private stockholder, and does not own even a majority of the shares. It has, in fact, an equity which might, in conceivable circumstances, be extinguished altogether. The affairs of the canal are governed from Paris. On the board of directors are 21 French members, 10 English and one Egyptian. The manager and secretary, along with the president, and even the manager of the London office, are French. The majority of the stock is owned by private interests in France."

***The Wall Street Journal*, 1913**

RE: misconception by the public of Great Britain's ownership of the *Suez Canal* being the occupying power of *Egypt* at the time and/or holder of a majority of shares.

"…the deepening of the Suez Canal has been completed, and the waterway now has a depth of 29 ft. for its entire length. Originally, it was planned to give the canal a depth of 26.25 ft., and for years after it was completed this depth was maintained. Increase in size of vessels routed through this short cut to the Orient made it necessary to deepen the cut, and dredging operations, conducted in the early eighties, added 1 ft. to the depth. Six years ago, the now finished undertaking was begun, and throughout the 100 miles of navigation from Port Said to Suez dredges have removed silt and sand, deepening the waterway to 29 ft. Already proposals are being considered for a further dredging, which will make the minimum depth 30 ft. The Panama Canal, while but 50 miles long, cost nearly $300,000,000, as compared with the Suez expenditure of $86,500,000 for twice the distance. The Panama Canal, however, is 40 ft. deep and 300 ft. wide, while its eastern rival is considerably narrower, only 200 to 265 ft. wide and is a sea-level excavation, mainly through sand."

***Popular Mechanics,* April 1914**

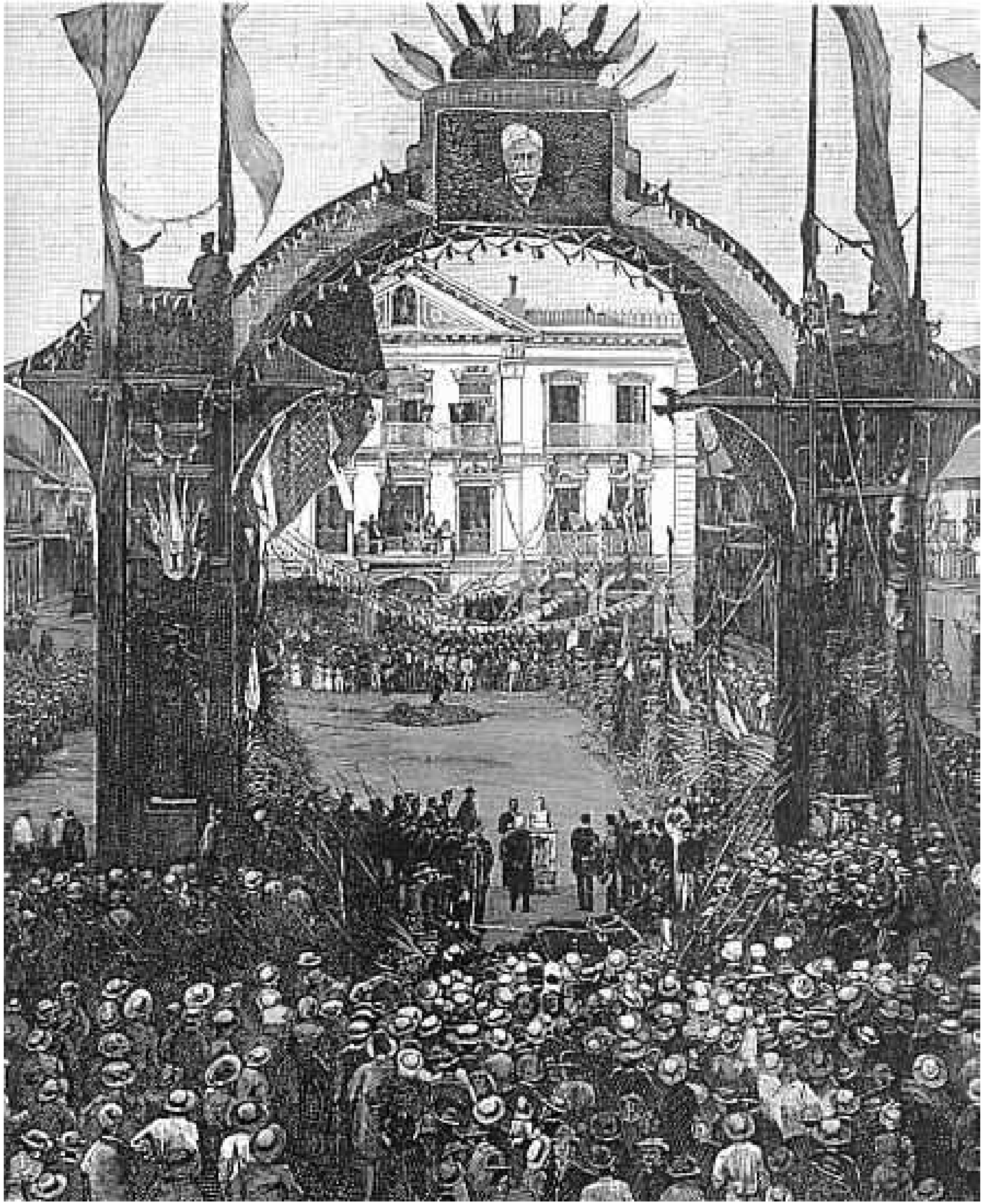

20c
20c
CANAL MARITIME
DE SUEZ
20c
20c
POSTES

"…So the group of French financiers to whom Lieutenant Wyse sold his Panama Canal concession shrewdly persuaded Count de Lesseps to become their chief engineer. The Panama Canal Company was organized at once under the general laws of France. Six million shares at 500 francs ($100) each were sold to the French people…"

***Popular Mechanics,* December 1913**

In 1875, de Lesseps made his first public declaration of interest in an inter-oceanic canal. On January 1st 1880, on board a steam launch standing of the mouth of the *Rio Grande River*, de Lesseps' daughter *Ferdinande* dug the first shovel of sand symbolically beginning the French effort to build a canal across the Isthmus. By the end of January 1881, the first group of French engineers of the *Compagnie Universelle du Canal Interoceanique* arrived at *Colon* and the great task of construction commenced. In the years to follow men and machinery poured into *Panama* to confront the geographical obstacles of the Isthmus: the backbone of the *Continental Divide* at the *Culebra Cut* and the mighty *Chagres River*. At the time, the French stood at the pinnacle of 19th Century engineering. Their finest engineers were sent to work, and die, in Panama by the score.

Left: caption: "Count Ferdinand de Lesseps The Hero from Suez and Panama" (1881)



"I have greater confidence than I had for Suez. The Atlantic and Pacific breezes blowing down the Isthmus will make it the healthiest region in the world. We were there for months, my wife, children, friends, and laborers had not a single death."

***Ferdinand de Lesseps,* 1881**

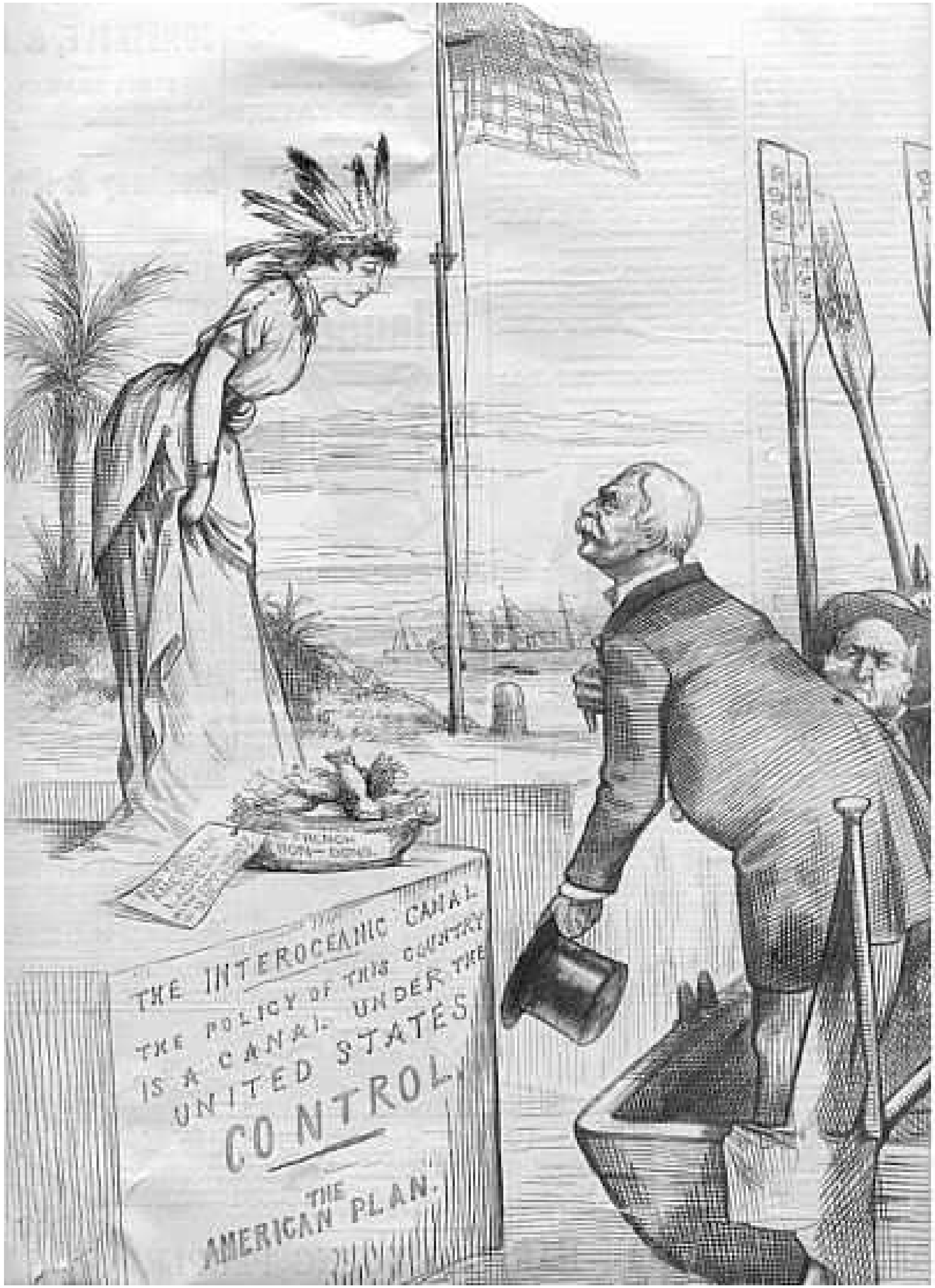
<u>Left</u>: elaborate reception for Count *Ferdinand de Lesseps* during his second visit to *Panama* in 1886. By then, thousands were dead.

"I refuse to die until I build my second canal across the Isthmus of Panama"

***Ferdinand de Lesseps,* 1879**

RE: following organization on August 17th 1879 of the *Compagnie Universelle du Canal Interoceanique de Panama*, with de Lesseps as president, the *Wyse Concession* was acquired from the *Societe Civile*. A new survey was ordered and an *International Technical Commission* of well-known engineers went to *Panama*, accompanied by de Lesseps, to get a first-hand look at the Isthmus. As de Lesseps was a trained diplomat and not an engineer, his son Charles took on the task of supervising the daily work. De Lesseps himself handled the important work of promoting and raising money for the project from private subscription. Not having the least scientific or technical inclination, de Lesseps relied upon a rather naive faith in the emerging technology. Thus he worried little about the problems facing this gigantic undertaking, feeling sure that the right people with the right ideas and the right machines would somehow miraculously appear at the right time and take care of them. His boundless confidence and enthusiasm for the project and his consummate faith in the miracles of technology attracted stockholders.

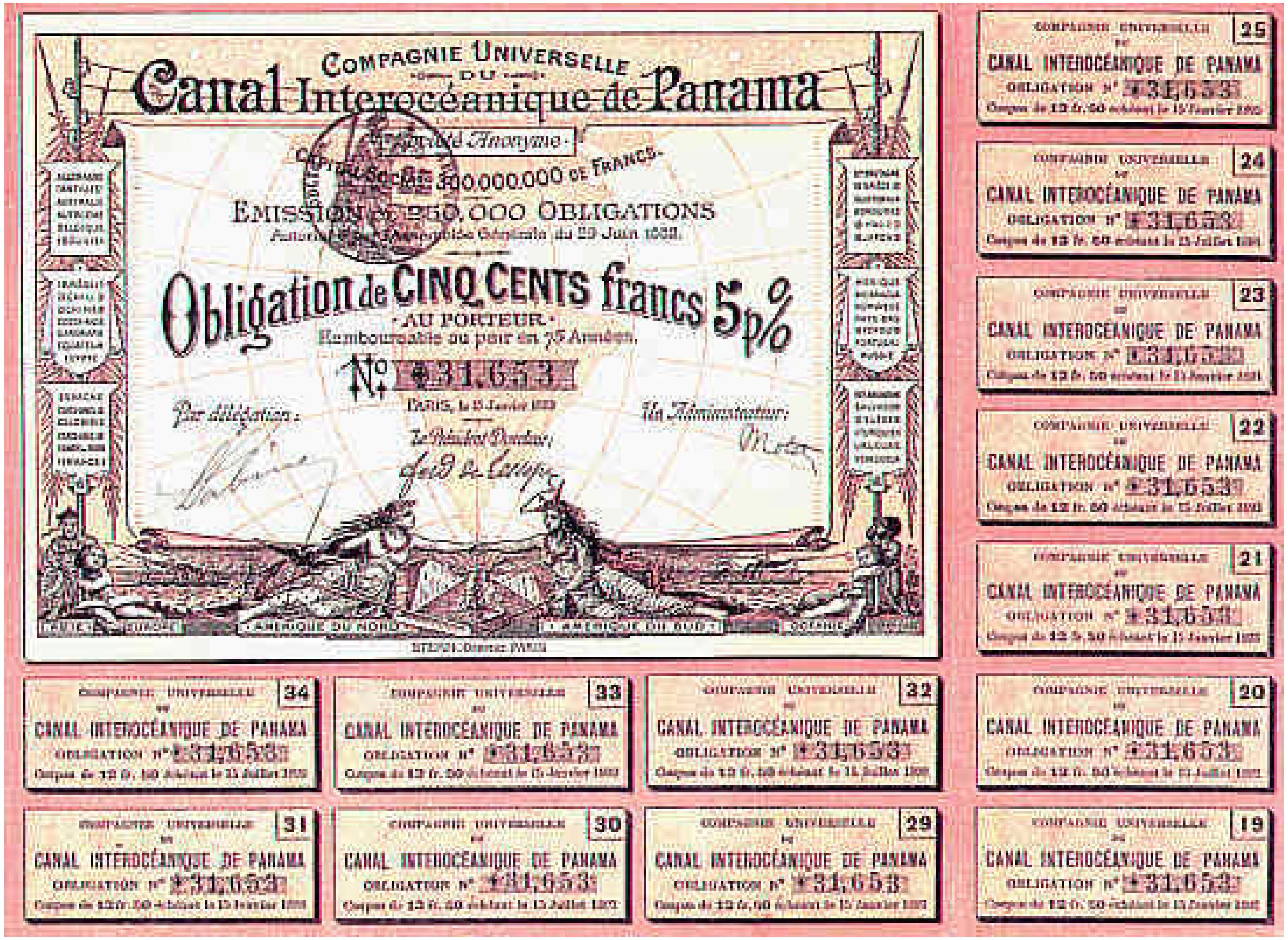
<u>Above</u>: *Panama City* headquarters of the French canal company



"Lastly, I may add that I have not against me that formidable obstacle, England. She is with me. This alone shows that the canal will be a fact, and I at once invite you to be present with me at the opening in 1887"

***Ferdinand de Lesseps,* 1881**

RE: excerpt from *London Graphic*. At *Suez*, his main opponent was *Lord Palmerston* of *England*. De Lesseps left *Colon* for the *United States* on February 22nd 1880, for the purpose of interesting Americans in the under-taking. Although he was received with a great deal of enthusiasm everywhere, he was unable to dispose of the stock which he had reserved. Americans were interested in a canal, but not in a canal under French control. He then proceeded on a similar tour of *Europe*, where he was more successful from a pecuniary point of view. The first issue of stock; 600K shares of $100 each, was subscribed twice over, mostly taken in *France*. These shares were distributed among 100K persons, indicating the great Frenchman's popularity with the French people. By 1888, the total subscriptions, stocks and bond issues, had reached $393,505,100 and the shareholders numbered 200K.


Compagnie Universelle du Canal Interocéanique de Panama
Société Anonyme
300.000.000 de Francs
Obligations
Obligation de Cinq Cents francs 5 p%
Au Porteur
Remboursable au pair en 75 Années.
N° 31,653
Par délégation:
Un Administrateur:
Amérique du Nord
Amérique du Sud
Compagnie Universelle du Canal Interocéanique de Panama
Obligation N° 31,653
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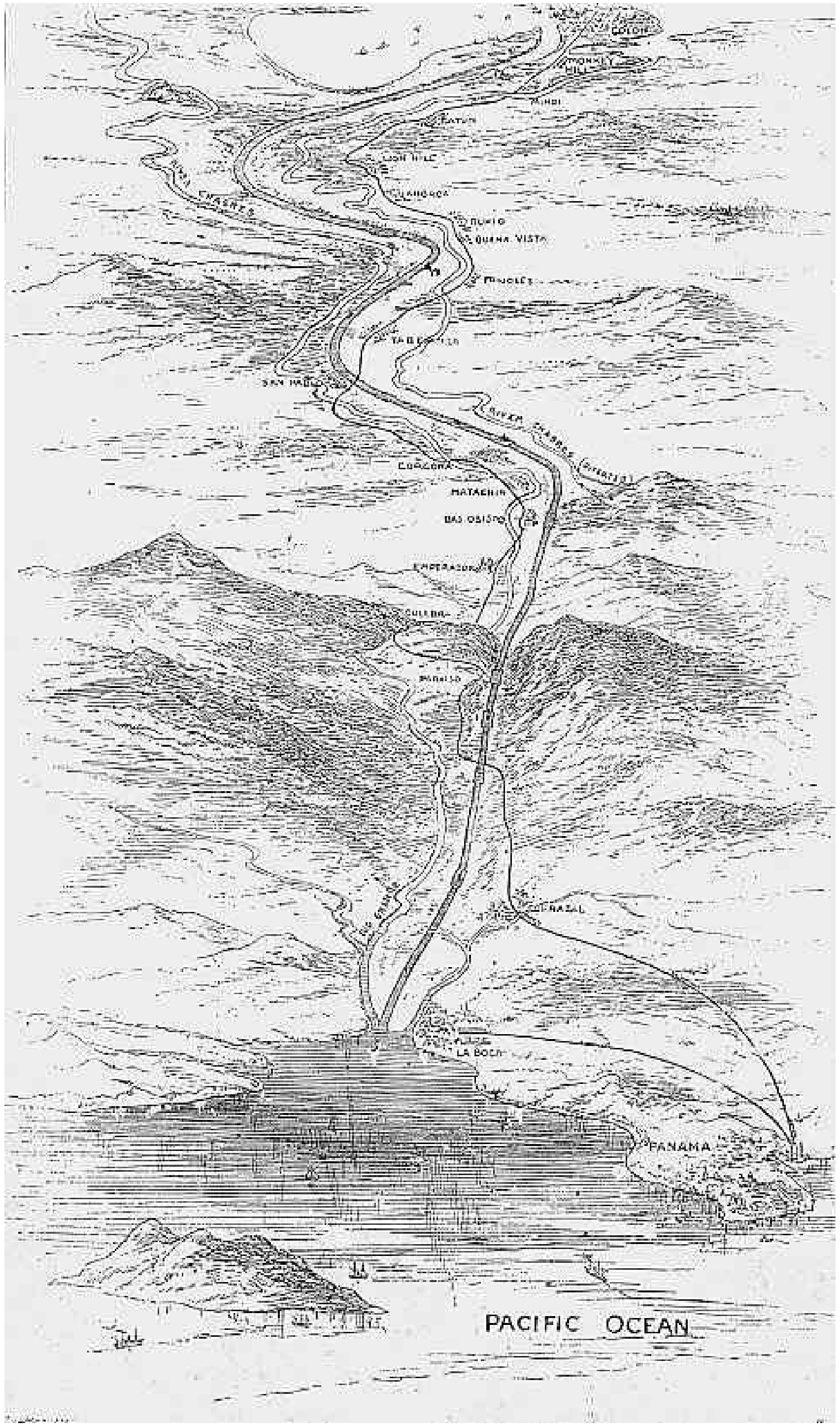
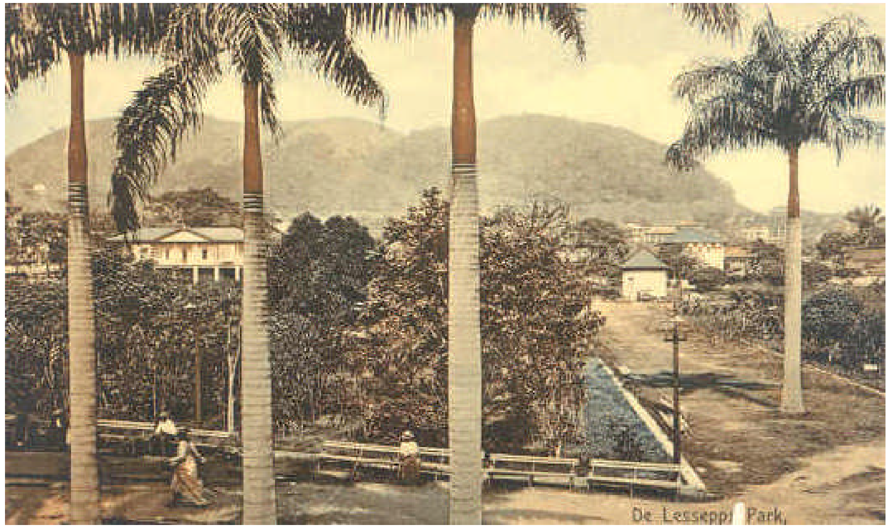


"…Now, when it is stated that the route of the proposed canal followed for over twenty-five miles a river which in the rainy season which is subject to enormous freshets, and that in passing through the Cordillera mountains an excavation eight miles in length and varying from 100 to 325 feet had to be made, it is evident that the first duty of de Lesseps was to secure the results of careful gagings of the rainfall, and to make elaborate borings along the route of the canal to ascertain the nature of the material to be excavated. Neither of these precautions was taken, were so incompletely carried out as to leave the engineering features of the scheme very much in the air…"

***Scientific American Supplement,* Jan. 18th 1902**

Left: The *Chagres River's* flooding in the rainy season proved a major obstacle for construction causing landslides and loss of equipment. Hence, to calm investors and facilitate the canal's construction, from 1885-1886 the French planned to divert the river as shown in the drawing at left, but the river diversion was never completed.

Ferdinand de Lesseps
(1805-1894)



"In the history of visionary undertakings and financial bubbles there are few things comparable to this old man's canal at Panama."

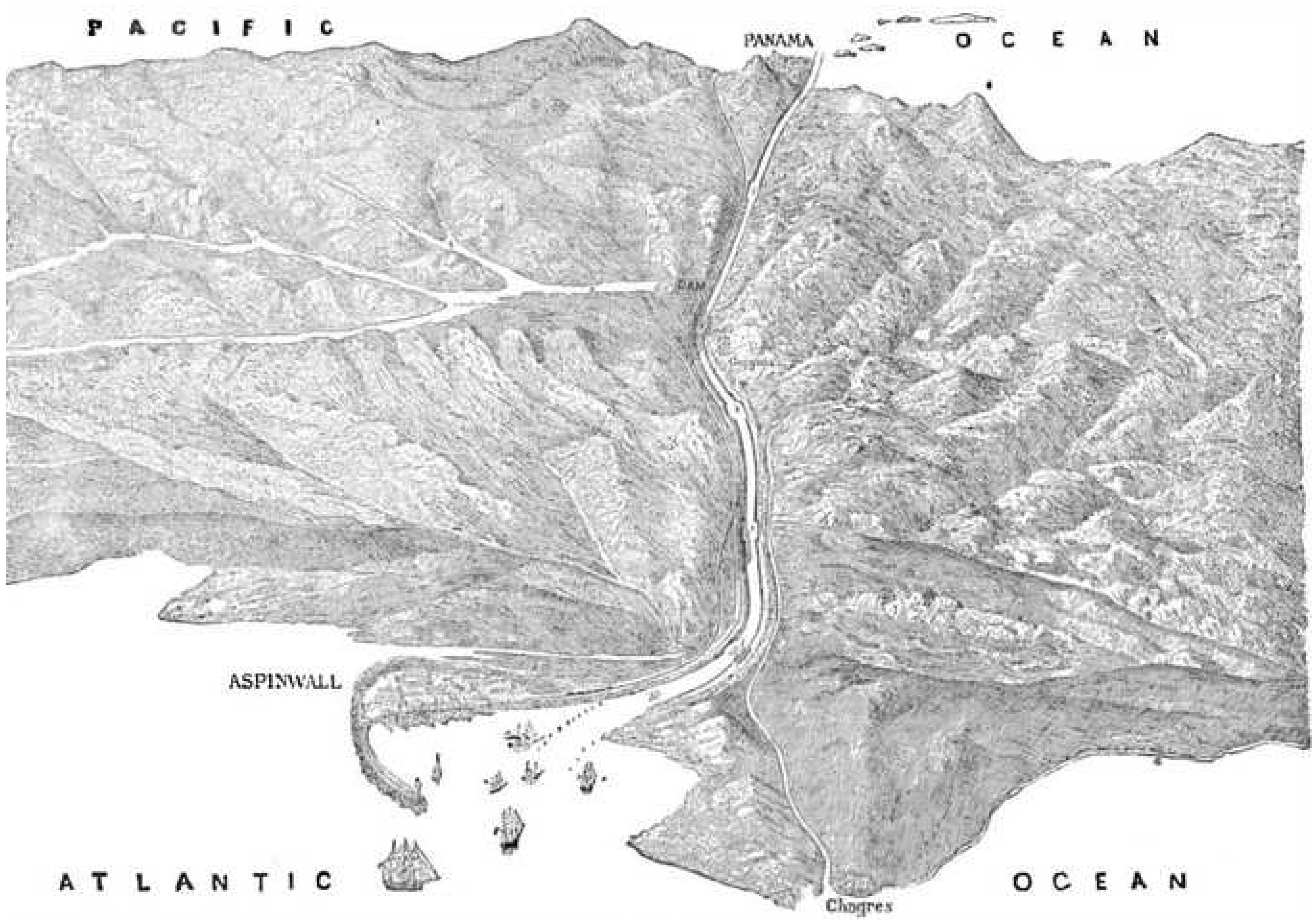
Scientific American Supplement, **March 5th 1881**

Above: postcard featuring *De Lesseps Park* in *Panama City*

The Expedition

The *International Technical Commission* (ITC) set about the difficult task of exploring and charting the French canal route. Between Colon and *Panama City*, the canal line was divided into sections, each section in charge of a team of engineers. Survey findings were compiled into a final report by the commission headquarters in Panama City. The ITC was required to verify all previous surveys, including those done by Wyse and the U.S. studies of Lull and Menocal. The ultimate goal was to determine the final line of the canal leading to the preparation of design specifications and working plans. Another goal was to convince investors that de Lesseps was not just the promoter of what, in reality was, a hastily conceived, half understood, imperfectly planned project with unreliable cost estimates. However, the few weeks' time allowed for this survey work was far too short for an investigation of such importance. Owing to this fact, the content of the ITC's report, submitted on February 14th 1880, was scientifically and professionally wanting. In fact, it comprised little more than a rubber stamp for the project as conceived by de Lesseps. In approving a sea-level canal, the ITC reported no significant construction difficulty in cutting the deep channel through the continental divide at the *Culebra Cut* and estimated that construction would take approximately eight years. The recommendations also included a protective breakwater at *Limon Bay* and a possible *Pacific*-side tidal lock.

Above: caption: "Direction Line of the Panama Canal"



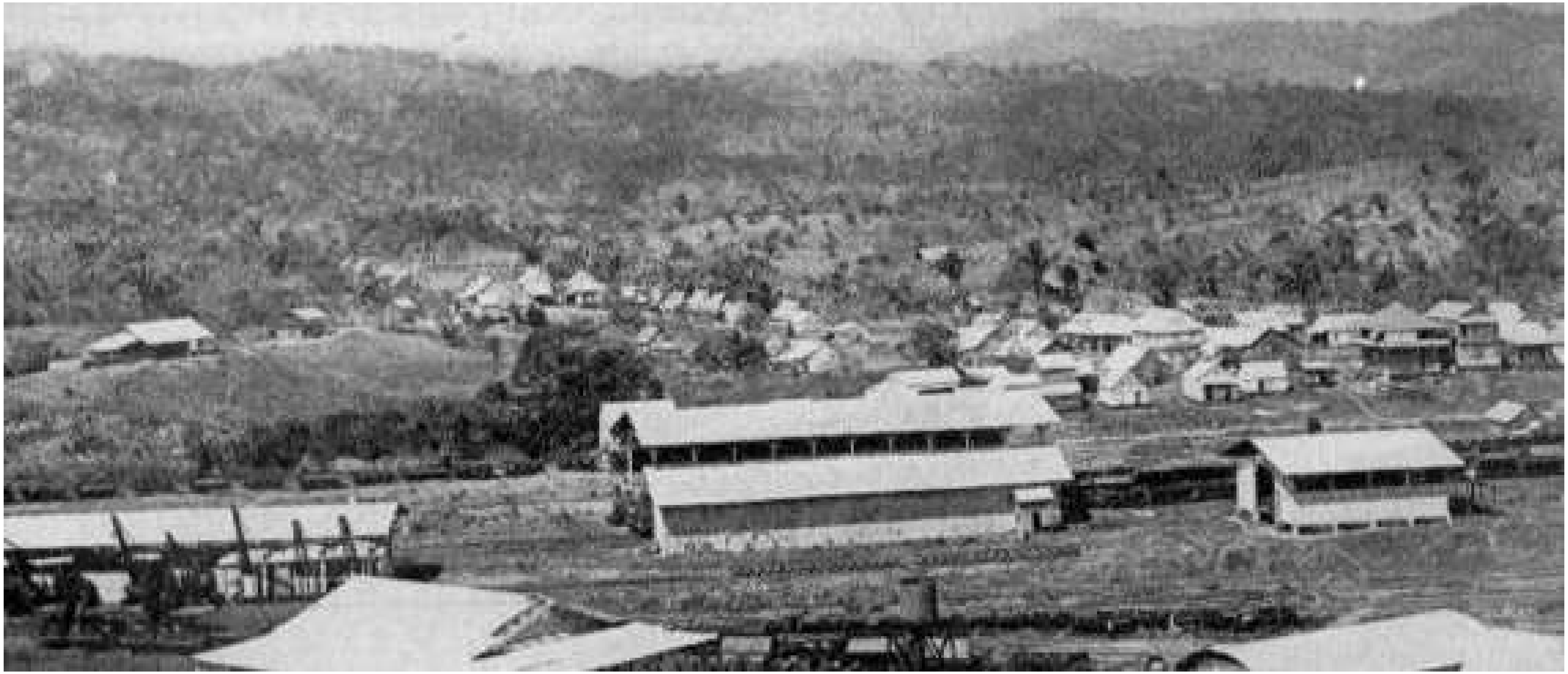
PANORAMIC VIEW OF THE PANAMA CANAL.

Above: Bird's-eye view of the de Lesseps plan, 1881. De Lesseps wanted to dig a canal that was at the same level as the *Atlantic* and *Pacific Ocean/s*, as he had done at *Suez* between the *Mediterranean* and *Red Sea/s*. When the French started digging in 1881, this is the canal they thought they were going to build.

The ITC's February 14th 1880 report estimated the cost of the sea-level canal to be $168.6 million. The engineering congress estimated the cost at $214 million. On February 20th 1880, de Lesseps reduced this estimate to $131.6 million, and again on March 1st 1880, without apparent reason, to $120 million. The proposed sea-level canal was to have uniform depth of 29.5-feet, a bottom width of 72-feet, and a width of the water line of about 90-feet and involved excavation estimated at 157 million cubic yards. De Lesseps, with his usual optimism, reduced the time to construct the canal from an estimated seven to eight years to just six years. To control the floods of the *Chagres River*, various schemes were proposed, the principal one being the construction of a dam at *Gamboa*, slightly below *Cruces*, and the construction of channels to the sea to carry the impounded water away from the canal. On account of the great difference in the tides of the two oceans, a maximum of 2.5-feet in the *Atlantic* and 21-feet in the *Pacific*, a tidal basin or lock was to have been built at the Pacific entrance (the higher tide/s on the Pacific-side is due to the fact that the *Bay of Panama* is funnel-shaped). No work was ever accomplished on either of these two projects. A dam at Gamboa was found later to be impracticable and the problem of the diversion of the Chagres River was left to be resolved sometime in the future.

“It is interesting to note the difference in the tides of the two oceans at the termini of the Panama Canal. The mean level is the same, but on the Atlantic side the oscillation does not exceed 2 ft., whereas on the Pacific side it is at times as great as 20 ft.; 10 ft. above and 10ft. below the mean level.”

Popular Mechanics, **November 1907**

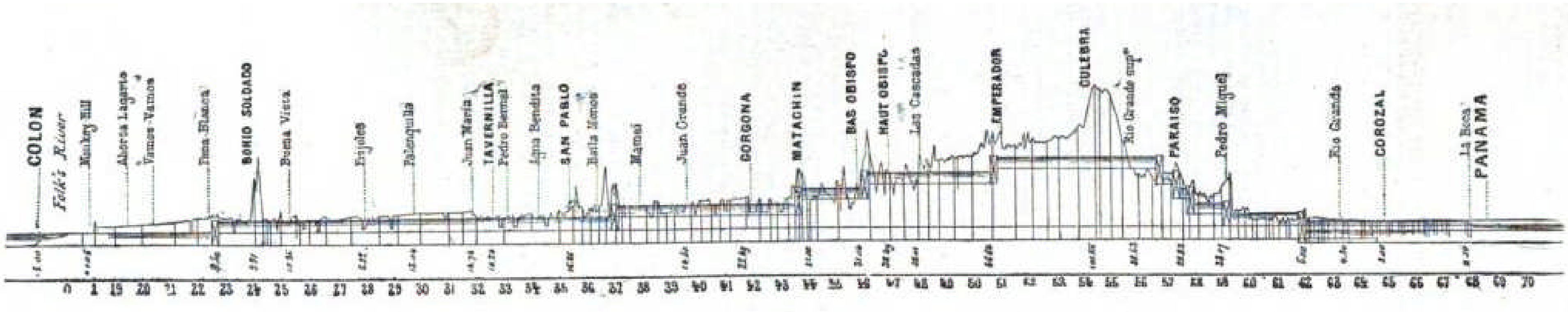


"The first work in the great cut of the maritime canal was formally inaugurated today at Empire in the presence of the dignitaries of the state, the leading citizens of the city and a great assemblage of the people. The first locomotive has arrived at the newly opened excavation. The city of Panama is celebrating the event with a great fete."

The Bulletin du Canal Interoceanique

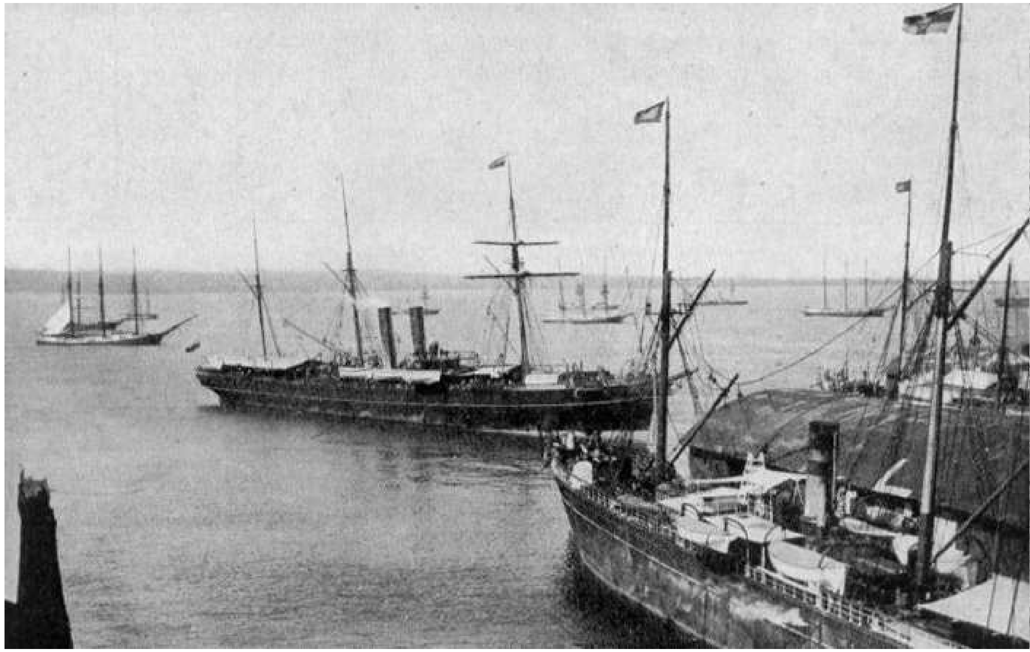
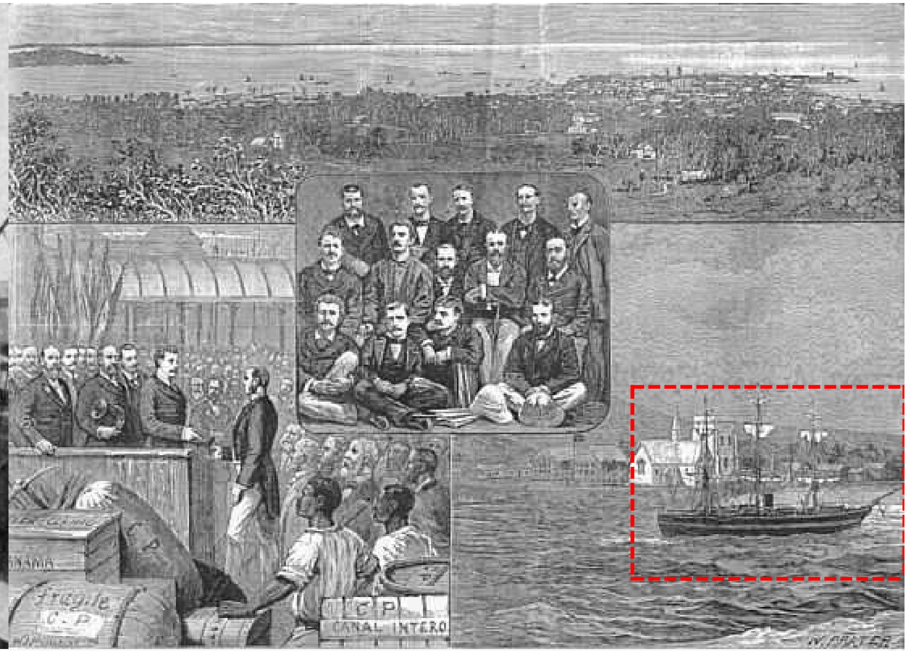
RE: commencement of excavation work in the *Culebra Cut* (January 20th 1883)

Above: caption: "The village of Empire in the old French days. The French began their first excavation in the cut near this point in 1882"

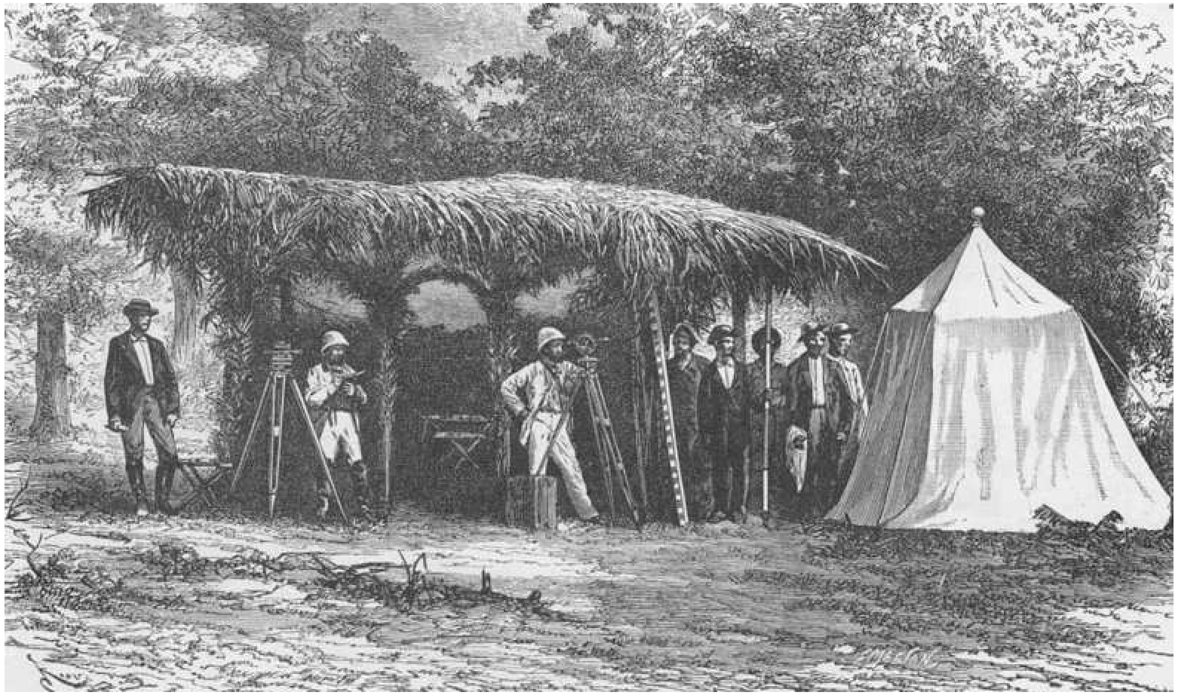


To perform the construction work, de Lesseps contracted *Couvreux and Hersent*, with whom he had worked at *Suez*. Looking at the work in retrospect, it can be seen as falling into four phases. During the first phase; from March 12th 1881 to the end of 1882, the entire project was under Couvreux and Hersent. During the second phase; 1883 through 1885 (following the withdrawal of Couvreux and Hersent), the work was accomplished by a number of small contractors under supervision of the company itself. The third phase; between 1886 and 1887, saw the work done by a few large contractors. Finally, in the fourth phase; beginning in 1888, the sea-level project was finally, though temporarily, abandoned for a lock canal with the idea that, after the lock canal was functional, the channel could be deepened gradually to make a sea level canal. But it was already too late, and the work gradually ground to a halt.

<u>Above</u>: caption: "Longitudinal Profile of the Lock Canal (1888)"

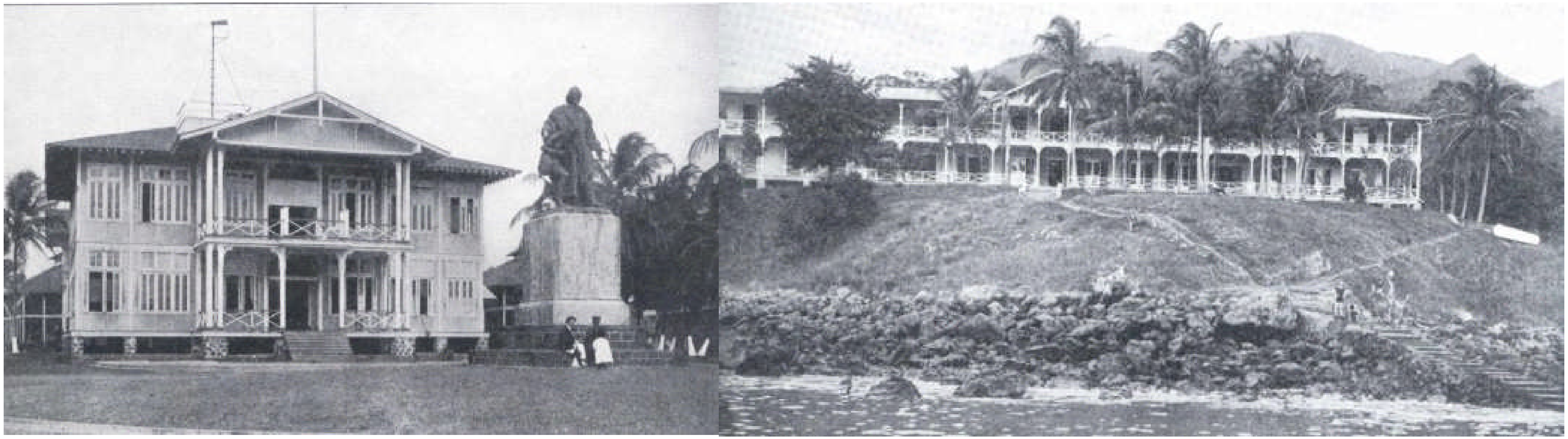
Armand Reclus, **the Agent General (Chief Superintendent) of the Compagnie Universelle, led the first French construction group of about forty engineers and officials. They landed at the port of *Colon* on *Limon Bay* (left) on January 29th 1881, aboard the *Lafayette* (right). An optimistic Reclus expected preparatory tasks to take about a year, but Panama's sparse population did not lend itself to labor recruitment nor did its thick jungles lend themselves to quick movement through the countryside to accomplish the work. *Gaston Blanchet,* Director of *Couvreux and Hersent's*, accompanied Reclus to the Isthmus. As Blanchet was known to be the company's driving force, it was a terrible blow when, just ten months into the project, he died of *Malaria*.**



"The expedition is divided into distinct sections or departments. Mr. Reclus is the general agent, with full powers from the canal company. Mr. G. Blanchet is director of the canal works. It is understood that the work is to begin at once. This will principally be in ascertaining the exact location of the canal; clearing away the timber, brush, etc., and the general land grants of the company and other matters of a preliminary character…"

***Scientific American Supplement,* March 5th 1881**

Above: caption: "Camp of the Surveying Brigade Commanded by Mr. Fontan at Paraiso." By the time of the first excavation, several teams of surveyors had been at work for two years making maps which helped greatly to determine the best route for the canal.



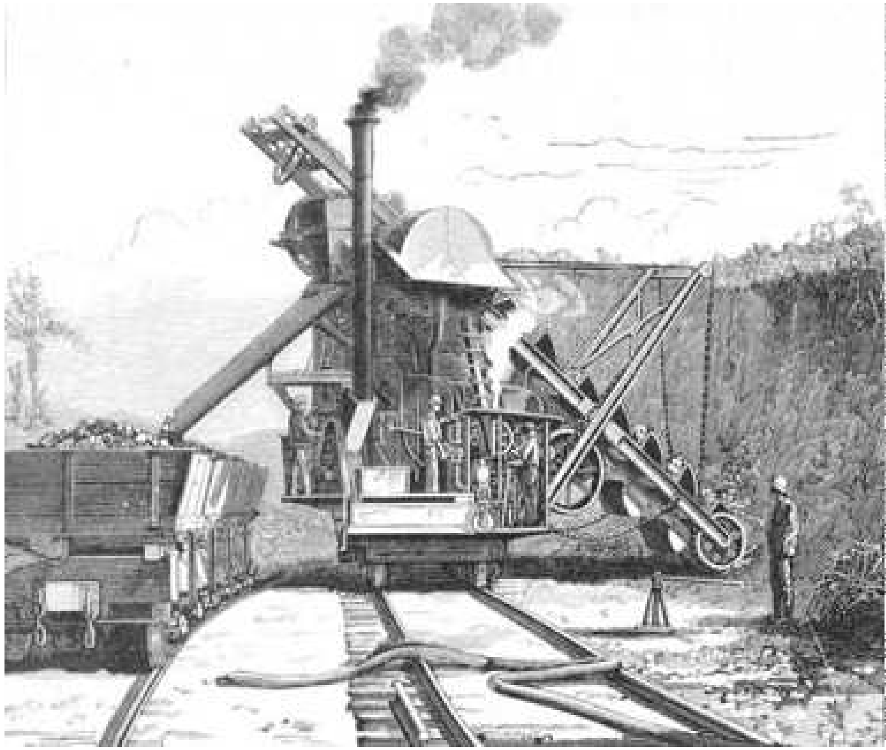
Though it was difficult recruiting locals, there seems to have been little difficulty experienced in obtaining a labor force which in 1888 numbered about 20K men. Ninety percent of these were negroes from the *West Indies*, many of them holding clerical and other positions. Caucasian employees, mainly from *France*, were treated with extreme generosity. Economy was an unknown factor in the administration of affairs of the first company. The average pay of a clerk was $125 per month and a division chief, from $200 to $300 per month. After two years' service, five months vacation with free traveling expenses to and from France were granted. The hours of labor for the clerical force was from eight to eleven a.m., and two to five p.m. (six hours per day). Free quarters, furniture, bedding, lamps, kitchen utensils, etc., were provided. As there was no system of accounting, many did quite a profitable business in the buying and selling of the company's furniture. Enormous salaries were paid to the directors, engineers and other officers on the Isthmus. The director-general/s lived in a house that cost $100K and they received $50K annual salary, and when they went out on the work they were allowed $50 per day additional. One of the private cars in which they rode cost $42K.

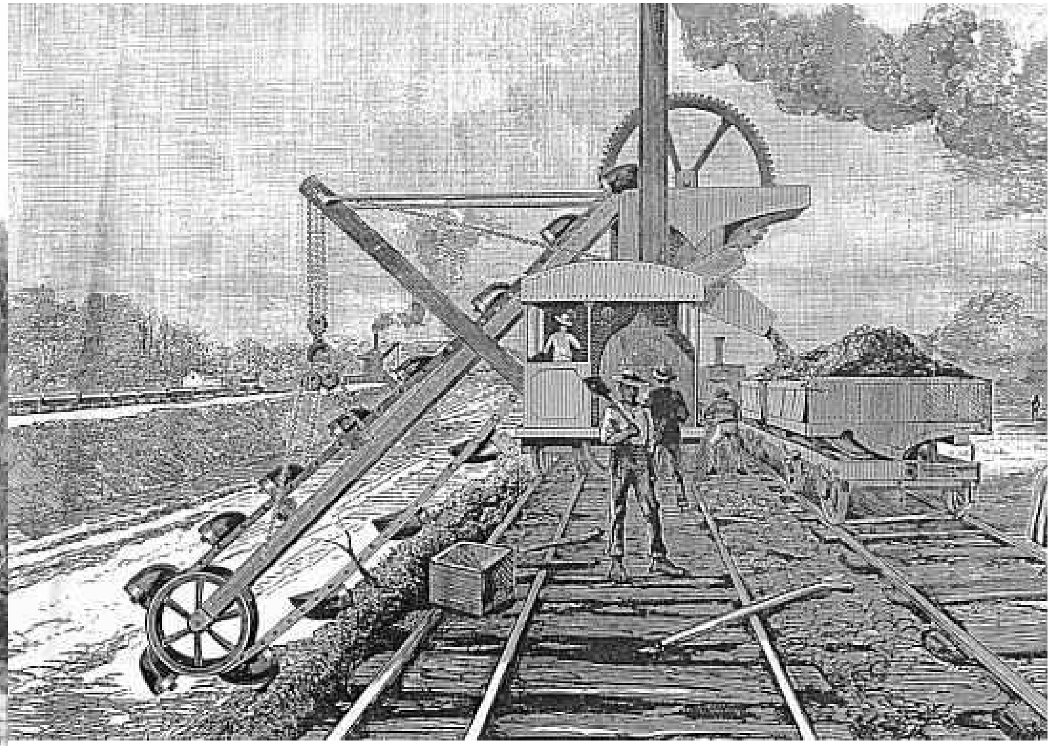
Above: ***Atlantic*** **headquarters of the canal company (left) /** ***Toboga Island Sanitorium*** **(right)**

"…The organization of the company itself will not be fully completed for several months, and the construction of the machinery necessary to carry on the work will take considerable time. A year or more must elapse before the employment of machinery will be possible…The expedition is composed of the following departments: 1. The Superior Agency, having direct control and immediate supervision of the technical and legal matters as well as accounts. 2. The Department of Real Estate. 3. Sanitary Service. 4. Work and Construction…"

***Scientific American Supplement,* March 5th 1881**

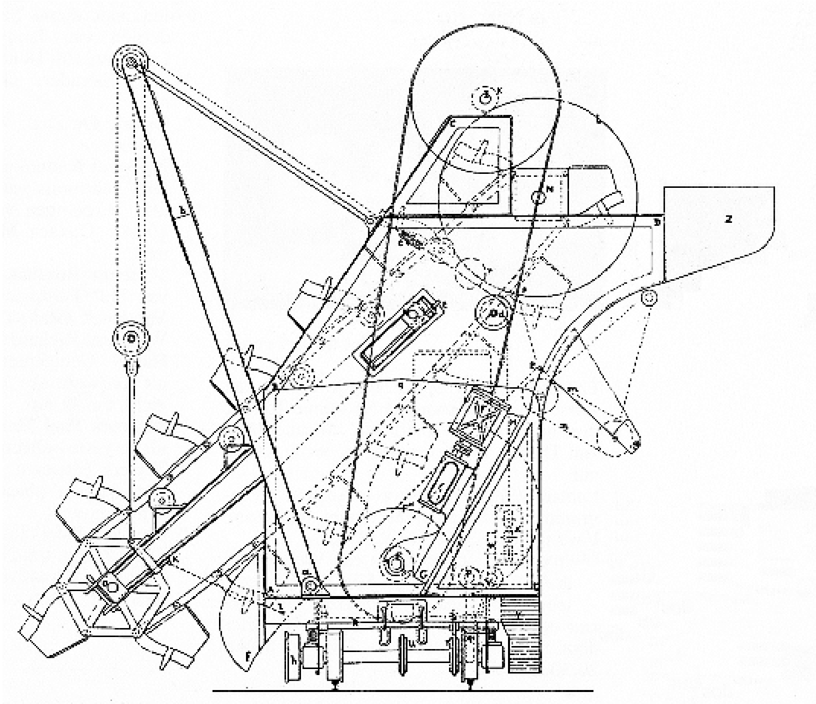
Above: caption: "The French at work in the canal at Cucaracha, 1885, just around the point from Gold Hill"





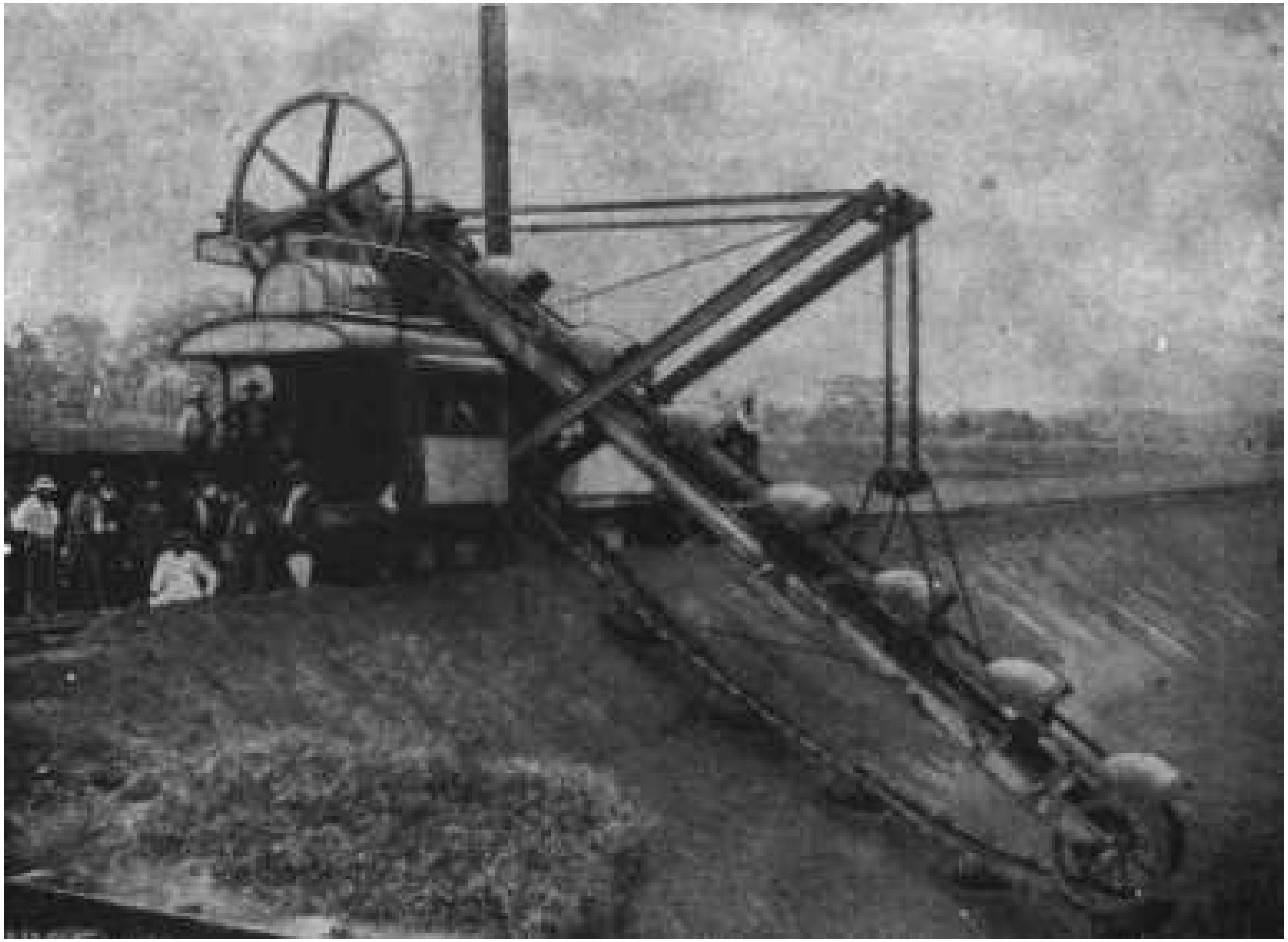
Left: French “Down Digger” excavator at work (ca. 1884). These large machines worked on digging dirt and rocks from the ground in *Panama*, digging the “prism” of the canal. They were operated by steam engines and moved a lot of excavated material, traveling on railway tracks that were put down exclusively for their use. The spoil was dumped in rail cars and dumped far from the site.

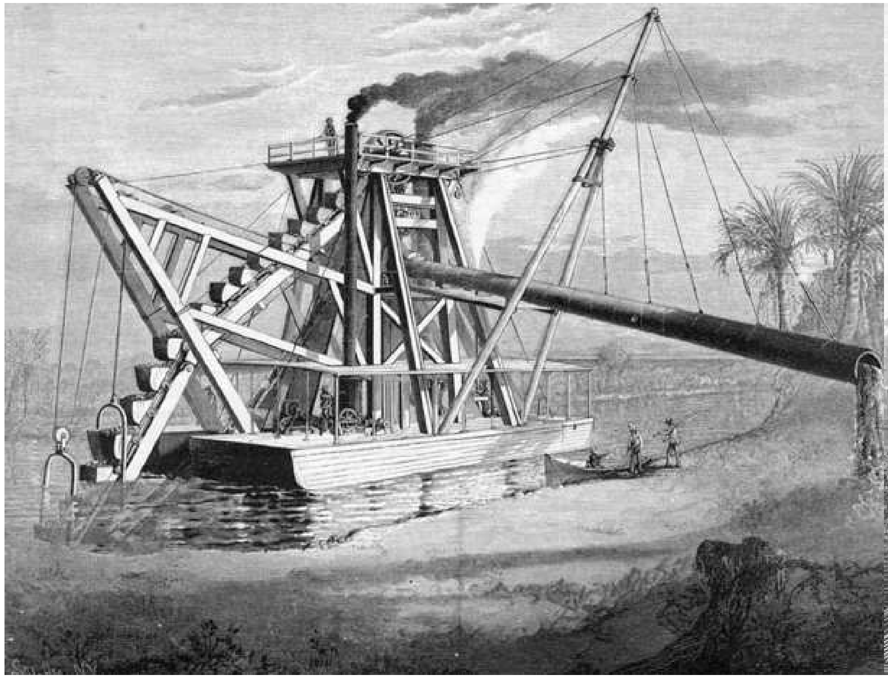
Right: steam dredge operating at *Bas Obispo*

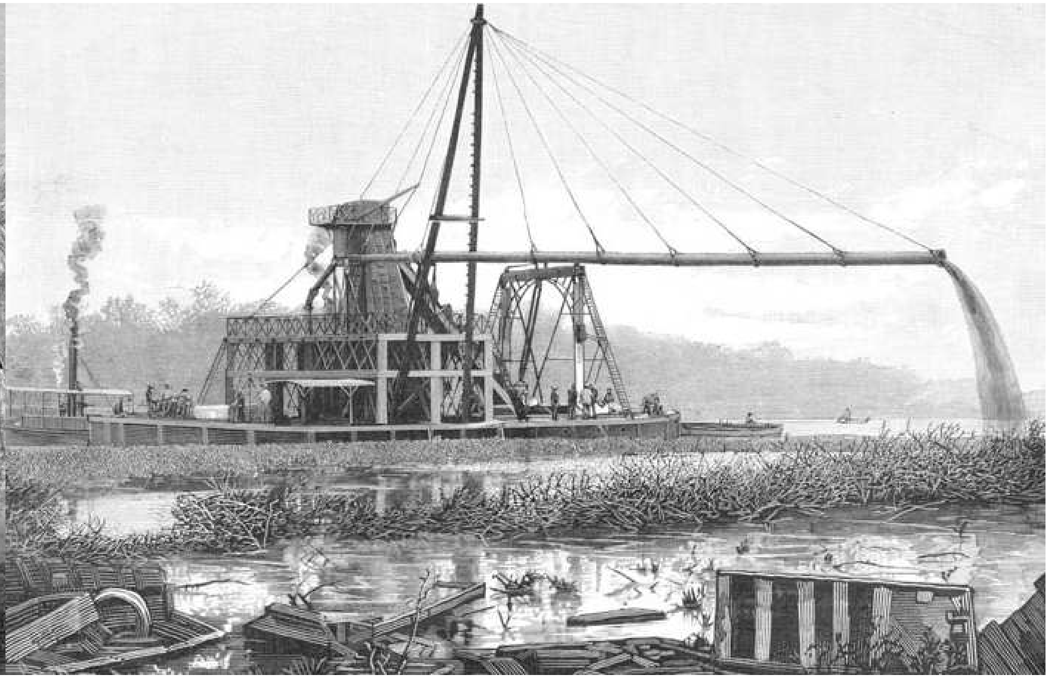


During the French era, the ***Compagnie Universelle de Canal Interoceanique de Panama*** was faced with a problem; find enough manpower and equipment to do the work. Contractors were paid by the cubic meter, whereby the unit rate depended upon the hardness of the soil or rock being excavated. ***Culebra Cut*** was excavated by an Anglo-Dutch consortium. The soil at the cut consisted of ***loam*** and ***slate*** and therefore a higher rate could be charged than that for dredged material but less than for rock. In order to speed up the work at Culebra, engineer ***Dresselhuis*** designed an excavator eleven meters long and three meters wide. The drive of this excavator moved along over railroad tracks and was powered by two steam engines; one 70 horsepower and the other 25. The big engine was used for the excavation, the small one for moving the excavator along the track and to adjust the position of the ladder. On the machine, special attachments were fitted to cut the soil and to prevent the sticky clay from adhering to the buckets. Depending on the hardness of the soil, three to eight meters per minute could be removed.

Above: original drawing for the French excavator







<u>Left</u>: caption: "'Hercules' Dredger for the Panama Canal." A big job needed big machines. This big machine is a floating dredge. It digs up mud from the bottom of the river and dumps it on the side. The dredges traveled along the shallow rivers and made them deep enough for large ships to navigate.

<u>Right</u>: caption: "Discharger and Excavator now in use on the Panama Canal"

Surveys were completed and the canal line more accurately determined. Construction began on service buildings and housing for laborers. The delivery of machinery was expected soon, some of which was manufactured in *Europe*, some in the *United States*. All manner of equipment was needed; from launches, excavators, dump cars and cranes to telegraph and telephone equipment. De Lesseps was aware that the railroad was important to the work, and control of this vital element was gained by the French in August 1881. But it cost them dearly, more than $25 million; about one-third of Compagnie Universelle resources. Strangely, the railroad was never organized to serve anywhere near its full potential, especially in moving material from the site of excavation to deposit areas.

<u>Above</u>: caption: "The Panama Railroad at Colon (ca. 1880)"

We Drank to His Good Luck

“The cause of death would be attributed in Paris to ‘complications in the region of the kidneys.’ But on the Isthmus, the story would be told for as long as the French remained. He had arrived from France to make a personal inspection for de Lesseps, and several of the engineers had arranged a dinner in his honor at the employees’ dining hall at the camp at Gamboa. It was a festive evening apparently. Bionne, the last to arrive, had come into the hall just as everyone was being seated. One of the guests, a Norwegian woman, was exclaiming with great agitation that there were only thirteen at the table. ‘Be assured, madame, in such a case it is the last to arrive who pays for all,’ Bionne said gaily. ‘He drank to our success on the Isthmus,’ one engineer recalled; ‘we drank to his good luck...’ Two weeks later, on his way home to France, Bionne died of what the ship’s doctor designated only as fever, not yellow fever. The body was buried at sea.”

***David McCullough*, Author/Historian**

RE: as the work force increased, so did illness and death. The first *Yellow Fever* death among the 1,039 employees occurred in June 1881 soon after the beginning of the rainy season. A young engineer named Etienne died on July 25th 1881, supposedly of “Brain Fever.” A few days later, on July 28th 1881, *Henri Bionne* died on his return voyage to *France*. Holding degrees in medicine and law, as well as being an international authority on finance, he was a significant player in the canal’s *Paris* operation. His loss was a precursor of worse to come.

On the Isthmus, the Compagnie Universelle established medical services presided over by the Sisters of *St. Vincent de Paul*. The first 200-bed hospital was established in *Colon* in March 1882 (left). On the *Pacific*-side, construction for *L'Hospital Central de Panama*, the forerunner of *Ancon Hospital*, was begun on *Ancon Hill* (right). It was dedicated six months later, on September 17th 1882. With the information on the mosquito connection in the transmission of *Yellow Fever* and *Malaria* not yet discovered, the French and the good sisters unwittingly committed a number of errors that were to cost dearly in human life and suffering. The hospital grounds were set out with many varieties of vegetables and flowers. To protect them from leaf-eating ants, waterways were constructed around flowerbeds. Inside the hospital itself, water pans were placed under bedposts to keep off insects. Both insect fighting methods provided excellent and convenient breeding sites for the *Stegomyia Fasciata* and *Anopheles* mosquitoes, carriers of Yellow Fever and Malaria. Many patients who came to the hospital for other reasons often fell ill with these diseases after their arrival. It got to the point where people avoided the hospital whenever possible.

"The health of the personnel formerly caused trouble, coolies and other races not well suited to hard labor under a tropical sun being employed. With negroes from the British Antilles, little difficulty is now experienced. This matter was carefully investigated during the inspection last spring. American engineers and employees on the Canal and the Panama Railroad being questioned, the fine hospital near Panama—where the Company provides for its sick—being visited, and the views of the medical officers and of the Sisters of Charity, acting as nurses, being obtained. All agreed that the dangers resulting from the climate have been much exaggerated. The surgeon in charge of the hospital, Dr. Lacroisade, who has resided on the Isthmus since 1887, after presenting full statistics covering the sick reports for the past year of a force of about 3,800 agents and laborers under employment, said:

"'Among the diseases attributable to the climate the most numerous are simple marsh fevers, which have not occasioned a single death. Two diseases only belonging to the epidemic type have appeared—the beriberi, of which there is no longer any question [it was imported with negro laborers brought from Africa as an experiment, and disappeared when they were sent back], and yellow fever. The latter, after having been absent from the Isthmus for at least six years, was imported in 1897, and continued about six months, from March to August, when it again disappeared after very light ravages (only six deaths). Thus it cannot be considered that this pest is really epidemic on the Isthmus. From the other infectious epidemics, such as variola, typhoid fever, diphtheria, etc., the Isthmus appears to be almost entirely exempt. From the foregoing we may conclude that life on the Isthmus scarcely incurs more dangers than elsewhere, even for Europeans who, after the blacks of the British Antilles, appear to resist the climate best. Residence here would, then, offer nothing alarming, were it not for a constant feeling of fatigue and uneasiness due to a temperature always high, and an atmosphere saturated with moisture.'

"There appears, therefore, to be no danger of serious mortality in the construction of the Canal, if due care be taken to benefit by past experience in selecting the laborers."

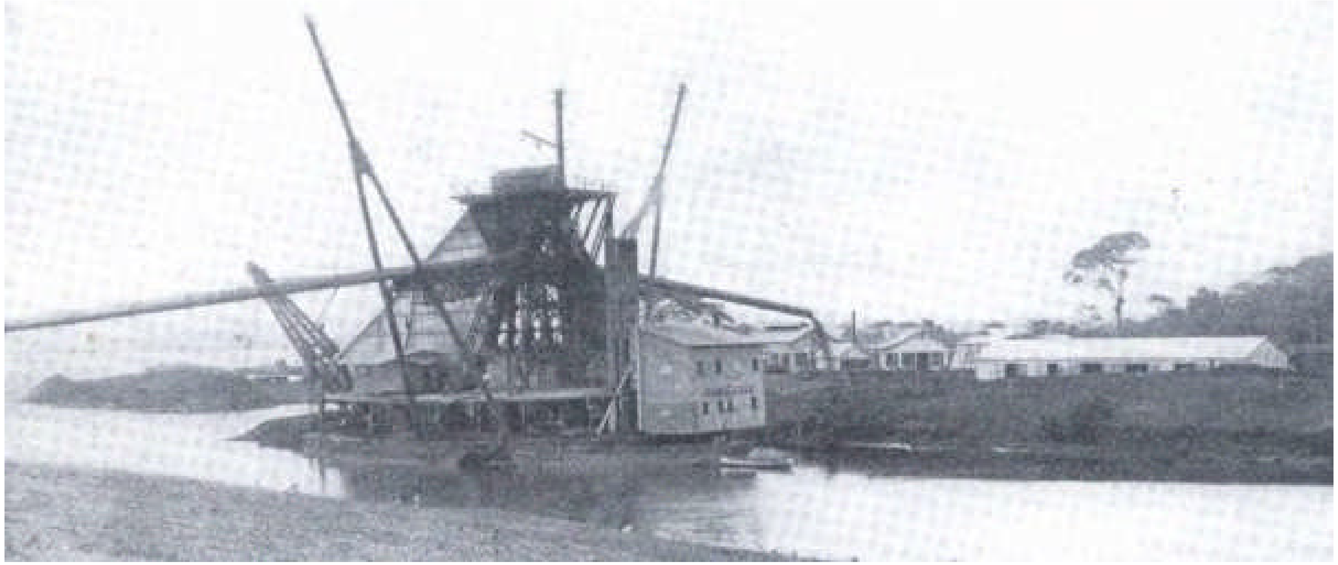
***Brigadier General Henry L. Abbot* – International Commission member**
RE: comments made in the November 1898 issue of *Forum*

<u>Above</u>: *Ancon Cemetery* (later moved to *Corozal*). Thousands of French canal workers were buried here.

Two hospitals were built in 1883. *Ancon Hospital* originally cost $5.6 million, and *Colon Hospital* cost $1.4 million; a total of $7 million. The hospitals, although fairly well equipped with excellent doctors and surgeons and supplied with the best medicines and instruments of the time, were poorly managed. They were handled under contract and the administration was left almost entirely to French *Sisters of Charity*, who, although they were devoted and religious women, were not trained nurses. These worthy women left the wards at night after prayer, closing the doors and windows tight to keep out the night mists which were supposed to bring malarial fever, leaving the patients without any other care than that which was given by the less feeble among themselves. When the wards were opened for morning prayer, it was often found that some patient had died during the night who might have been saved with proper care. The legs of the hospital beds were placed in tins of water to keep insects from crawling up. These pans of stagnant water, and also the many ornamental basins containing flowers and plants in the grounds outside, made ideal breeding places for mosquitoes, and it is quite probable that many patients fell victim to fever while in the hospital suffering with some minor illness due to the unscreened windows and doors. The hospital records show that during the construction period of the old company; 1881-1889, there were 5,618 deaths, 1,041 of which were from *Yellow Fever*. The West Indian negroes were immune to Yellow Fever and very few of them were admitted to the hospitals. The victims, therefore, were nearly all Caucasian, mostly Frenchmen. A large proportion of the sick did not enter the hospitals as the contractors were charged one dollar a day for skilled medical treatment of employees. Later, during the American period, Colonel Gorgas estimated the number of laborers who died from 1881 to 1889 at 22,189. He also estimated that as many died of Yellow Fever outside the hospitals as in. In September 1884, during an attack of Yellow Fever, the Canal Company lost 654 employees out of a force of about 18K. The truth was partly suppressed or minimized by the canal company in order not to destroy the confidence of the people working on the project. Outside of the hospital rolls, the records were incomplete. A virulent form of *Malaria*, known as "Chagres Fever" caused a greater toll in lives than any other one disease. The negroe laborers, although immune from Yellow Fever, succumbed quickly to attacks of this form of Malaria. Under the new canal company, the hospitals were turned over to the Sisters of Charity who took care of the few patients admitted at a fixed charge. Since the revenue from patients was small, they had a hard time to keep them open at all and were compelled to sell flowers, fruits, vegetables and other products from the hospital grounds. When the Americans took charge, these women were replaced by properly trained nurses.

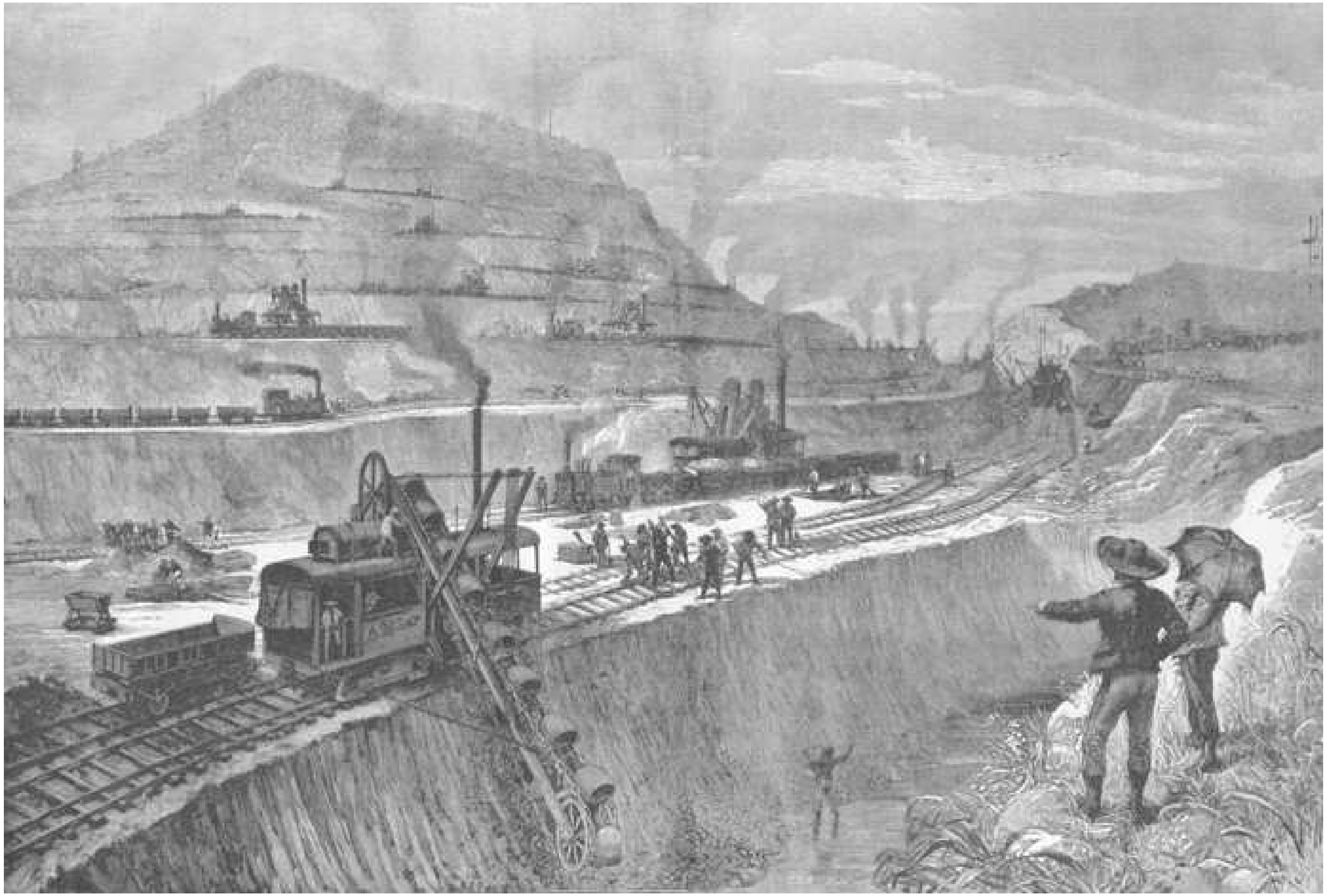
 

By October 1881, equipment and materials were arriving and accumulating in *Colon* (left) faster than a work force could be hired to use them. By December 1881, the French had set up headquarters in *Panama City* at the *Grand Hotel* on *Cathedral Plaza* (right). A banquet and ball in Panama City marked the official beginning of *Culebra Cut* excavation on January 20^{th} 1882. However, little actual digging was accomplished because of lack of organization in the field. Engineers continued doing survey and preliminary work; work necessary to the project considering the skimpy studies originally done, and sending reports to *Paris*. With all excavating arrangements made, *Couvreux and Hersent* decided to withdraw from the project and wrote to de Lesseps requesting cancellation of their contract on December 31^{st} 1882. For a time, confusion reigned, until appointment of *Jules Dingler* as the new *Director General*. An engineer of outstanding ability, reputation and experience, Dingler was un-phased by the *Yellow Fever* threat, and, accompanied by his family, arrived in Colon on March 1^{st} 1883, along with *Charles de Lesseps.*



Dingler concentrated on restoring order to the work and the organization. However, in doing so, he incurred no small amount of dislike. At the time, a new system; the system of small contracts, was initiated and nearly thirty were granted. For these contracts, the Compagnie Universelle rented out the necessary equipment at low rates. It wasn't particularly efficient, requiring a great deal of paperwork and involving numerous lawsuits in Colombian courts, but the work was getting done, making use of the available labor force. Dry excavation work was progressing in the *Culebra Cut* and was expected to be finished by May 1885. However, there was growing concern about bank stability and the danger of slides. At the *Atlantic* and *Pacific* entrances, dredges worked their way inland. Machinery came from many quarters; *France*, the *United States* and *Belgium*. Equipment was constantly being modified and used in experimental combinations, but mostly it was too light and too small. A growing accumulation of discarded, inoperative equipment along the canal line testified to earlier mistakes. With some 10K men employed, work was going well in September of 1883. The maximum force employed by the French at any one time was reached in 1884, with more than 19K. The labor force came from the *West Indies*.

<u>Above</u>: French Suction Dredge



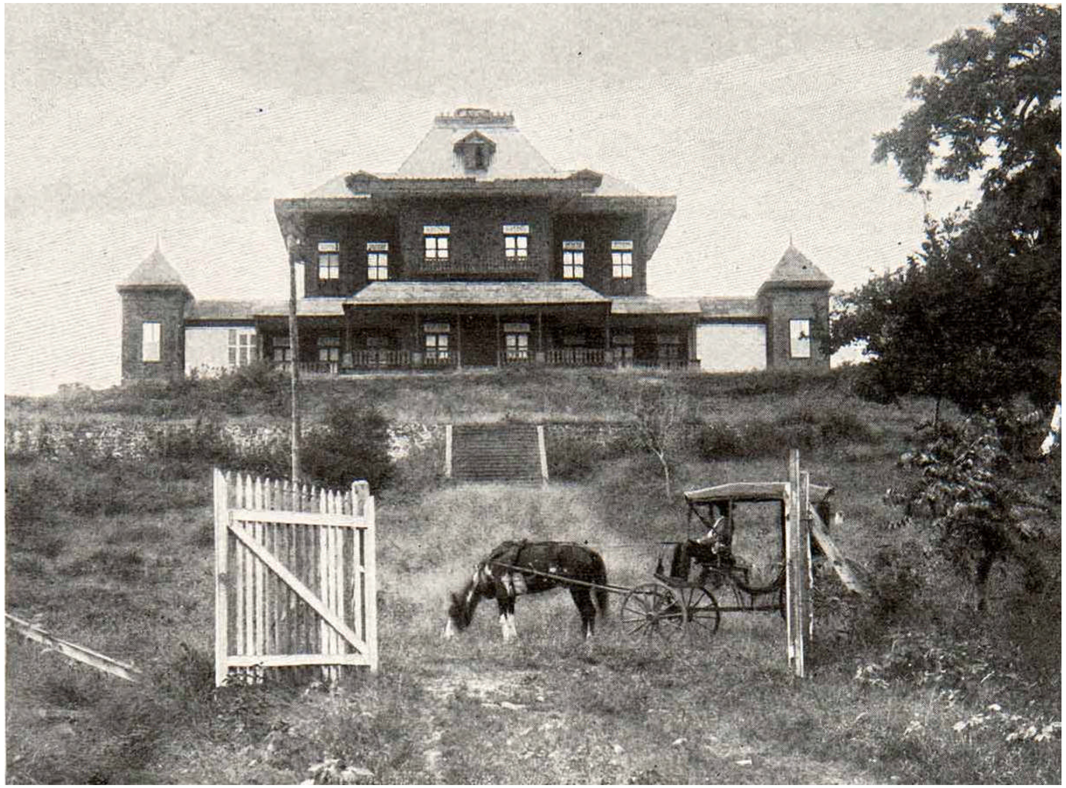
<u>Above</u>: caption: "Digging through the Culebra Mountain: General view looking west, towards Panama." The biggest challenge for the French in building the *Panama Canal* was digging through the *Culebra Hill*. It was only 333-feet high, but it was very difficult to cut a wide valley through it. Since the soil was unstable, the sides kept falling in requiring the workers to continuously dig them out again and again.

La Folie Dingler

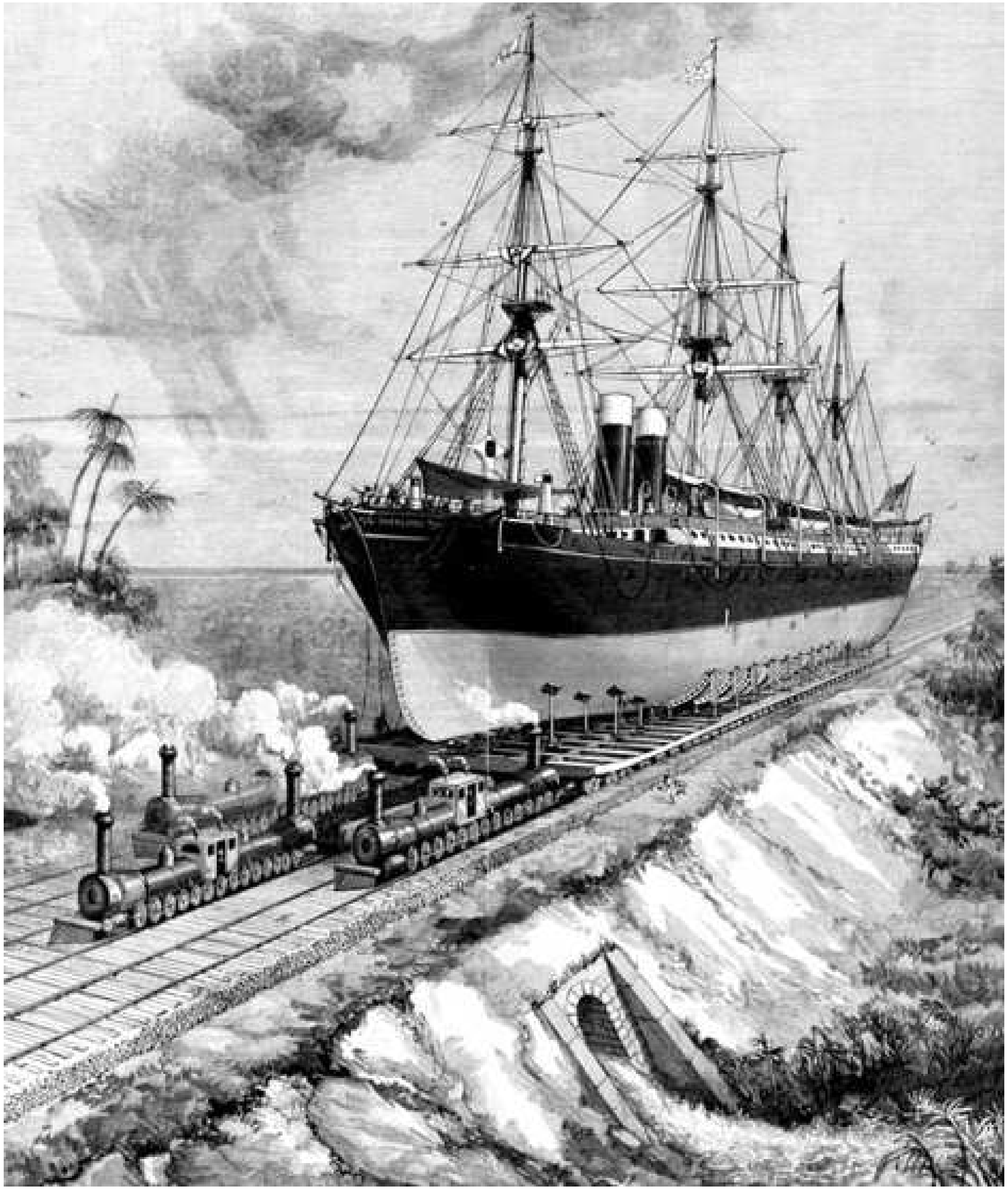
"I am going to show them that only drunkards and the dissipated contract yellow fever and die."

***M. Jules Dingler*, Director General**

RE: stories of the fatal effect the climate of the Isthmus was said to have on foreigners reached *France*, but Dingler (left) scoffed at these reports. He brought with him to the Isthmus his wife, son and daughter. His daughter, Louise, died of *Yellow Fever* in January 1884. A month later, Dingler's twenty-year-old son, Jules – who was made *Director of Posts*, died of the same disease. As if that weren't enough, his daughter's young fiance, who had come with the family from *France*, contracted the disease and also died. He went back to France with his wife on business in June 1884, returning to the Isthmus in October 1884. Then, tragedy struck the Dingler family once more. Dingler's wife died of Yellow Fever, just about a year after her daughter and son had succumbed to the disease. A devastated Dingler stayed on the job until June 1885, after which he relinquished his post and returned to France, a man broken in both body and spirit.

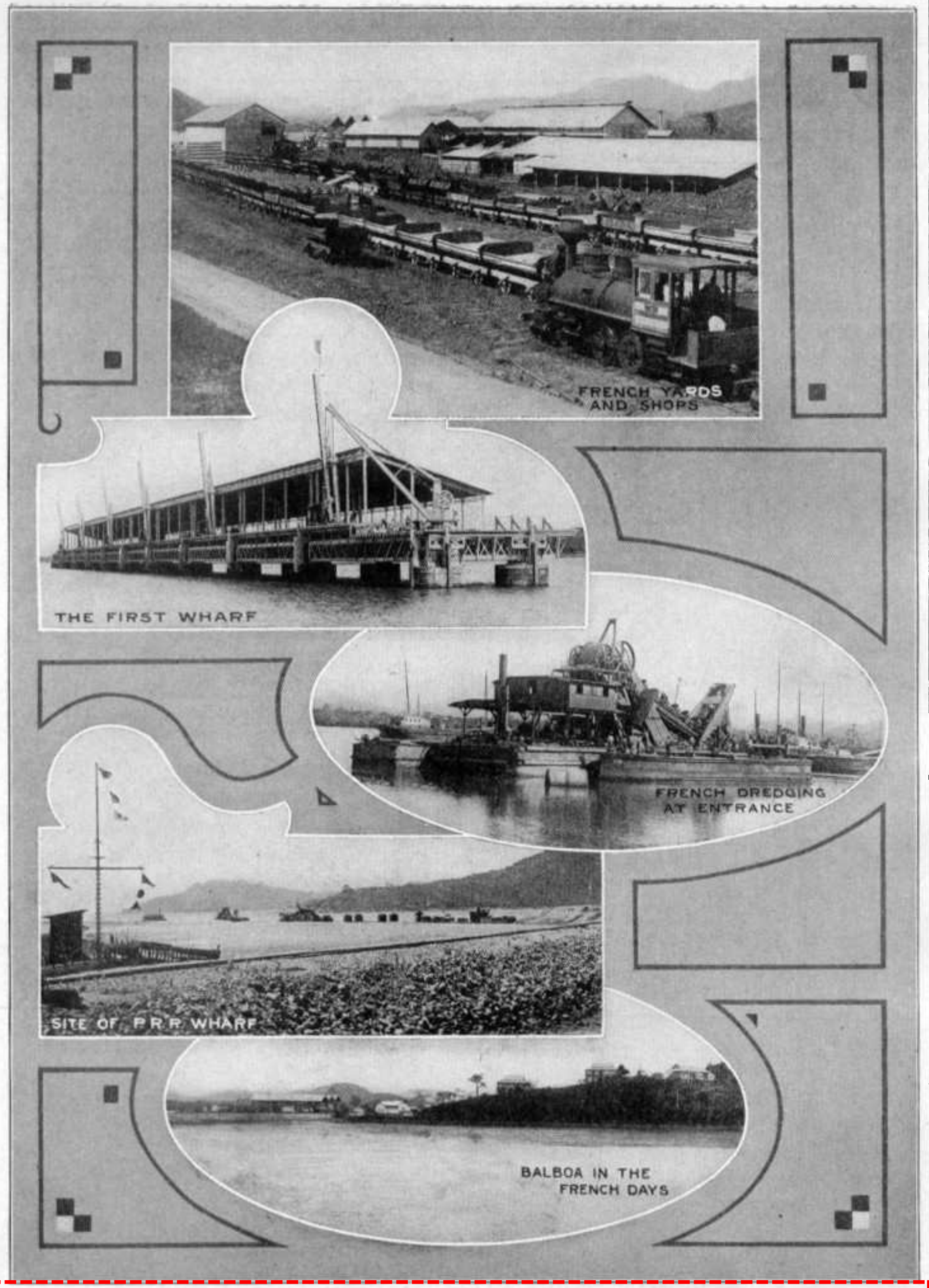


There formerly stood (on an artificial terrace on the western slope of *Ancon Hill*) a building (above) that commanded ready attention from passersby on the road from *Panama City* to *La Boca* (now *Balboa*). It was the prospective home of *M. Jules Dingler*, perhaps the foremost *Director General* of the first French canal company. Prospective because he never occupied it. Work on the mansion was begun shortly after he came to the Isthmus in February 1883 and the cost, including the grounds, is said to have been about $50K. For many years it had been called "La Folie Dingler" (Dingler's Folly). The experience of M. Dingler and his ill-fated family on the Isthmus constitutes one of the saddest incidents in all of French canal history.

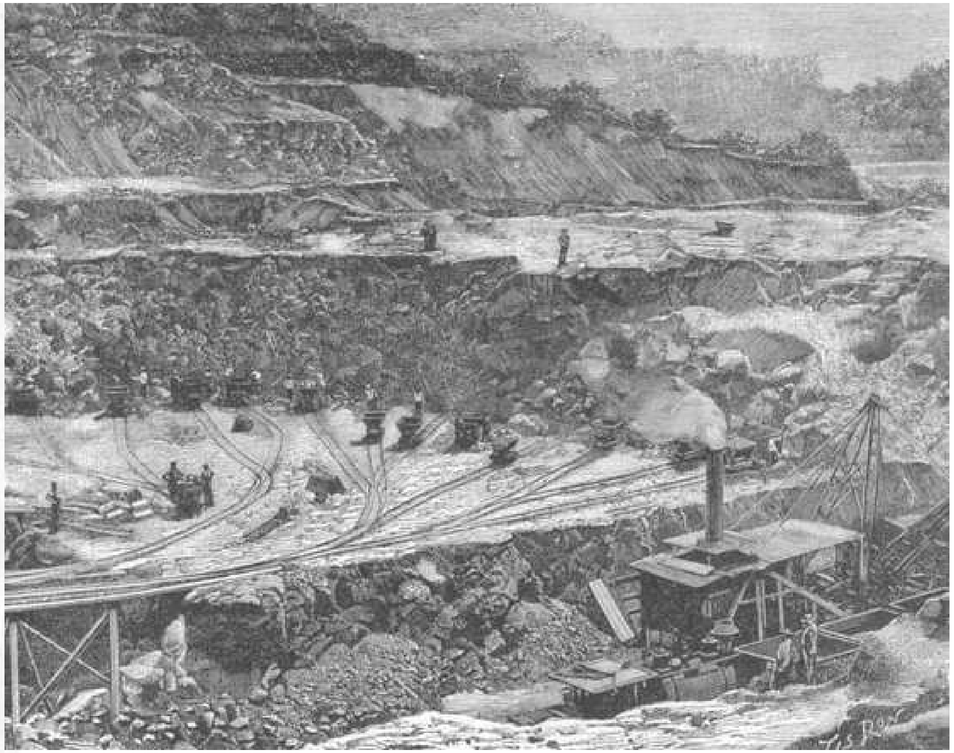


By 1884, work on the *Panama Canal* was proving more difficult and costing more money than anyone had ever imagined. Some engineers, like *James Buchanan Eads*, thought it would be cheaper and easier to put ships on "Ship Railways." Teams of giant steam engines would pull ships across the land on rails from ocean to ocean. Problem was that, like today, ships were getting bigger and heavier. The cargo ship in the illustration at left might weigh 5K-tons. A modern freighter could be 50K-tons. Thus, the railway was never built in *Panama* nor across the *Isthmus of Tebuantepec* in *Mexico* as Captain Eads had planned/hoped.

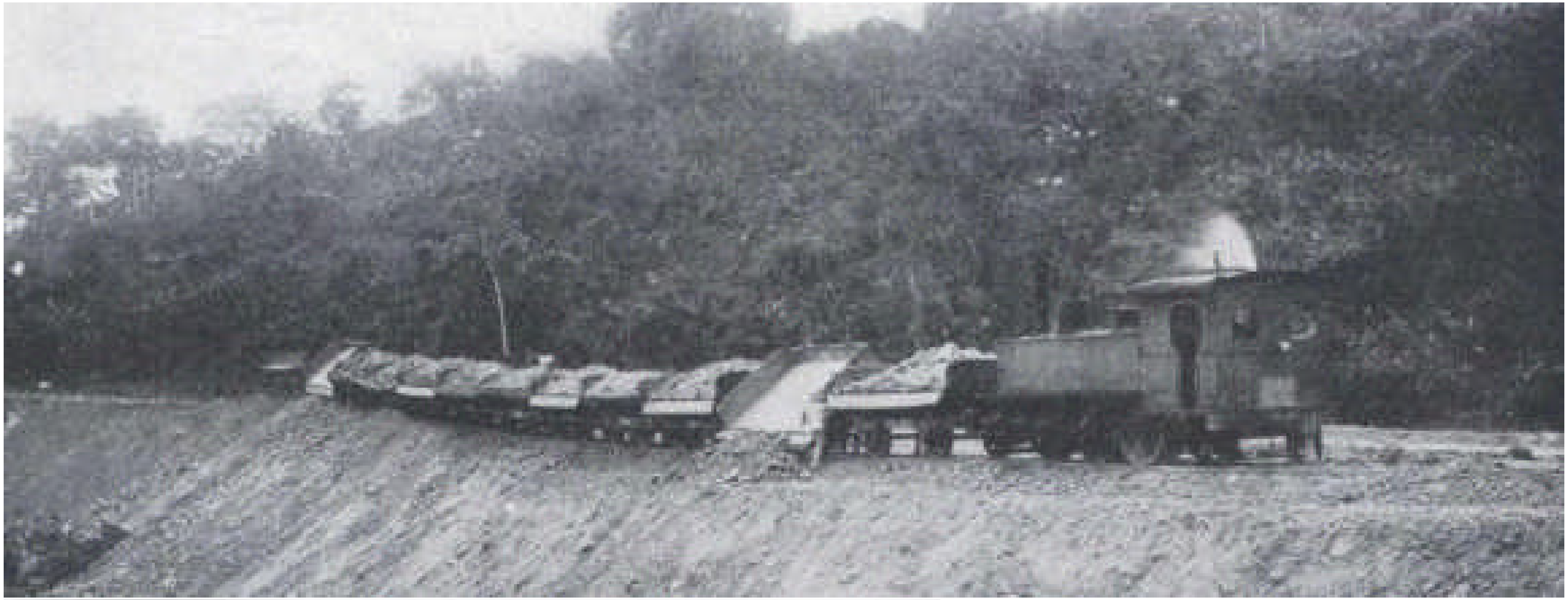
When Dingler and his wife returned to the Isthmus in October 1884, they brought with them a young, capable and energetic engineer named *Philippe-Jean Bunau-Varilla* (left), a man destined to play a pivotal role in the history of *Panama* and of the *Panama Canal.* Bunau-Varilla was assigned as division engineer in the key work of *Culebra* and *Pacific Slope* construction, involving both dry excavation and dredging. At this time, work at Culebra needed someone like Bunau-Vanilla to expedite the work. *Maurice Hutin* was serving as acting *Director General* until he was forced to return to *France* for health reasons. Twenty-six year old, Bunau-Varilla was made acting *Director General*. Worker morale improved under Bunau-Varilla and excavation increased along the line. Still, there was inadequate equipment and work organization. *Decauville* handcars were doing most of the work at Culebra, on the *Pacific*-side. Each of five excavators working on the *Atlantic*-side could remove 300 cubic-meters per day, but lack of spoil trains rendered their work ineffective. As it turned out, removing the spoil was as important as digging it out efficiently.



A group of views of Balboa and the canal entrance and operations, during the days of both the First and Second French Companies. The wharf was the first constructed by the French. The one-sided dump cars shown in the top picture are now obsolete.

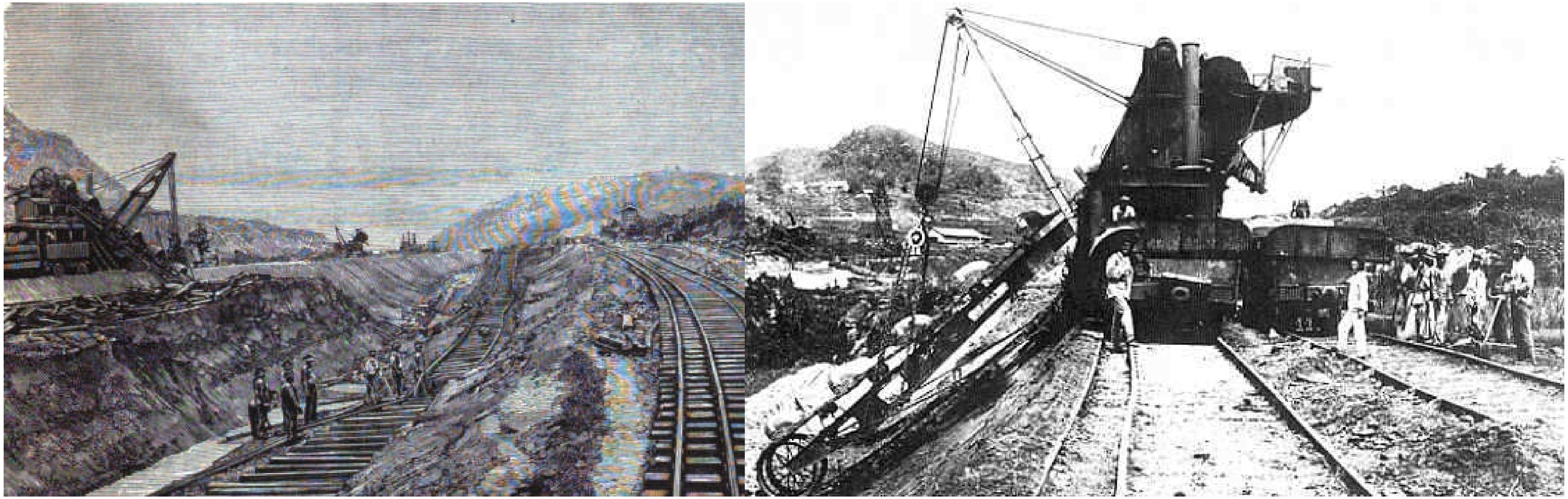


Above: caption: "Work on the San Pablo Section." Work went on over different parts of the canal simultaneously. Here, small rail lines were laid and carts were pushed right up to where the dirt was being dug-out. Workers with shovels would fill the carts and they would then be taken away. The progress on the canal was measured in how many cubic yards of dirt came out of the ground or the river beds each working day.



Above: caption: "Old French dump cars. Steel cars, 18 feet long were used exclusively. The cars dumped one side only, and were too small for economical use. Most of these were scrapped by the Americans."

Left: "Pick & Shovel Brigade" of French canal workers



There continued to be not enough of the right type of equipment; it was still too small and too light and there was a large turnover of the labor force. The spoil disposal system was inefficiently organized and managed, dump areas were too close to the excavation and slid back into the channel whenever the rains came. Drainage ditches built parallel to the canal helped, but ultimately proved inadequate to the task. The deeper the excavation, the worse the slides. Making the slopes less steep by carving them back was another method of alleviating the slides, but this added to the total amount of digging required. And, while the soil slid with ease into the channel, the sticky clay consistency adhered with tenacity to shovels and often had to be scraped off. French bucket-chain excavators got caught and were stopped by stones and rock.

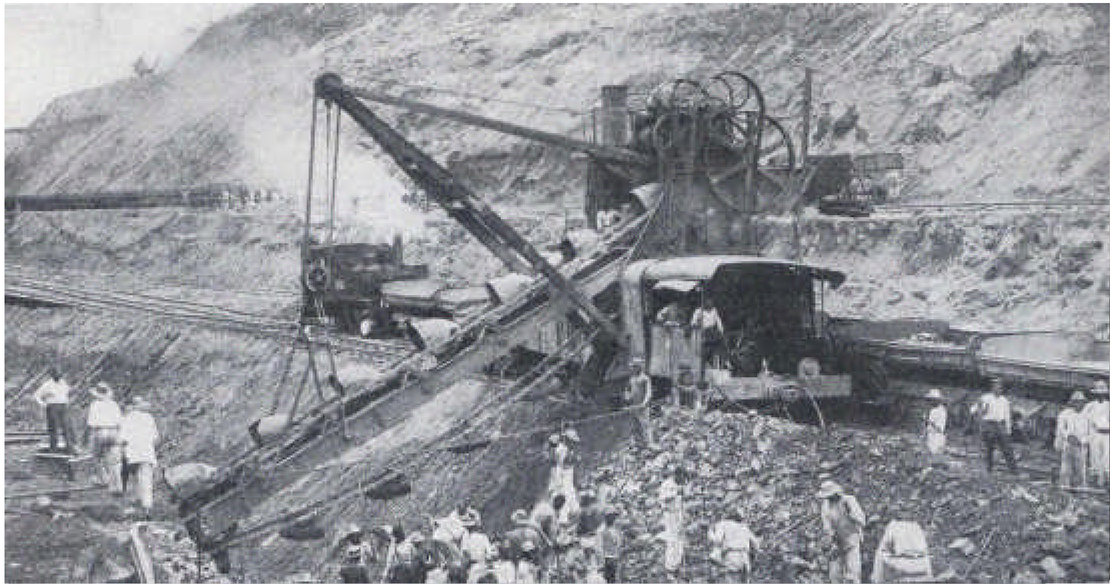
Above: caption: "Work on the Culebra section" (ca. 1885, left) / right: excavator at work near Empire (ca. 1886). Up to 400 cu. yds. Per day could be removed by these machines.

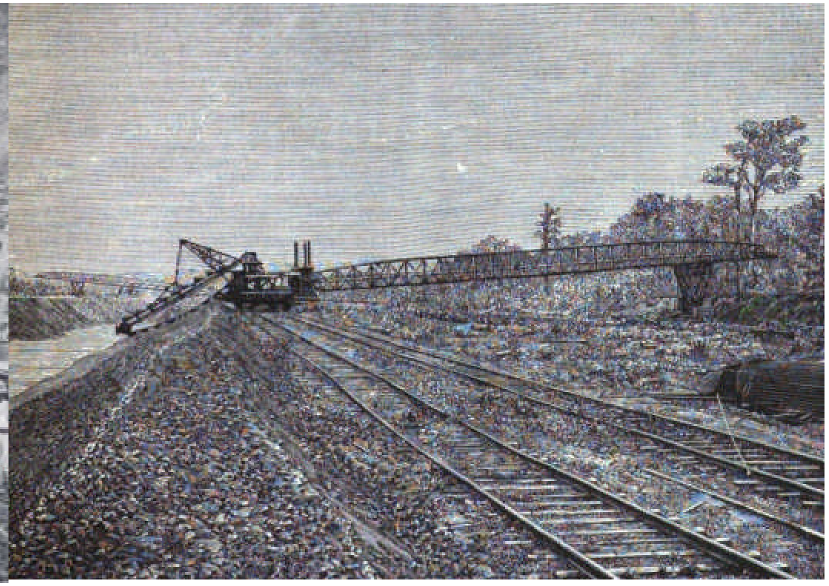
<u>Above</u>: caption: "The Cut in French times, showing their cableway plan of excavation. These cableways carried the material out of the canal and deposited it to one side, but unfortunately not far enough, for much of it slid back into the Cut, causing extra excavation."

<u>Top Left</u>: caption: "View of the Canal at Emperor, on the Western Slope of the Divide. The American Cableway is in use removing materials from the trench"

<u>Top Right</u>: caption: "View of the Canal at a distance of 53 Kilometers from the Atlantic, looking toward Panama City. Workmen are seen digging in the bottom of the excavation."

<u>Left</u>: caption: "View of the Canal as it appears 52 Kilometers from the Atlantic. Looking toward Colon and showing American Cableway."





Top Left: caption: "A French excavator opening a pioneer trench in the south end of the Cut. This was the best known method of excavating in that day"

Top Right: caption: "Work on the Tabernilla Section"

Left: caption: "Las Cascadas"

Above: caption: "View near Folk's river, opposite the mouth of the canal at Colon"
Left: caption: "Using drills on a rocky eminence"

One contractor had let so many subcontracts in Culebra's western hill (at the saddle) that it became known as "Contractors Hill." In a move toward greater efficiency, Bunau-Varilla went back to the old scheme of large contractors, but instead of just one, hired several. Hand labor was cut considerably. As late as July 1885, only about 10% of the estimated total had been excavated. Ultimately, the unresolved problem of the slides would doom the sea-level canal plan to failure.

<u>Above</u>: caption: "The valley of the Rio Grande in the French days. The present canal is between the hills. The old Panama RR bridge is shown at the south end of the Cut"

All the while, the toll in human lives was mounting, peaking in 1885. *Yellow Fever*, which used to come in two or three year cycles, was now constant. *Malaria* continued to take even more lives than Yellow Fever. Because the sick avoided the hospitals whenever possible (because of its reputation for propagating disease), much of the death toll was never recorded. A new *Director General*; *Leon Boyer*, arrived in January 1886, relieving Bunau-Varilla. Soon after, Bunau-Varilla contracted Yellow Fever, but did not die. However, greatly weakened, he went back to *France* to recuperate. Boyer communicated to his superiors his conviction that, within current time and cost limits, it would be impossible to construct a sea-level canal. To soften the report, he recommended the design proposed by Bunau-Varilla of a temporary lake and lock canal that could later, after it was built and functioning, be gradually deepened to sea-level. But, by May 1886, he too was gone - another victim of Yellow Fever. The job of provisional director went to his assistant; *Nouailhac-Pioch*, until another Director General (a man by the name of *Jacquier*), the sixth since 1883, was appointed in July 1886, a position he held until 1888.

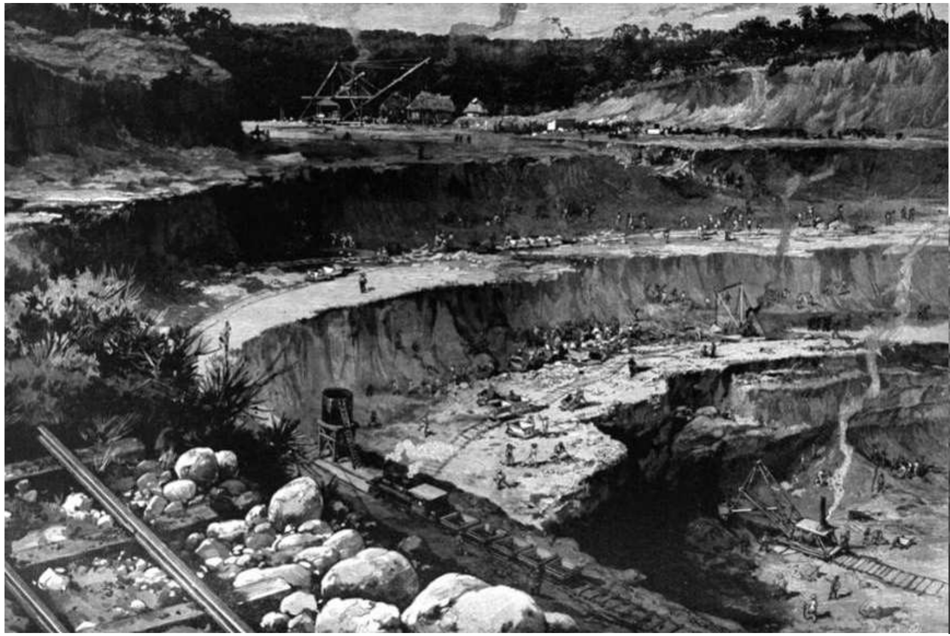
"…It is necessary to state precisely that (1) the company but temporarily renounces the great and broad solution of a level canal; (2) that the work already done will all be utilized; and (3) that the change in front consists solely in the intervention of important works that are alone capable of leading to a provisional exploitation, during which, as at Suez, it will be possible to continue the operation of deepening to a level…"

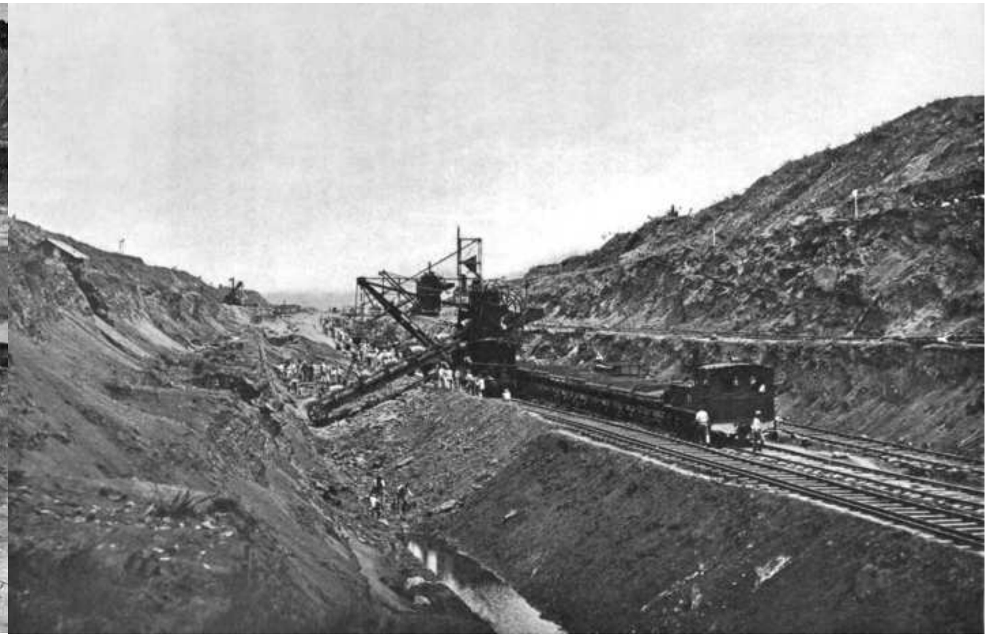
Scientific American Supplement, **March 10th 1888**

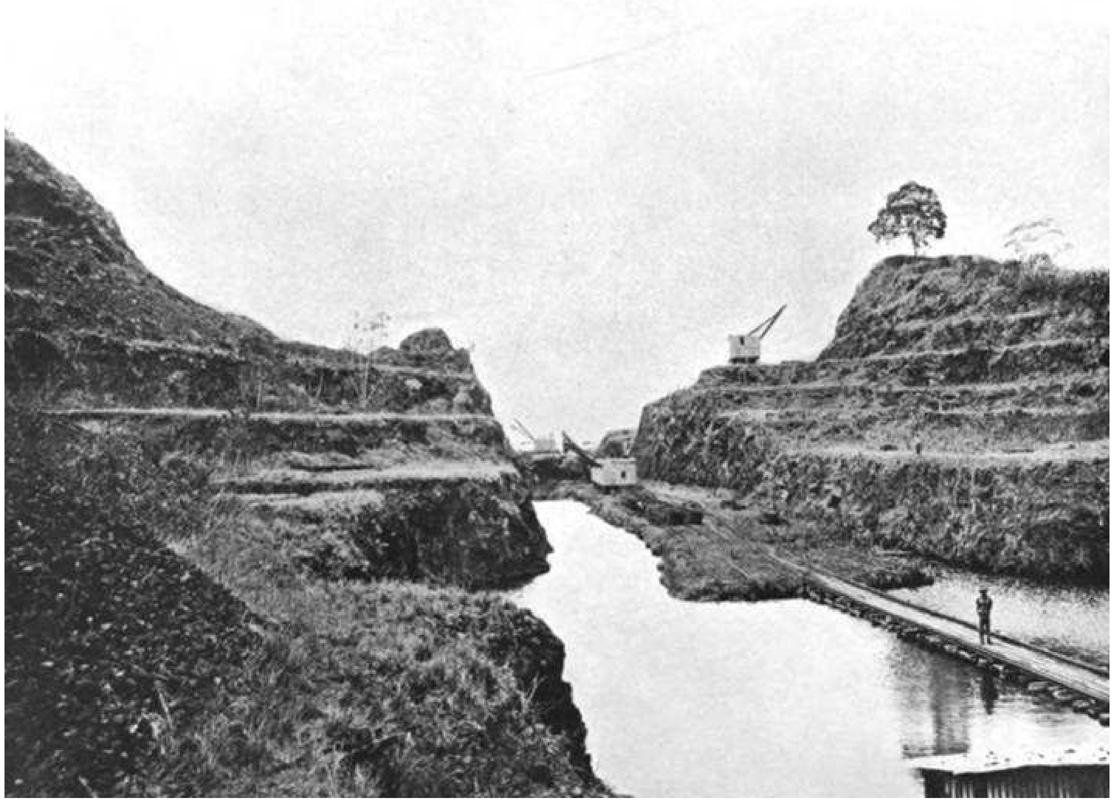
Early in 1885, it became apparent that the canal could not be completed under the sea-level plan within the time or estimated cost. During 1884, the promoters foresaw the end and began to sell their stock. *M. Leon Boyer*, who succeeded *M. Jules Dingler* as *Director General*, had time to report before his death from *Yellow Fever* a few months after his arrival on the Isthmus that the canal could not be completed by 1889 and submitted a plan for a lock canal. In May 1885, de Lesseps asked the French Government for authority to issue lottery bonds for a loan of $120 million, to replenish the depleted treasury. Before granting permission, the French government sent out *M. Armand Rousseau*, an eminent engineer, to investigate conditions. He reported that the canal could not be finished within the time and cost estimated unless changed to the lock plan. Similar reports were made by an engineer sent out by the company and by the agent of the Colombian government on the Isthmus, the latter stating that the canal could not be completed before the expiration of the concession in 1892. In February 1885, Lieutenant/s Winslow and McLean of the *United States Navy* reported that there remained to be excavated 180 million cubic yards; that the work would take twenty-six years at the present rate of progress and that the cost would total $350 million. De Lesseps withdrew his request for permission to issue lottery bonds, but would not consent to a change in plans from a sea-level canal. He obtained temporary financial relief by the issue of bonds to the value of about $70 million, but as money again began to get scarce, he consented to a change in plan and in October 1887, a temporary lock canal, with summit level above the flood line of the *Chagres River*, to be supplied with water by pumping was decided upon. Under the new plan, it was estimated that the cost would reach $351 million and would require twenty years to build. There had already been spent at this time nearly $250 million and only about 20% of the work had been completed. The end was in sight.

By 1886, the area of heaviest excavation; the stretch between *Matachin* and *Culebra,* appeared to be one continuous project. The French organization on the Isthmus had, though top-heavy with management, improved, and equipment was plentiful. Housing was clean and adequate (although not screened against flies and mosquitoes). In spite of improvements, a lack of progress at Culebra was beginning to concern Parisian officials. *Charles de Lesseps* proposed to Bunau-Varilla the organization of a company to take on the work at Culebra, which he did in July 1886. The company was called "Artigue, Sonderegger et Cie," after the two engineers who were the company's technical members. Bunau-Varilla decided to take over the actual field supervision of the work himself. As American engineers would do later, he moved into quarters at *Culebra Cut* so he could watch the progress of the work. About six months later, the French work at Culebra had reached peak activity. Twenty-six French excavators were digging and carrying the spoil to the dump site; still the *Panama Railroad* had not been harnessed to the effort of hauling spoil.

<u>Above</u>: excavation between Empire and Culebra







<u>Top Left</u>: caption: "The Panama Canal – The Great Colima Cutting in 1886"

<u>Top Right</u>: caption: "View of the canal excavation at a distance of 53 kilometerss from the Atlantic, showing French excavators loading cars"

<u>Left</u>: caption: "View of the excavation at La Corasita, showing the canal at a distance of 45 Kilometres from the Atlantic"

The Inter-oceanic Canal Question

“Mr. J. Foster Crowell lately read a paper before the Engineers’ Club of Philadelphia upon the Present Situation of the Inter-oceanic Canal Question, presenting the subject from a general standpoint. He sketched the history of the various past attempts to establish communication through the American Isthmus, and traced the developments in the different directions of effort, which finally concentrated the problem upon the three projects now before the world, summarizing the progress in each case, and stating the following propositions:

I. That Panama is the only possible site for a Sea Level Canal, and that such treatment is the only feasible method at that place.

II. That Nicaragua is the only practicable site for a Slack Water system (for a canal with locks), and that it is pre-eminently adapted by nature for such a use; that there are no obstacles in an engineering sense, and no physical drawbacks that need deter the undertaking.

III. That the Ship Railway, as a mechanical contrivance, has the endorsement of the best authorities, and may be admitted to be the ‘ne plus ultra’ as a means of taking ships from their natural element and transporting them over the land.

IV. That none of these plans has as yet advanced sufficiently to warrant our considering its completion as beyond doubt.

V. That, as the additional sum now asked for by De Lesseps (even if sufficient) to complete the Panama Canal is greater than the estimated cost of either Nicaragua Canal or the Ship Railway, it would be economical to abandon the Panama Canal, and the money sunk in it, to date, unless its location and form possess paramount advantages; and we therefore may profitably consider the relative merits of the three lines without regard to the past, from four standpoints, viz.:

1. Geographical convenience of location.

2. Adaptiveness to all marine requirements, present and future.

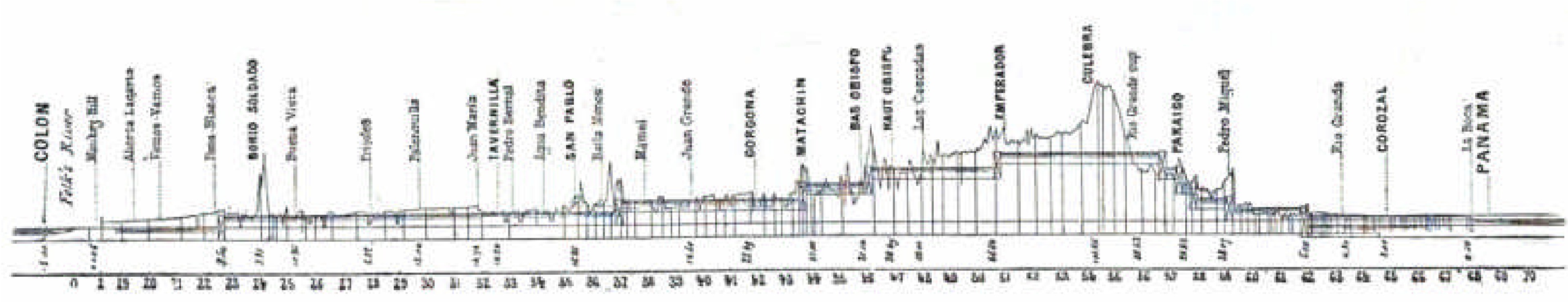
3. Political security.

4. Economy of construction and operation…”

Scientific American Supplement, **February 27th 1886**

"…He then discussed the comparative claims to excellence. In the first consideration, after classifying the several grand divisions of future ocean traffic, and noting especially the needs of the United States, he claimed that while there was little to choose, in this respect, between Nicaragua and Tehuantepec, either was far superior to Panama. In the second particular he maintained that owing to the characteristics of the Panama Canal and the practical impossibility of enlarging it hereafter, excepting at stupendous cost, it could not serve the purposes of the future, although it might, if completed, supply present need. He praised the ingenuity of the plans for the Ship Railway, but emphasized the fact that it will be the movement of the traffic, not merely the lifting and supporting of ships in transit, that will test the system, and suggested that even the beautiful application of mechanical force which had been contrived might be powerless to insure the high grade of service which is an absolute necessity. In this connection the general features of the Nicaragua Canal, in its latest form, were referred to, and the opinion expressed that even were all difficulties in the way of the Ship Railway eliminated, it could not be superior to the canal in respect of adaptiveness. In point of political security he claimed that both Tehuantepec and Nicaragua were reasonably free from doubts, with the advantage in favor of the latter, while at Panama no security, for United States interests at least, could be counted on, without the liability of a military expenditure far exceeding the cost of the canal itself. The matter of comparative cost of construction and operation was discussed generally, and in conclusion the author stated that 'this all-important question is still an open one, of which the future needs of our country justify and demand at this time a most searching scrutiny, and moreover our interest and the interest of mankind require that before this century closes, the best possible pathway between the Atlantic and the Pacific shall be open to the navies of the world.' The paper was illustrated with maps and diagrams."

Scientific American Supplement, **February 27th 1886**

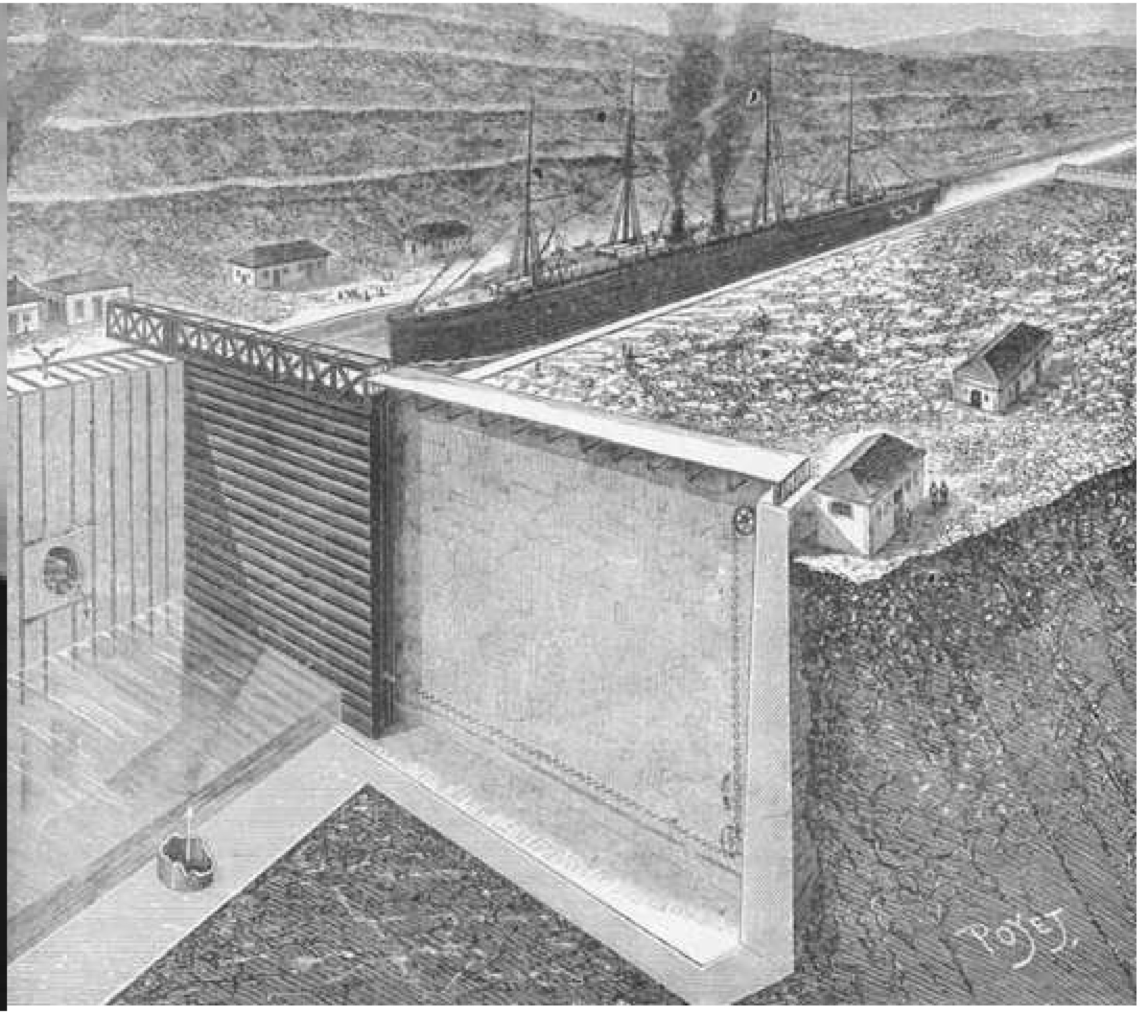


When de Lesseps finally agreed to consider making a change in plans, he delayed the inevitable for another nine months with the study of alternate plans. In October 1887, the *Superior Advisory Committee* released its report. The eminent French engineers established the possibility of building a high-level lock canal through the *Isthmus of Panama*. The plan would allow vessel transits while, simultaneously, permitting dredging of a channel to sea-level sometime in the future. It was never intended to be a permanent solution. De Lesseps finally, though reluctantly, agreed. Bunau-Varilla's idea was to create a series of pools in which floating dredges could be placed; the pools would then be connected by a series of ten locks. The highest level of such a canal would be 170-feet. Work on the lock canal started on January 15th 1888. *Gustave Eiffel*, builder of the Eiffel Tower in Paris, would construct the canal locks. The waterway would have a bottom width of 61-feet.

<u>Above</u>: caption: "Longitudinal Profile of the Lock Canal" (1888)

"…has recognized the necessity of a provisional solution to the question, and has decided to construct, with as brief delay as possible, a lock canal. Here it is that intervenes Mr. Eiffel, whose personal experience guarantees the possibility of rapidly constructing the necessary locks after a few slight modifications in the direction line, and through well established junctions, in the general plan, with the work under way. When the locks are established, the company will have a provisional communication between the two oceans, and will find itself in a position to provide for an exploitation responding to the first total traffic expected by the congress. It will be Mr. Eiffel's sole mission to study the question of storing the water and of the means of feeding the lock canal thus established…"

Scientific American Supplement, **March 10th 1888**



<u>Above Right</u>: caption: “Sliding Locks of the Panama Canal – Designed by Eiffel for Canal with Locks, 1888.” The French finally realized after their bitter experience trying to dig a sea-level canal that it would be easier to build a lock canal whereby the waterway would go over the hills instead of through them. Locks are a part of the canal that has gates at both ends. Ships entering the locks can be raised or lowered by flooding and/or draining the lock. Gustave Eiffel (left), the famous engineer who had built the *Eiffel Tower*, designed the huge lock gates in 1888. He wanted to use large sliding doors as illustrated at right.

"…The essential thing to state is that the system of locks adopted has not been combined or devised for the needs of the cause – it exists. Mr. Eiffel can answer for its operation and base his expectations on striking examples borrowed from the history of great public works. Any other project for traversing the two Americas, moreover, would have necessitated locks of this or some other kind, from the moment that the necessity of opening the canal at a fixed date intervened. The fantastic ship railway proposed by the late Captain Eads would have alone escaped the practical necessity. The dead canal is the only desirable and final one – the lock canal is an immediate and practical solution…"

Scientific American Supplement, **March 10th 1888**

Above: northern end of excavation for proposed lock at *Bas Obispo*
Left: hilltop at Bas Obispo torn up by dynamite. The French dump cars had a capacity from five to eight cubic yards.

The Crash

In *Culebra Cut*, where the average level had been lowered only three-feet in 1886, was lowered ten-feet in 1887 and twenty-feet in 1888, ultimately bringing the level to 235-feet at the time work was stopped. Under *Artigue, Sonderegger et Cie*., work was going very well indeed. Some areas of the canal were nearly complete, the *Panama Railroad* was being rerouted away from the cut, the first lock was nearly ready to begin installation and preliminary work on a dam had been started. But suddenly there was no more money. The crash came in December 1888. At this time, $156,654,687 had been expended on the Isthmus, and in *Paris*, $78,140,330, for a total of $234,795.017l. This vast sum is said to have been "one-third expended on the canal work, one-third wasted, and one-third stolen." Of that spent at Panama, salaries and expenses of management aggregated $16,540,883; rents and maintenance of leased property, $3,301,070; material and supplies, $29,722,856; buildings, $15,397,282; construction and engineering expenses, $89,434,225; land purchases, $950,655; and medical and religious attendance; $1,836,768. In view of the various forms of graft, extravagance and waste, it's not surprising that there was so little to show in actual work accomplished. At the end of eight years the work was about two-fifths completed. A public subscription asked for by de Lesseps had failed. Shareholders, at their last meeting in January 1889, decided to dissolve the Compagnie Universelle, placing it under legal receivership under the direction of *Joseph Brunet*. An ignominious end to the great French effort. Some aspects of the work struggled on for a few months, but by May 15th 1889, all activity on the Isthmus ceased. Liquidation of the company was not completed until 1894.

A RECEIVER TAKES OVER THE PANAMA CANAL COMPANY

On the fourth day of February, 1889, the civil court of the Seine appointed Joseph Brunet judicial receiver of *La Universelle Compagnie du Canal Interoceanique de Panama.*

We will give a brief statement of the receipts and expenditures of the Panama Canal Company from the date of its organization until the end of the year 1889.*

RECEIPTS.

Proceeds from the Capital Stock, various loans and bond issues	†$254,336,547
Other receipts from sundry sources	7,933,317
Expenses incurred but not paid	3,668,770
Total amount collected and due by the Company	$265,938,634

EXPENDITURES.

(Outlay on the Isthmus.)

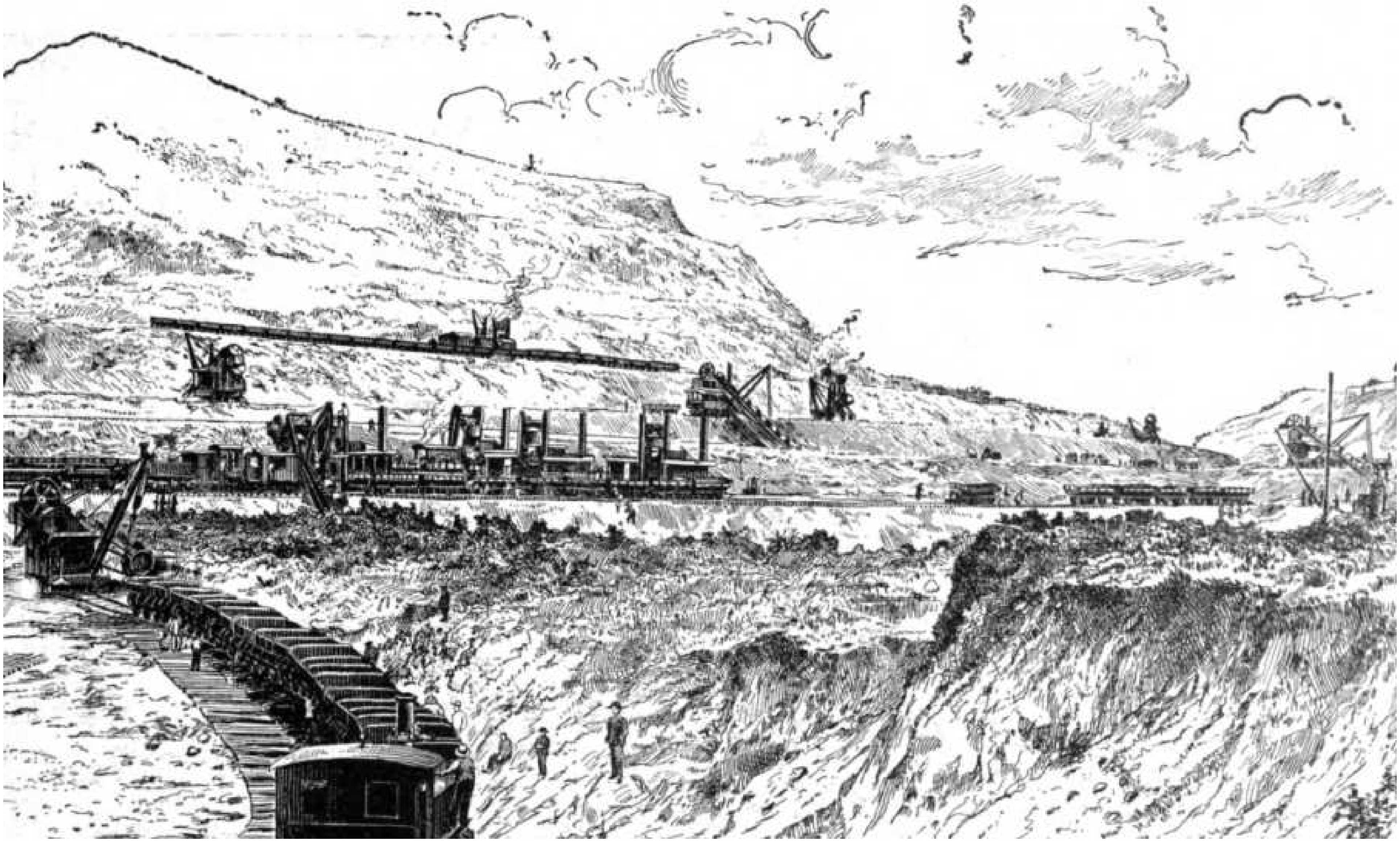
Salaries and expenses of management	$16,540,883
Rents and maintenance of leased property	3,301,070
Purchase of articles and material for consumption	5,847,920
Purchase and transportation of machinery, etc	23,874,935
Surveys and preparatory work	270,946
Central workshops and management	5,989,577
Various constructions, buildings, and general installation	9,407,705
Work of excavation and works of construction	89,434,224
Purchase of lands	950,655
Sanitary and religious service	1,836,768
Total expenditures on the Isthmus	$156,654,687

(Outlay at Paris.)

Paid for the Concession	$2,000,000
Paid to the Colombian Government	150,000
Various expenses incurred before organization	4,612,244

* A few comparatively small sums should strictly come within the account of 1890, but, for the present purpose, may without impropriety be included in the above statement.

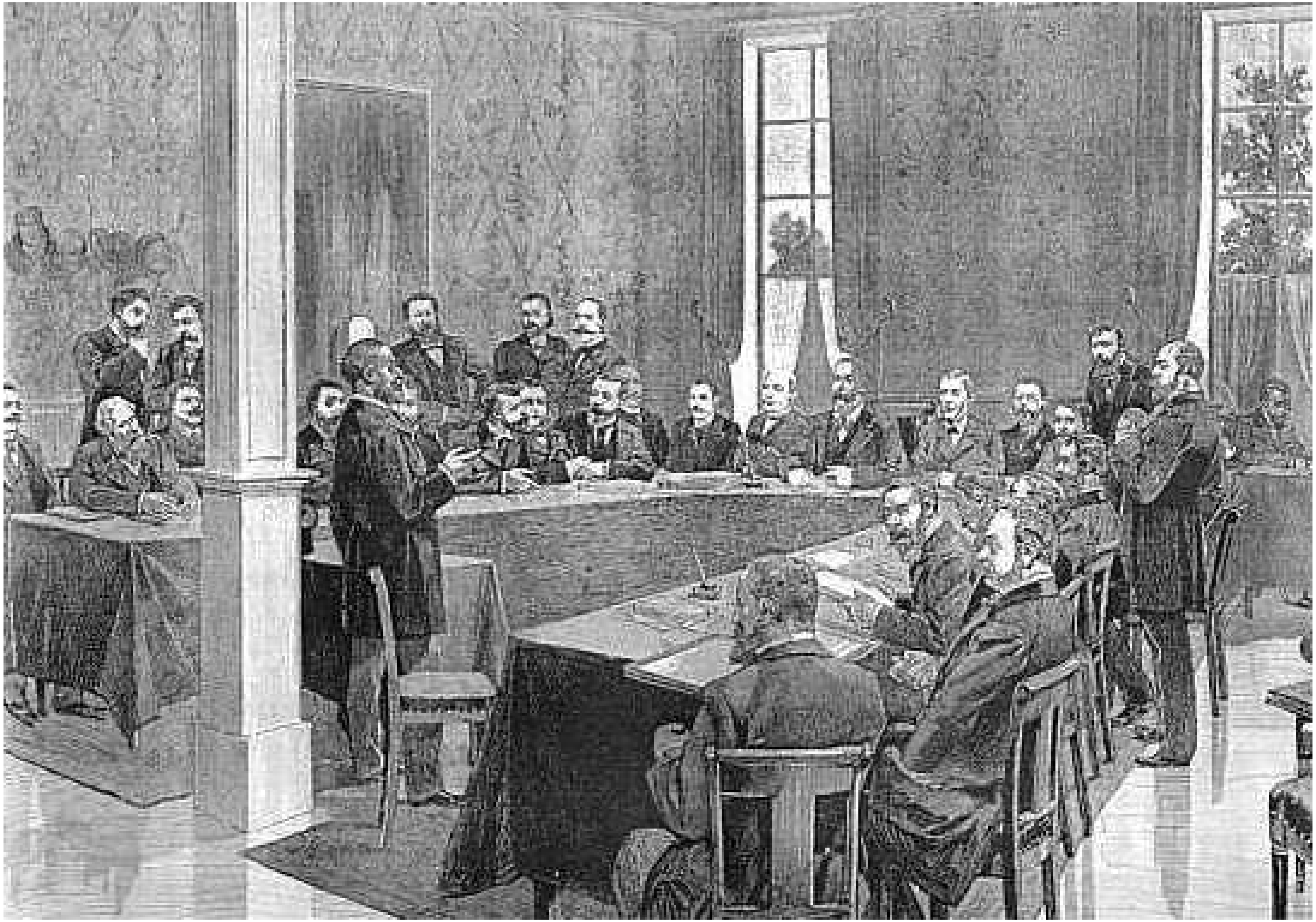
† Fractions have been discarded throughout.



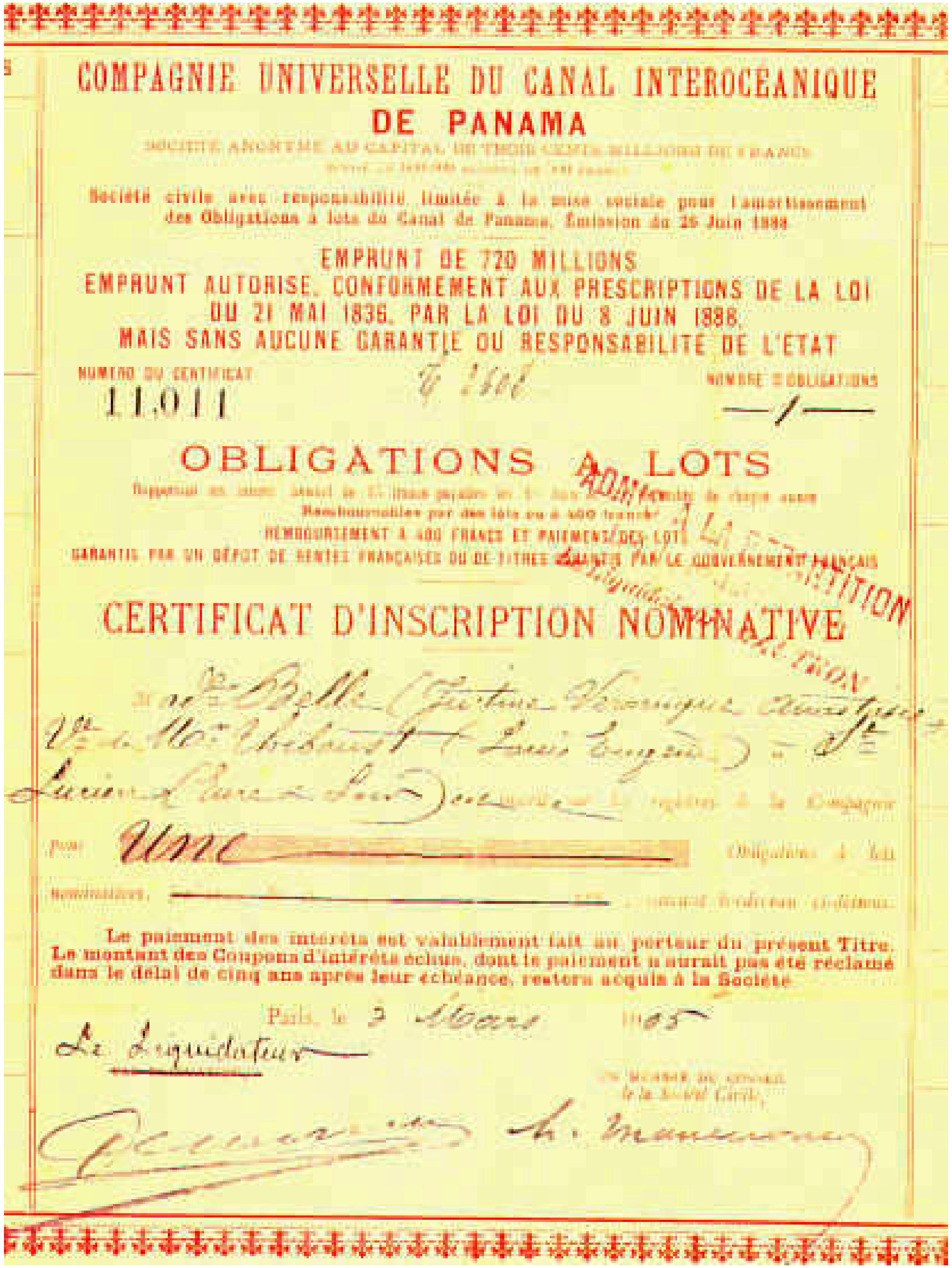
<u>Above</u>: caption: “Culebra Cut, Panama Side, In 1889”

The Panama Affair

In France, popular pressure on the government regarding what was called the "Panama Affair" (a.k.a. "Panama Plunder") led to prosecution of company officials, including *Ferdinand* and *Charles de Lesseps*, who were both indicted for fraud and maladministration. Advanced age and ill health excused the senior de Lesseps from appearing in court, but both were found guilty and given five-year prison sentences. However, the penalty was never imposed, as the statute of limitations had run out. Charles, in a second trial for corruption, was indicted and found guilty of bribery. Months he had already spent in jail during the trials were deducted from his one-year sentence. Then, becoming seriously ill, he served the remainder of his sentence in hospital. *Gustave Eiffel* was also convicted of fraud for charging for materials he never supplied to the canal company but escaped serving his two-year sentence due, also, to statute of limitations expiration. The work was let to contractors, very few of whom faithfully performed the service for which they were paid. Many made small fortunes. In many cases, the excavation contractors took out what was most easily excavated, avoiding the difficult spots. One notable exception to this was the dredging work done by the *American Dredging and Contracting Company*, which dredged the opening of the canal from *Colon* to beyond *Gatun.*



<u>Above</u>: *Compagnie Universelle du Canal Interoceanique,* liquidation court trial in Paris, 1891


COMPAGNIE UNIVERSELLE DU CANAL INTEROCÉANIQUE
DE PANAMA

EMPRUNT DE 720 MILLIONS
EMPRUNT AUTORISÉ, CONFORMÉMENT AUX PRESCRIPTIONS DE LA LOI DU 21 MAI 1836, PAR LA LOI DU 8 JUIN 1888,
MAIS SANS AUCUNE GARANTIE OU RESPONSABILITÉ DE L'ÉTAT

NUMÉRO DU CERTIFICAT 11.011

NOMBRE D'OBLIGATIONS —1—

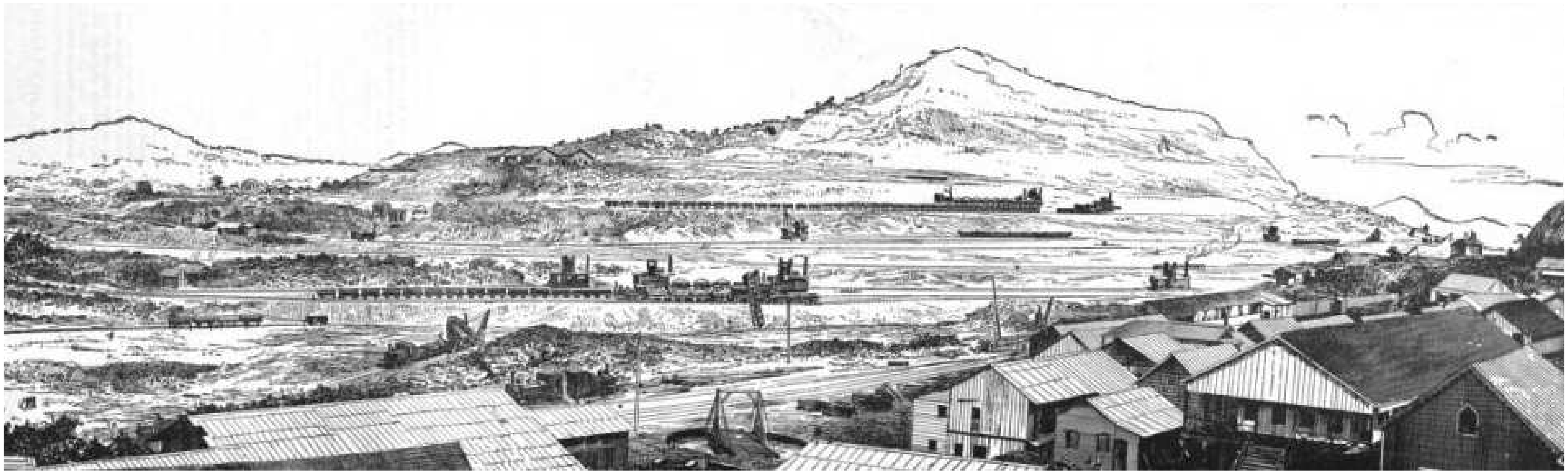
OBLIGATIONS A LOTS

CERTIFICAT D'INSCRIPTION NOMINATIVE

Le paiement des intérêts est valablement fait au porteur du présent Titre. Le montant des Coupons d'intérêts échus, dont le paiement n'aurait pas été réclamé dans le délai de cinq ans après leur échéance, restera acquis à la Société.

After liquidation of the company in began in May 1889, it was soon realized that the only way anything could be salvaged for the thousands of stockholders was to continue the project. Late in 1889, the receiver appointed a commission composed of French and foreign engineers, eleven in number, to visit the Isthmus and determine whether or not the canal could be completed. This commission reported on May 5th 1890 that a lock canal might be completed within eight years at a cost of $174.6 million. It reported that the plant on hand was in good condition and would probably suffice for completing the canal. It also estimated the value of the plant and the work already accomplished at $87.3 million, or one-half of the total cost.

Left: liquidation notice



"…The enormous amount of material at hand ready to be utilized, the great number of works established, lands received, labor actually expended, experience gained, supplies laid in, preliminaries mapped out, including the right of way, are worth to the new company at least $90,000,000…"

***Committee of Investigation,* 1889**

<u>Above</u>: caption: "The Great Culebra Cut Through the Divide in 1888"

The New Panama Canal Company

ORGANIZATION OF

THE NEW PANAMA CANAL COMPANY.

OCTOBER 20, 1894.

The Receiver asked for and obtained from the Colombian Government two successive extensions of the concession, extending the time for the completion of the Canal to October, 1904. (*The Government of Colombia has just granted an additional extension of six years more.*)

Finally, in 1894, the Court and those having legal charge of the interests of the old Company made an impartial examination of the situation and came to the following conclusions:

FIRST.—*That the work actually aocomplished by the old Company in the Isthmus was very large, substantial and available.*

SECOND.—*That notwithstanding an interregnum of four years, the work previously accomplished was in a satisfactory condition.*

THIRD.—*That the locations occupied, and the plant on the Isthmus, had been well cared for by the Receiver, and were sufficient for the continuation and accomplishment of the work without extensive and expensive preparation.*

FOURTH.—*That the climatic dangers, the difficulties of the undertaking, and the cost necessary for its accomplishment, had been grossly exaggerated.*

It was therefore resolved to reorganize the old Company, under new management and new conditions.

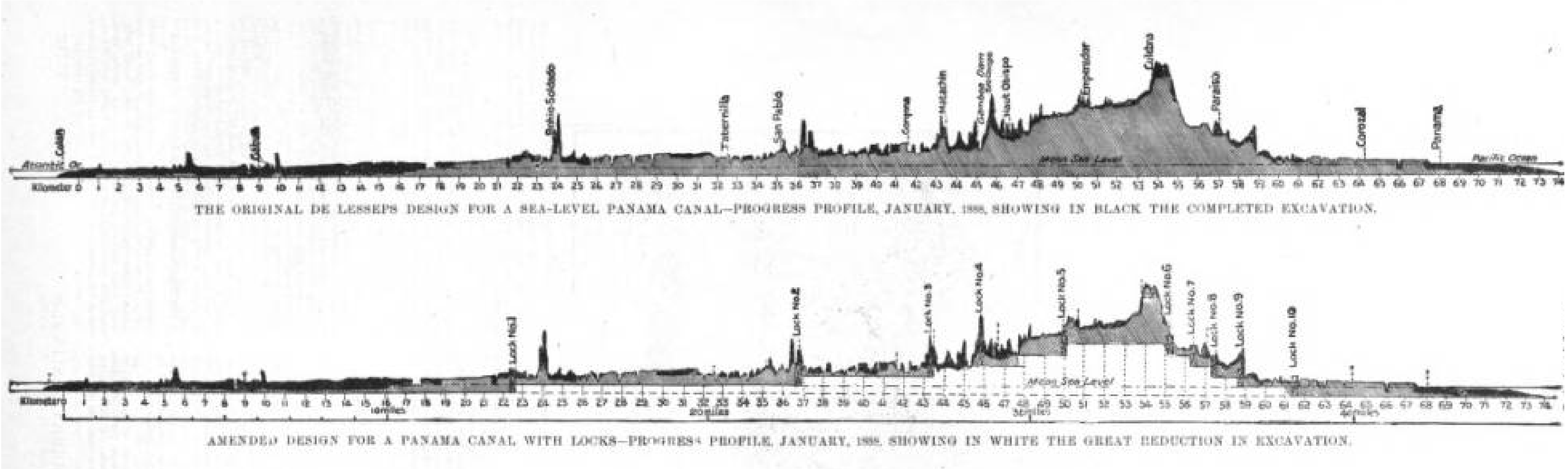
On the one hand the work was to be renewed and continued.

On the other hand, to ascertain by investigation and the widest experience, whether the construction of the Canal could be completed under reasonable conditions of time and money.

It was in this spirit that the New Panama Canal was organized in October, 1894, under the general laws of France. Its constitution and method of operation were rigorously restricted.

With the *Wyse Concession* nearly expired, the receiver obtained from *Colombia* an extension of ten years (to 1904). It was stipulated that the new company should be formed and work upon the canal resumed on or before February 28th 1893. As this condition was not fulfilled, a second extension of six years was obtained (to 1910) to run not later than October 1894. The *Compagnie Nouvelle du Canal de Panama* (the "New French Canal Company"), as it is generally known, was organized under a special law on October 20th 1894, with a capital stock of $13 million and shares valued at $20 each. Six hundred thousand shares were sold for cash, the greater part being taken by the receiver, the contractors, and others, who had been interested in the old company and escaped criminal prosecution by taking the new stock; and 50K shares given to the Colombian government for the extension of the concession. The new company took possession in 1894, and work was immediately resumed in *Culebra Cut* with a force large enough to comply with the terms of the concession. As excavation work to this point was necessary under any plans that might be decided upon, it was continued, while elaborate and extensive studies of the canal project were begun by competent engineers.

Above: Culebra Cut - second French canal company (1894)



THE ORIGINAL DE LESSEPS DESIGN FOR A SEA-LEVEL PANAMA CANAL—PROGRESS PROFILE, JANUARY, 1888, SHOWING IN BLACK THE COMPLETED EXCAVATION.

AMENDED DESIGN FOR A PANAMA CANAL WITH LOCKS—PROGRESS PROFILE, JANUARY, 1888, SHOWING IN WHITE THE GREAT REDUCTION IN EXCAVATION.

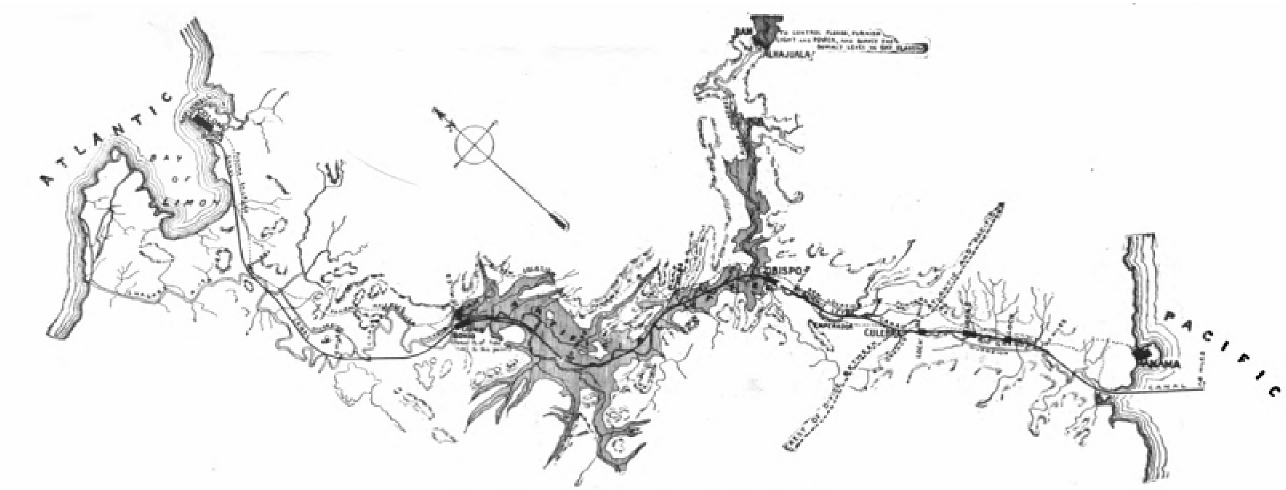
"…The new company decided at the outset to abandon De Lessep's extravagant idea of a sea-level canal and substitute a system of locks. This decision opened up the question of sufficient supply of water to compensate for losses and supply the summit level. The floods of the Chagres evidently afforded an abundant supply, and the problem then took the form of an investigation of the amount of the Chagres River discharge and the possibility of storing it in suitable reservoirs, which should at once serve to feed the summit level and to hold back the rush of the Chagres waters in times of flood. With the question of the Chagres control was associated that of the most desirable elevation of the various locks…"

***Scientific American Supplement,* January 18th 1902**

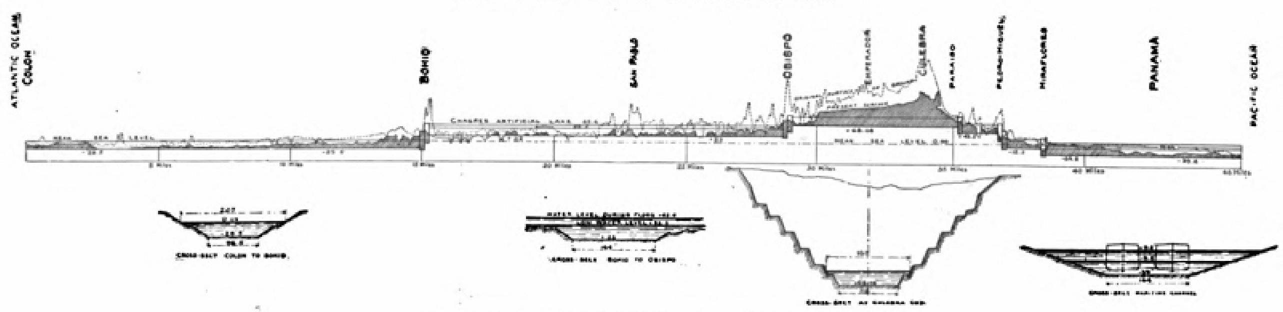
The *Comite Technique*, a high level technical committee, was formed by the Compagnie Nouvelle to review the studies and work - that already finished and that still ongoing - and come up with the best plan for completing the canal. The committee arrived on the Isthmus in February 1896 and went immediately, quietly and efficiently about their work of devising the best possible canal plan, which they presented on November 16th 1898. The plan involved two levels above the sea; one an artificial lake to be created by a dam across the *Chagres River* at *Bohio*, and another a high-level canal through *Culebra Cut* at an elevation of 68.08-feet above mean tide, to be fed by water by a channel leading from a reservoir to be constructed at *Alhajuela* in the upper *Chagres River Valley*. The lake level was to be reached from the *Atlantic* by a flight of two locks, and the summit level by a second flight of two locks. On the *Pacific*-side, four other locks were provided for; the two middle ones at *Pedro Miguel* being combined in one flight and the others being located at *Paraiso* and *Miraflores*. On the *Atlantic*-side there was to be a sea-level channel to *Bohio*, seventeen miles inland, and on the Pacific-side at Miraflores, about eight miles inland. The depth of the canal was to be 29.5-feet, with a bottom width of 98-feet. The locks were to be in duplicate, 738.22-feet long, 82.02-feet wide with a normal depth of 29.5 feet. The lifts were to vary from 26 to 33-feet. A second plan was also worked out in which the upper level was omitted, the cut through the divide being deepened to 32-feet above sea-level making the artificial lake created by the dam at Bohio the summit level. Under this plan, the feeder from Alhajuela was omitted, although the dam was to be retained to control the Chagres. One flight of locks on the Atlantic-side and one lock on the Pacific-side were also to be omitted. The estimated cost of completing the canal under this plan was not much greater than the first and all work on the first plan for several years would be equally available under the second.

“…This investigation was entrusted to 150 engineers who, with their corps of assistants, have been occupied for four years in exhaustive surveys, the total cost of which has amounted to $1,200,000. This includes, in addition to superintendence of the work at Culebra, extensive borings at the sites of the proposed dams and locks, sufficient to determine the exact nature of the whole site covered by their foundations; gagings of the river; the complete cross-sectioning of the basins of the proposed storage and control reservoirs, together with every kind of research that is necessary to the determination of the feasibility and cost of an engineering work of this magnitude…”

Scientific American Supplement, **January 18th 1902**



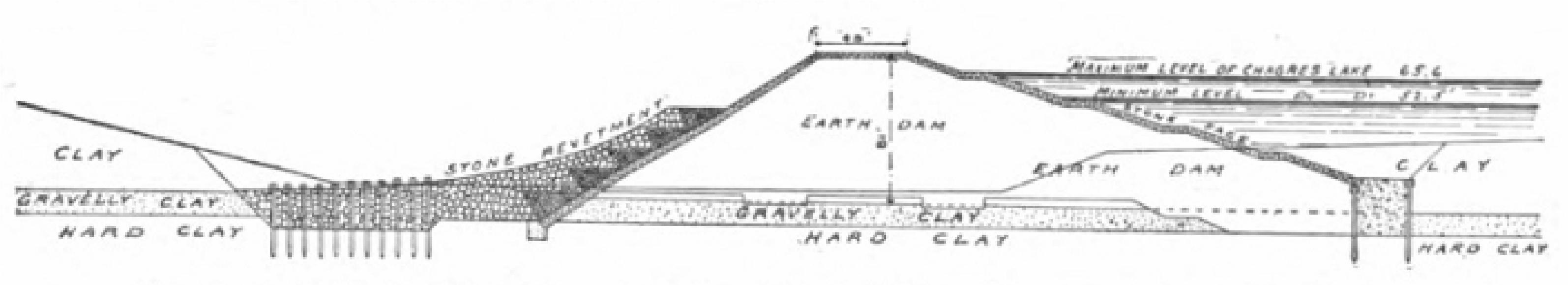
9.—GENERAL PLAN OF THE NEW PANAMA CANAL.



10.—PROFILE AND CROSS-SECTIONS OF THE NEW PANAMA CANAL.

"…The canal is forty-six miles in length. The map (Fig. 9) shows its location, and the profile (Fig. 10) shows by a dotted line the amount of excavation that has been done and by a full line and shaded portions, the excavations remaining to be done. The engineers drew up three designs for a canal with locks. In the first the summit level was to be 97.75 feet; in the second 68.08 feet; and in the third, 32.75 feet above the sea level. The technical commission recommends the second, which is the one shown in the map and profile…"

Scientific American Supplement, **January 18th 1902**

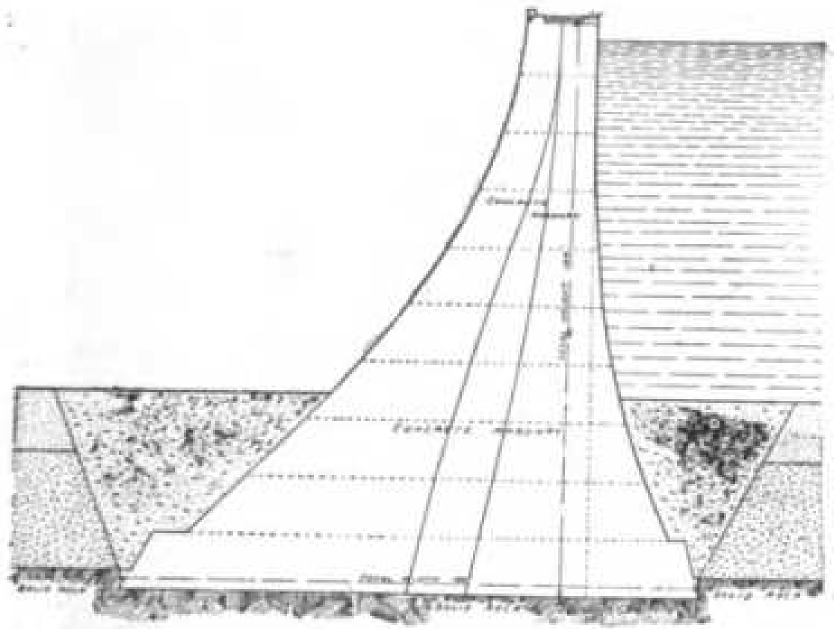


12 —CROSS-SECTION THROUGH BOHIO DAM. HEIGHT, 75½ FEET. LENGTH OF CREST, 1,286 FEET.

"...As the determination of the levels and number of locks is dependent on the means taken to control and utilize the Chagres River, it will be well to explain that this control is secured by constructing two large dams, one at Alhajuela, in the upper Chagres, about nine and one-third miles above the canal, and the other at Bohio, at the end of the sea level length of the canal on the Atlantic side. The Bohio dam will be thrown across the Chagres valley at a point about half a mile to the left of the canal at Obispo. It will be of earth, upon a bed of compact clay. The general features are shown in the cross-section, Fig. 12. The crest is 1,286 feet long and the extreme height above the bed of the river is 75.5 feet, and above the foundation 93.5 feet. This dam will create a vast artificial lake, which will extend thirteen and a half miles to Obispo. Its lowest level will be 52.5 feet and its highest level, when the river is in flood, 65.5 feet. The channel of the canal will be in the bed of this lake, which will not only take care of a large part of the flood waters, but will greatly reduce the amount of excavation necessary for the canal…"

***Scientific American Supplement,* January 18th 1902**

<u>Above</u>: caption: "View of the excavation at Bohio"



11.—CROSS-SECTION THROUGH ALHAJUELA DAM. HEIGHT, 164 FEET. BASE, 166 FEET. LENGTH OF CREST, 936.7 FEET.

"…The other dam, at Alhajuela, will be built everywhere upon solid rock, and will consist of concrete masonry. Its crest, 936.75 feet long, will be 134.5 feet above the river bed and 164 feet above the lowest foundation. This dam will be connected with the summit level by a feeder with a capacity of 6,605 gallons per second. The dam will also furnish energy for the electric lighting of the canal and the electric operation of the locks, etc. The storage capacity of the two artificial lakes thus formed will be 66 billion gallons, which provides a wide margin of safety, as shown by careful records, over any possible flood discharges of the river…"

Scientific American Supplement, **January 18th 1902**

3.—BOHIO—SITE OF LOCKS AND DAM. CHAGRES RIVER IN THE FOREGROUND. LOCKS WILL BE BUILT IN THE ROCK CUT BEYOND THE RIVER.

"…Commencing at Colon on the Atlantic, the first section of the canal, 15 miles in length, is tidal up to the two double locks at Bohio, by which vessels will pass into the Chagres River lake. These locks are of masonry and will be built upon rock foundations, as will all the locks of the canal. The deep cut shown in Fig. 3 is the site of the Bohio locks. The Obispo dam will be half a mile to the left of the locks in the bend of the Chagres River, which is seen in the foreground of this same illustration…" 139

***Scientific American Supplement,* January 18th 1902**

"…What will be the system of traversing the lock canal by ships? It is agreed that a vessel moving at a fitting, but moderate, speed will make six miles per hour in the large reaches and 1,050 ft. in the short ones. It is admitted, besides, that it will take about an hour to pass through a lock. Hence, taking account of the time necessary for the entrance of ships in the lock chambers, their exit, the filling and emptying of the chambers, the maneuvering of the gates, etc., an isolated ship ought to pass from one ocean to the other in 17h. 28m., and a ship with convoy 28h. 25m. The maritime power of the provisional canal thus established can therefore be estimated at 10 ships per 24 hours, say at a rate of 2,000 effective tons per ship, 25,000 tons daily, or 9,125,000 tons per annum. The first traffic estimated by the congress is 7,500,000 tons…"

***Scientific American Supplement,* March 10th 1888**

5.—COMPLETED CANAL, 10 MILES FROM ITS ATLANTIC ENTRANCE. CANAL IS EXCAVATED TO WIDTH SHOWN FOR 15 MILES, OR UP TO BOHIO.

"…The working length of the locks will be 738.22 feet, the width of one of the twin locks being 82.02 feet and of the other 59.05 feet. Of this sea-level stretch of the canal, the first 11.8 miles are navigable, the depth varying from 16.4 feet to 29.5 feet, the finished depth. It has been excavated to the original width (see Fig. 5), and not much dredging will be necessary to complete it for the whole 15 miles to Bohio…"

Scientific American Supplement, **January 18th 1902**

"…The quantity of water necessary for the maritime transit just mentioned is about 1,450,000 cubic feet per lock chamber, and 2,290,000 per ship, crossing from one ocean to the other, say a daily consumption of 22,290,000 cubic feet of water, furnished by the Chagres at the rate of 324 cubic feet per second. This figure may be carried to 350 cubic feet on including the losses by evaporation and infiltration. The supplies of water disposable are the following: the waters of the Chagres basin, which has an area of about 360,000 acres; the basin of the Obispo, of an area of 36,000 acres; and the basin of the upper Rio Grande, of an area of 4,000 acres…"

***Scientific American Supplement,* March 10th 1888**

"…After passing the locks the canal channel extends for about 13.5 miles along the bed of the lake to Obispo, where two double locks (built like all the other locks of the company upon a rock foundation) will admit vessels to the summit level 5 miles in length, where the bottom of the canal is 68.08 feet above mean sea level. On the Pacific slope admission is gained at Paraiso by one double lock to a level 7,963 feet in length, and at Pedro-Miguel two double locks lead down to a level 7,930 feet long, from which at Miraflores one double lock will admit vessels to the tide level of the Pacific. This portion of the canal is 7.5 miles in length. The depth of water in the lock will be 29.5 feet and will not exceed 32.8 feet. It should be noticed that the slopes of the canal, particularly in the Culebra cut, are to be reveted with stone, and that the curvature of the canal is easy throughout, the smallest radius being 8,200 feet and the prevailing radius 9,843 feet…"

***Scientific American Supplement,* January 18th 1902**

Many aspects of the plan were similar in principle to the canal that was finally built by the Americans in 1914. It was a lock canal with two high level lakes to lift ships up and over the *Continental Divide*. Double locks would be 738-feet long and about 30-feet deep; one chamber of each pair would be 82-feet wide, the other 59-feet wide. There would be eight sets of locks, two at *Bohio Soldado* and two at *Obispo,* on the *Atlantic*-side; one at *Paraiso*, two at *Pedro Miguel* and one at *Miraflores,* on the *Pacific*-side. Artificial lakes would be formed by damming the *Chagres River* at *Bohio* and *Alhajuela*, providing both flood control and electric power. Tolls would be based on a ships actual displacement of water; ten Francs ($2 USD) per cubic meter. If directors of the Compagnie Nouvelle still entertained the idea that the canal could somehow be completed, they were soon faced with the reality of the situation. During and following the bitter scandal of the old company, the public had lost all faith in the project. There would be, therefore, no funds forthcoming from a bond issue and none was tried, nor did the French government have any support for the project. With half its original capital gone by 1898, the company had few choices; abandon the project or sell it. Company directors decided to proffer a deal to the most likely taker, the *United States of America*. It was no secret that the *United States* was interested in an Isthmian canal. With the technical commission report and a tentative rights transfer proposal in hand, company officials headed for the United States where they were received by President *William McKinley* on December 2nd 1899. The deal was five years in the making, but was eventually signed. Certainly the lessons learned from the French experience were helpful, but the American success was considerably more than that avoiding the mistakes of their predecessors.

The United States of America is the only Nation with which Colombia has ever made a Treaty wherein is guaranteed to Columbia the neutrality of the Isthmus of Panama and the sovereignty of Colombia over said territory, as above provided; and, therefore, it is the only Nation having the "special or remarkable advantages" provided for by the Treaty.

Under this Treaty, Colombia granted concession to the Panama Railroad, which railroad was thereupon constructed and for forty-three years has been in continuous operation. On several noteworthy occasions the United States has protected the railroad property, in compliance with the obligations of this Treaty.

Also, in contemplation of the provisions of this Treaty, Colombia granted in 1878 the Concession for the Panama Canal now owned by the new Panama Canal Company; and like protection to the Canal, as to the railroad, will, of course, be assured by the United States under this Treaty. Over $150,000,000 have been actually invested in the Panama Canal works, two-fifths of the entire Canal work have been completed, and the balance is under active construction, in firm reliance upon the protection assured by the United States under said Treaty to the "Isthmus of Panama from its southernmost extremity until the boundary of Costa Rica."

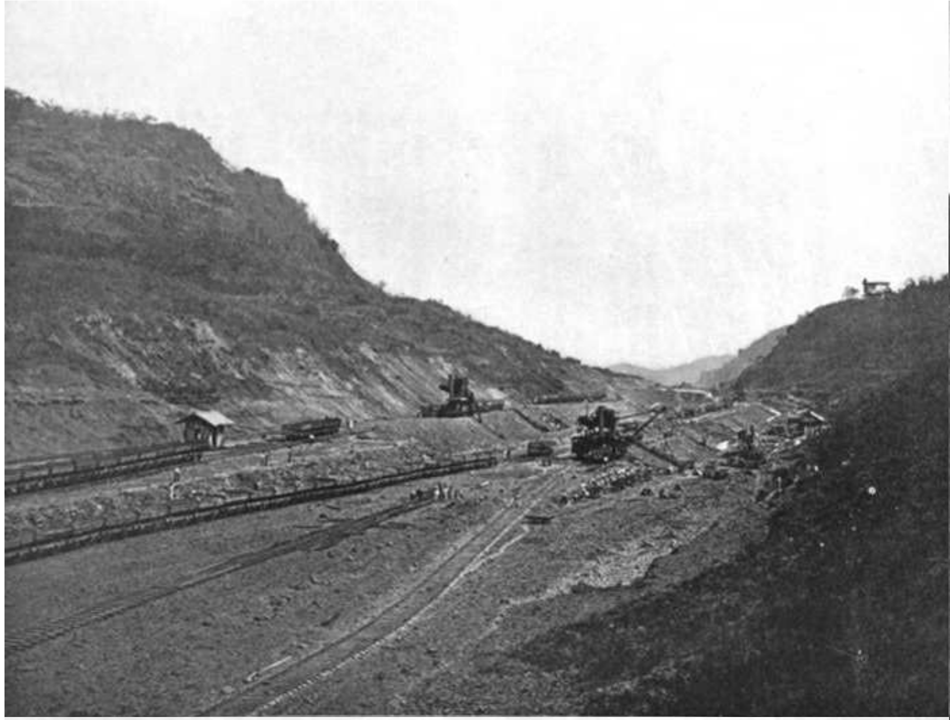
Above: excerpt from: *The New Panama Canal Company*, December 1898
RE: *The Treaty of 1846-48, Between New Granada* (now *Republic of Columbia*) *and the United States*

The Old Bugbear

“The question of caving in the deep central cut has been studied in the most thorough manner, involving not only many borings and pits to determine the material to be encountered, but also a cunette excavated throughout the troublesome region along the axis of the Canal, having a projected width at bottom of 32.75 feet, with slopes of about 45 degrees, and a projected elevation above sea-level varying from 128 feet to 157.5 feet. This work, together with a tunnel 689 feet long and 975 feet wide, pierced, at an elevation of 134.5 feet above sea-level, at the spot which had given the most trouble on the whole route, combined with the evidence afforded by the borings and pits at greater depths, leads to the conviction that, at Culebra, where the deepest cutting is required, the excavation has already passed through the strata subject to caving, and that the remainder traverses an indurated argillaceous schist changing to compact rock, where no fear of yielding to pressure need be entertained. At Emperador, where the cutting required for the Canal is much less, the indications are similar, except that the material at present reached is less resisting; but with proper precautions in the way of drainage, which were wholly neglected by the contractors of the old Company, little or no difficulty from serious caving need be apprehended. This work of experimental excavation has been continued for more than three years, involving the removal of about 3,924,000 cubic yards. It was projected, partly to determine for the proper inclination for the side slopes and partly to estimate the unit cost. The results are highly satisfactory; and the old bugbear of a sliding mountain divide has been proved to be imaginary.”

Brigadier General Henry L. Abbot **– International Commission member**

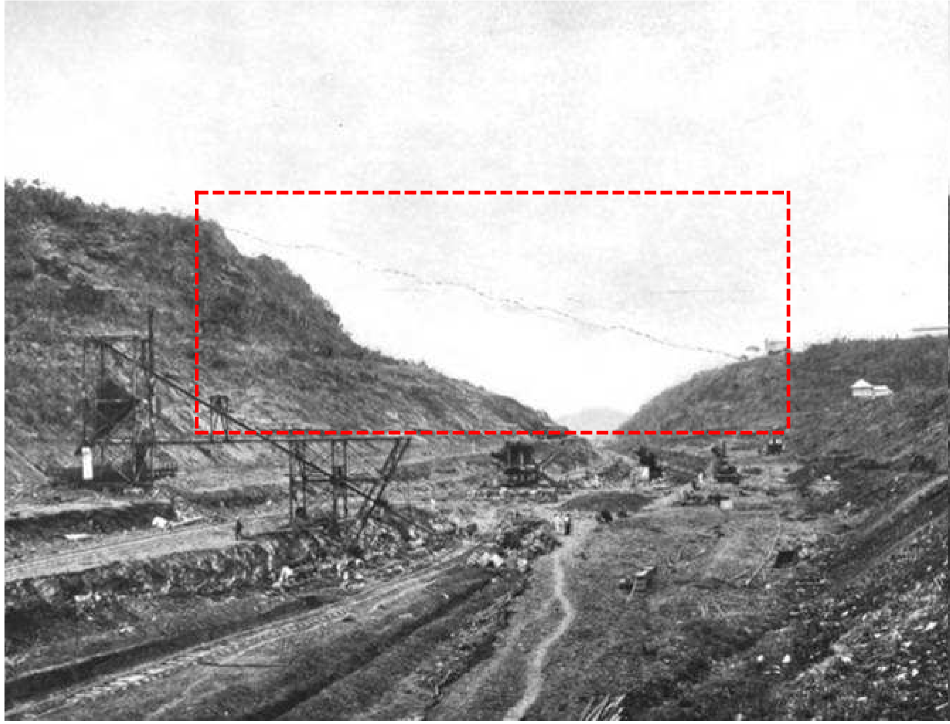
RE: comments made in the November 1898 issue of *Forum*



<u>Top Left</u>: caption: "View of the Great Culebra Cut, at Kilometer 54 from the Atlantic" (ca. 1897)

<u>Top Right</u>: caption: "View of part of the Grand Cut at Culebra, at Kilometer 54.5 from the Atlantic, showing the condition of the work in September 1897"

<u>Left</u>: caption: "View of Culebra at 55 Kilometers from the Atlantic" (ca. 1897)



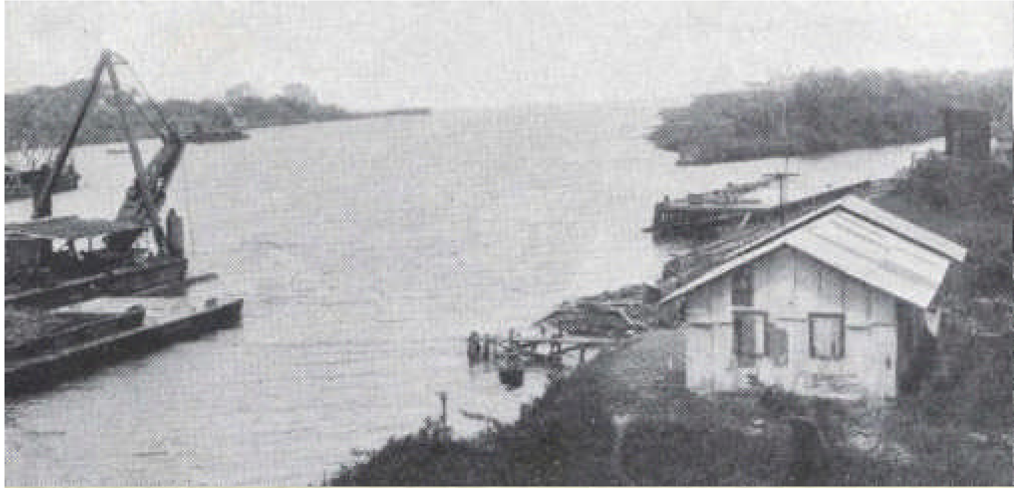
<u>Top Left</u>: caption: 'View of the Culebra Cut - the highest elevation of tide-water between the Atlantic and Pacific. The dotted line indicates the former level of the ground"(ca. 1897)

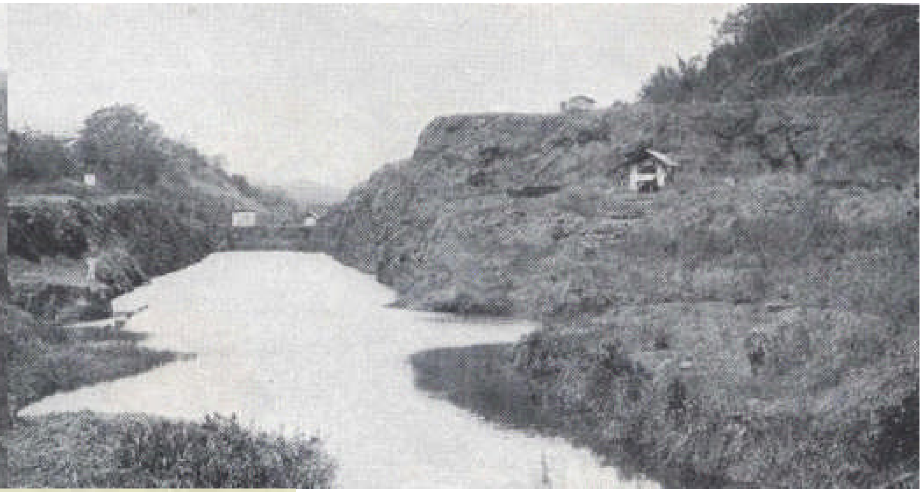
<u>Top Right</u>: caption: "View of the extreme western end of the Great Culebra Cut, showing excavator at work" (ca. 1897)

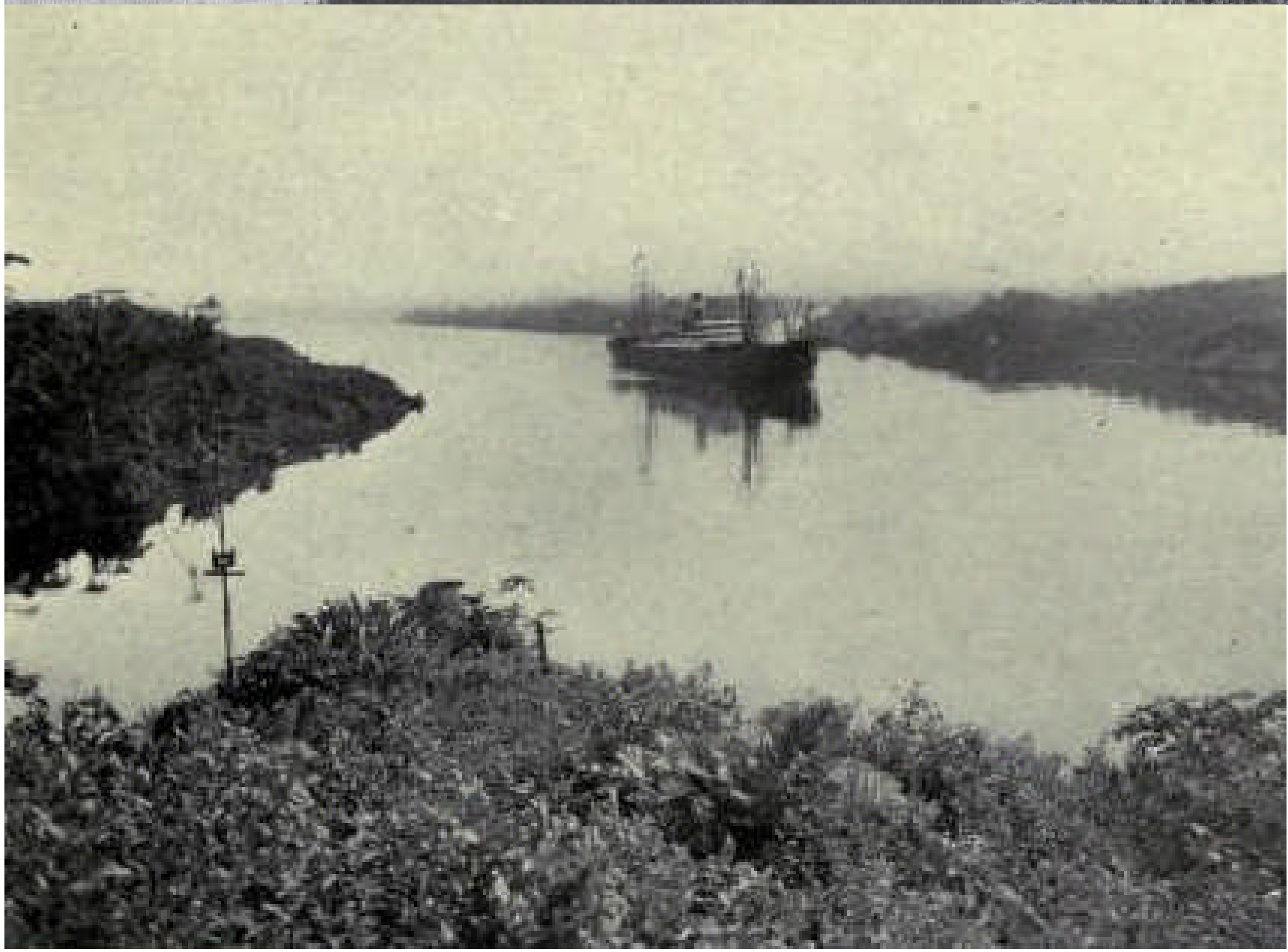
<u>Left</u>: "View of the Canal at the outlet of the Culebra Cut on the Pacific Slope" (ca. 1897)

The *Culebra Cut* in 1898

Although the first lock plan was adopted on December 30th 1899, no effort was made to carry it out on account of the interest being shown by the *United States* in a canal across *Nicaragua*. It was realized that if the United States should undertake to construct such a waterway, the work accomplished and the plant on the Isthmus would be practically worthless. In 1895, there was a force of men numbering about 2K at work in the *Culebra Cut*. A year later, this was increased to 3,600. This was the largest number of men employed under the new company for only enough work was done to hold the concession and keep the equipment in a salable condition. The French at that time were beginning to look for a purchaser; they wanted $100 million for the work completed and equipment, but the only likely buyer was the United States. The *Isthmian Canal Commission*, appointed by the *Spooner Act of 1899*, reported in November 1901 in favor of the Nicaragua route unless the French company was willing to sell-out for $40 million. This recommendation became a law on June 28th 1902 and the new *Panama Canal Company* was practically forced to sell for that amount or get nothing. Although the French on the Isthmus worked under difficulties which eventually forced them to give up the canal undertaking, they removed with their clumsy side excavators, obsolete dredges, small *Decauville* cars and Belgian locomotives a considerable amount of material. The old company excavated 66,743,551 cubic yards from 1881 to 1889 and the new company excavated 11,403,409 cubic yards (up to 1904), a total of 78,146,960 cubic yards; 18,646,000 cubic yards of this total were taken from Culebra Cut, the operation of the new company being practically confined to that portion of the work. Of this total, it has been calculated that 29,908,000 cubic yards was useful to the Americans. The old company dredged a channel from deep water in *Panama Bay* to wharves at *Balboa* useful to ships docking at that port. On the *Atlantic*-side, the channel dredged inland; known as the "French Canal," was found useful upon deepening in bringing sand and stone for the locks and spillway concrete at *Gatun*.





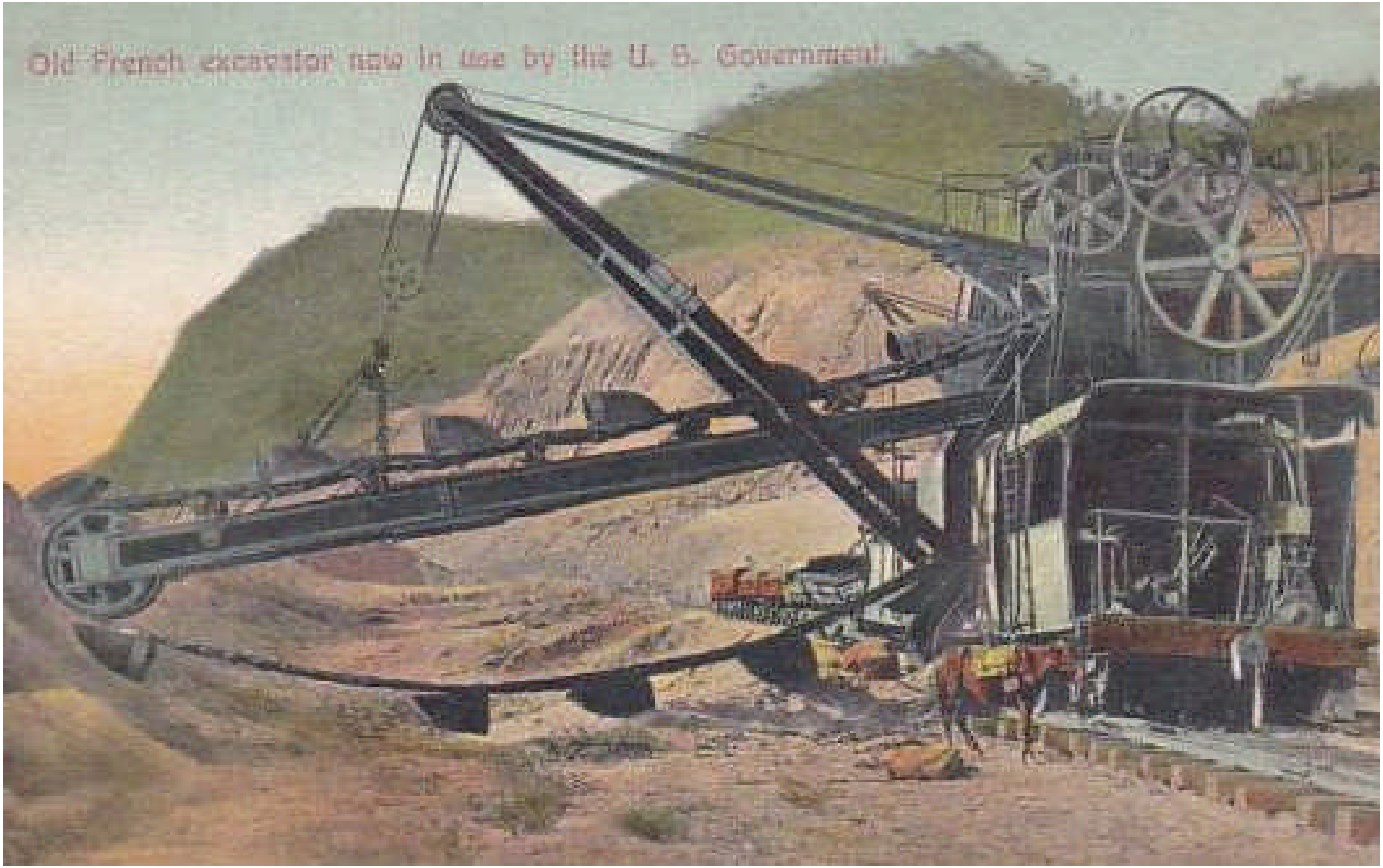


<u>Top Left</u>: juncture of French and American Canals (Atlantic Side)
<u>Top Right</u>: old French canal at *Mindi*
<u>Left</u>: caption: “The crossing of the American and French Canals at Mindi”

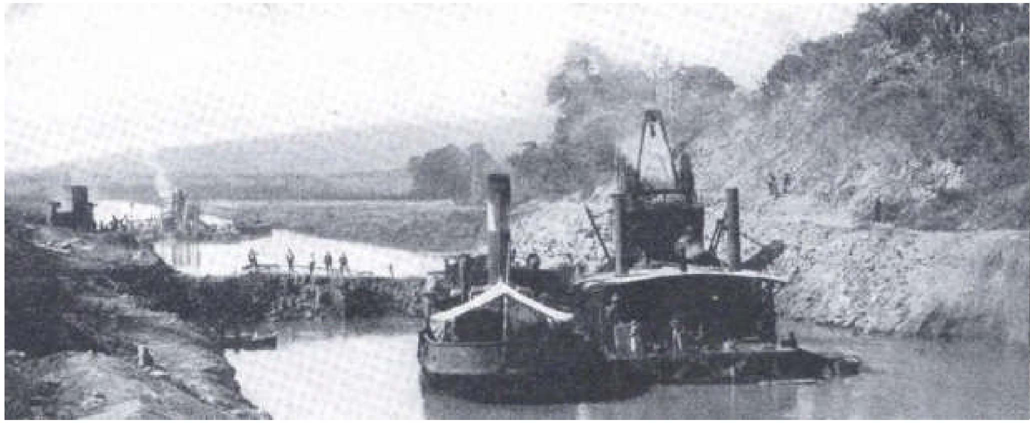
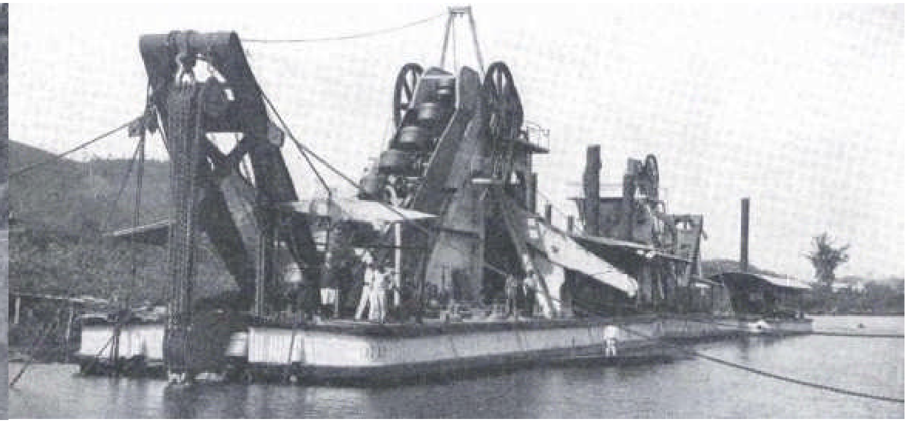
The French turned over valuable surveys and studies of the work, together with plans that were great value to the Americans, the best of which was done under the new company. This is especially true of the records kept of the flow and floods of the *Chagres River* along with rainfall records. During the first two years of the American effort, French locomotives were the only ones available. On June 30th 1906, there were 106 in service and only fifteen American locomotives. The same is true of the French *Decauville* dump cars. In 1904, there were 308 in service and in 1905, over 2K had been repaired and put to work as compared with 300 American-built cars. In December 1904, there were six old French excavators working in *Culebra Cut* which had been overhauled and placed in service. These were similar to ladder dredges and the excavation was accomplished by an endless chain of buckets which carried earth and rock from one side and dropped it into a hopper from which it fell into dump cars on the other side. These machines were effective only when working in soft material. They remained at work eighteen months before they were replaced by modern steam shovels.

Above: French Locomotives. A total of 119 were rebuilt and used by the Americans

Much of the work of preparation during the first two years of American effort (1904-1905) would have been seriously delayed without the French supplies and equipment. In the shops and storehouses were found a plentiful supply of repair parts, shop tools, stationary engines, material and supplies of all kinds of good quality. At *Gorgona*, where the principal shops were located (known during the French times as "Bas Matachin Shops") were found sheds filled with old locomotives, cranes and excavators. Repair shops were found at *Empire*, *Paraiso*, *Gatun* and *Bohio*. A small machine shop was uncovered in the jungle at *Cimito Mulato*, when American engineers were determining the center-line of the Canal. There was also a dry dock at *Cristobal*, which was originally 190-feet long, 32-feet wide and 16-feet deep over the sills at ordinary high tide. At *Balboa* on the *Pacific*-side, there was located a repair and marine shop for the floating equipment. The old French shops in every case formed the nucleus of the larger and better equipped shops maintained by the Americans during the period of construction.



<u>Above</u>: (postcard) caption: "Old French excavator in use by the U.S. Government"

The floating equipment on hand was considerable and many dredges, clapets (self-propelled hopper barges), tugs, launches etc. were found in the marine graveyards at *Folks River*, *Cristobal* and in the mouth of the *Rio Grande* at the *Pacific* entrance to the canal as well as along the banks of the *Chagres River*. Many of these were floated, rebuilt and placed in commission. On account of the excellent material used in the construction of this equipment, most of which was Scotch-built, the Americans found it highly profitable to repair them. Heavy coats of paint and oil, which twenty or more rainy seasons could not penetrate, had been given the machinery when it was retired so that when the hulls were not worth repairing, the valuable parts were used elsewhere. Several dredges were reconstructed from parts of others. A Scotch ladder dredge with a capacity of about 130K cubic yards per month was repaired at a cost of about $30K which, when new, cost about $200K. Two thousand, one hundred and forty-nine buildings scattered along the line of the *Panama Railroad* were included in the turn-over. These were generally small and ill-suited for use, other than as laborers' barracks or storehouses, but it was found profitable to repair some 1,500 of them even after they had stood unused for ten years or more. The large piles of French scrap, old locomotives, boilers, dump cars, parts of machines, etc., which used to be one of the sights along the line of the Panama Railroad, were removed with much of it sold as junk to contractors, while the copper, brass, white metal, rails and cast iron were used in the foundry at *Gorgona*. Old French rails were used in the reinforcement of concrete in the lock walls, for the repair of dump cars and for telephone and/or telegraph poles.

Left: dredging at *Mindi*

Right: Scottish-made ladder dredges at work on the *Chagres River*, opposite *Gorgona*

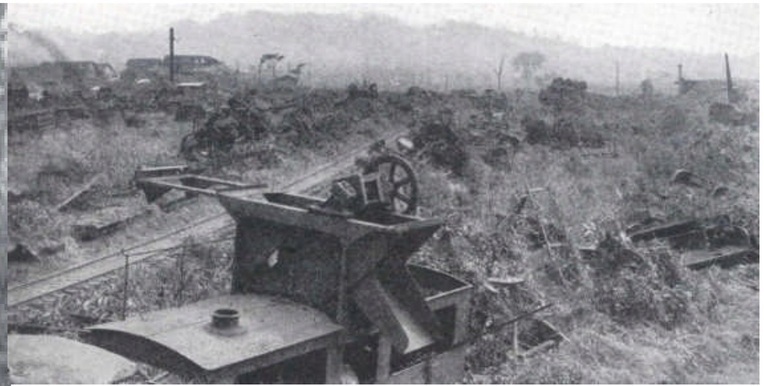
CANAL SERVICE

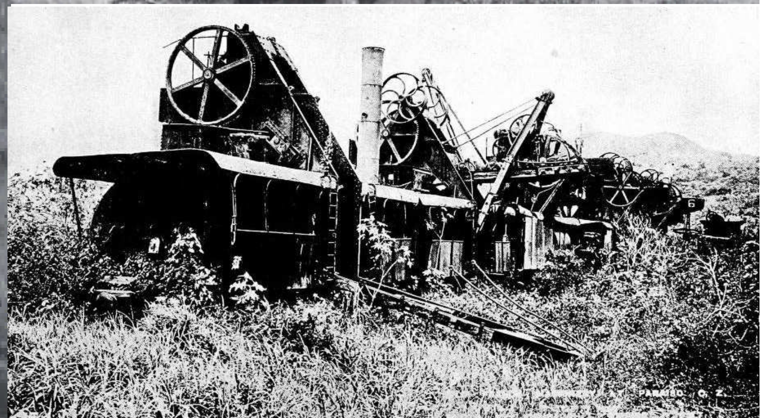
Steam shovels:		
105-ton, 5 cubic yard dippers		15
95-ton, 4 and 5 cubic yard dippers		30
70-ton, 2½ and 3 cubic yard dippers		33
66-ton, 2½ cubic yard dippers		10
45-ton, 1¾ cubic yard dippers		11
26-ton		1
Trenching shovel, ¾ cubic yard dipper		1
Total		101
Locomotives:		
American—		
106 tons	100	
105 tons	41	
117 tons	20	
Total		161
French		104
Narrow gage, American, 16 tons		33
Electric		9
Total		307
Drills:		
Mechanical churn, or well		196
Tripod		357
Total		553
Cars:		
Flat, used with unloading plows		1,760
Steel dumps, large		596
Steel dumps, small		1,207
Ballast dumps		24
Steel flats		487
Narrow gage		209
Motor		6
Pay Car		1
Pay Certificate		1
Automatic, electric		45
Decauville		224
Special, shops		12
Total		4,572
Spreaders		26
Track shifters		9
Unloaders		30
Pile drivers		14
Dredges:		
French ladder		7
Dipper		3
Pipeline		7
Sea-going suction		2
Clam shell		1
Total		20
Cranes		47
Rock breaker		1
Tugs		11
Tow boat		1
House boats		3
Clapets		12
Pile driver, floating		3
Crane boat		1
Barges, lighters and scows		72
Launches		29
Drill boats		2
Floating derricks		2

PANAMA RAILROAD

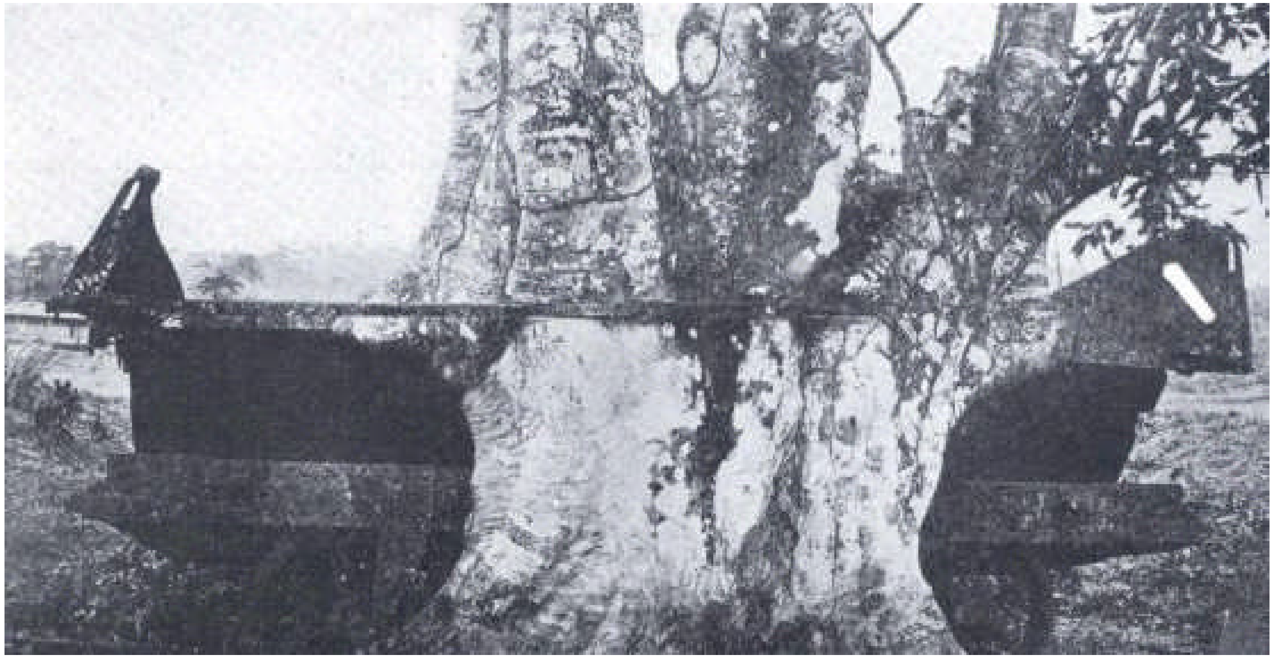
Locomotives:	
Road (12 oil burners)	36
Switch	26
Total	52
Cars:	
Coaches	57
Freight	1,434
Total	1,491
Locomotive	2
Wrecking	2
Total	4
Piledrivers:	
Track	1
Floating	1
Total	2
Tugboat	1
Lighters:	
Coal, all steel	5
Cargo, steel and iron	8
Total	13
Motor boats	2
Steam ditcher	1

The Futile Attempt of the French





<u>Above Top</u>: abandoned French machinery along the canal route
<u>Above Bottom</u>: old French machinery rusting in the Jungle
<u>Left</u>: a Belgian-made French locomotive engine over-whelmed by the jungle



"One of the most unusual photographs of nature's freaks, that describes better than words the futile attempt of the French to build the Panama Canal, is here reproduced. In 1888, when the French discontinued further attempts to build the canal, after having spent approximately $280,000,000, they were so utterly discouraged that the costly machinery was left along the route of labor to rust and turn into junk. As time passed by, a tree, which had taken root near the tilting dump car here pictured, grew until it had entwined itself about an iron rail of the vehicle. The tree continued to increase in size until the rail finally became a part of the tree. When the gates are finally closed this tree and car will lie at the bottom of Gatun Lake."

***Popular Mechanics,* April 1913**

“Using it as ballast, the government is bringing to the United States the junk left in the Panama canal zone by the French company when the canal project was abandoned. When it arrives in this country, the junk is sold by the shipload to the highest bidder. A Harrisburg steel company recently bought a shipload of the old engines and bridges abandoned by the French in Panama and is cutting it up, to be melted over into marketable steel.

***Popular Mechanics,* November 1910**

The Panama Route

VIII.—The existence and operation of a railroad (the Panama Railroad), which the line of the Canal closely follows, greatly facilitates the work of construction and is of enormous advantage.

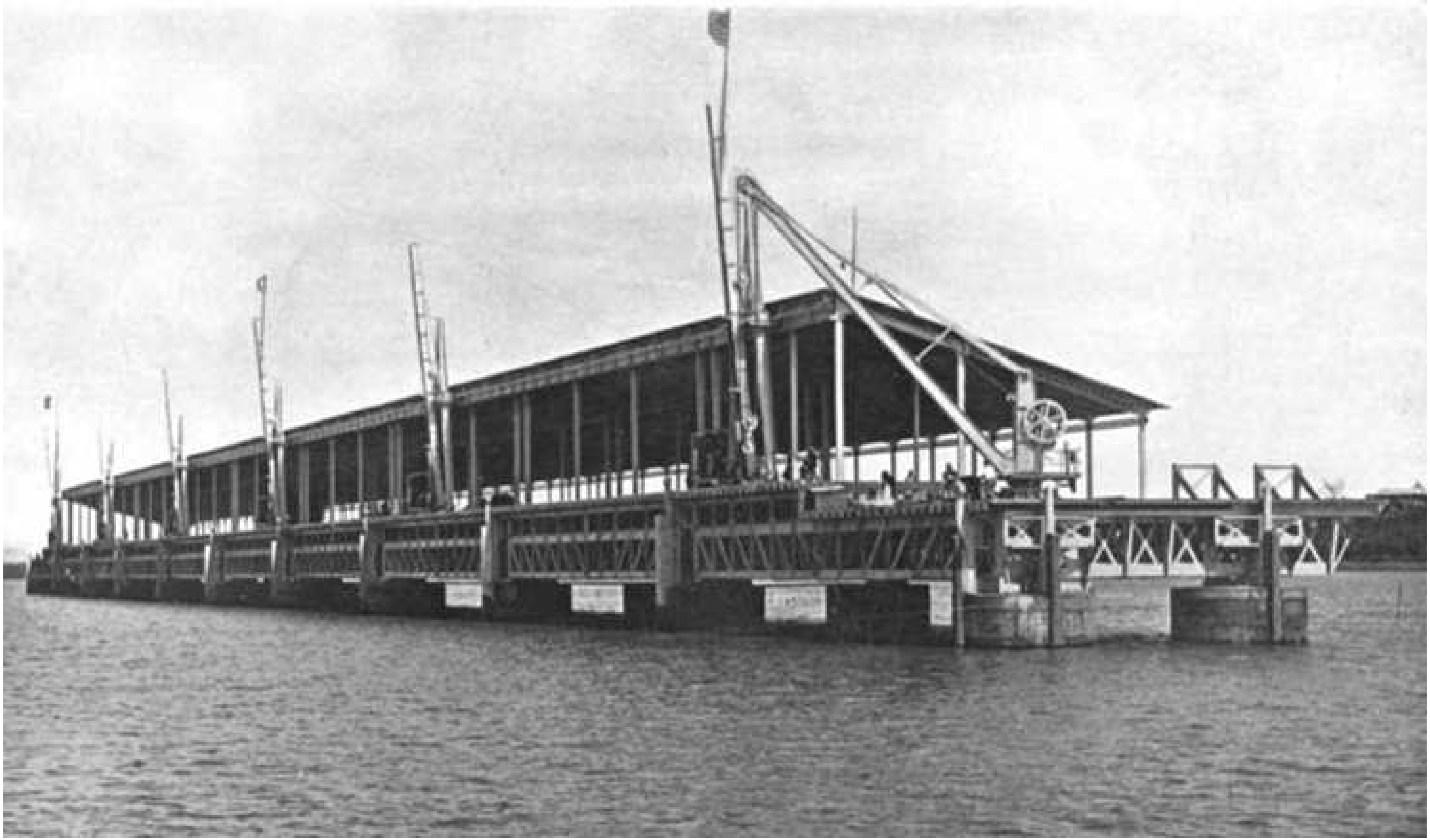
Commerce has employed the Panama Route for over fifty years. The conditions of traffic are established and well known.

The Panama Route constitutes a part of the coast line of the United States, connecting its Atlantic and Pacific coasts. Its terminal cities—Colon, Panama—are ancient and firmly established. Upon the intermediate line thirty railroad stations, serving the neighboring villages and settlements, give character to the route. It is not a marshy jungle. It is a settled country, and the line has been made readily accessible and habitable by fifty years' traffic, development and settlement.

Regular lines of steamers, from Germany, England, France, New York, Belgium, Spain and Italy, on the Atlantic side; and San Francisco and all Central and South American and Mexican ports, on the Pacific side, have for over fifty years regularly employed this route.

The Panama Route, therefore, needs no introduction to the commerce of the world, which has continuously employed it for nearly half a century.

<u>Above</u>: excerpt from: "The New Panama Canal Company, Dec. 1898"



<u>Above</u>: caption: "View of Iron Pier (+991 feet long – 302.20 meters) recently constructed by the Panama Railroad Company at La Boca at a cost of $1,250,000 and connecting with the Channel of the Panama Canal which is now open from the ocean to this pier" (ca. 1898)

V.—HARBORS AT TERMINI—COLON AND PANAMA.

These harbors are so well known to the commerce of the world employing the Panama Route that no extended remarks need be made.

They are natural, not artificial, harbors; good and easy of access.

The ships of many European, South and Central American nations, as well as of the United States, have for over fifty years regularly and daily availed of these ports, where the maritime conditions are most satisfactory.

Neither of these harbors require protection or further excavation. They are in excellent condition.

VI.—There are no active volcanoes within 200 miles of the Canal.

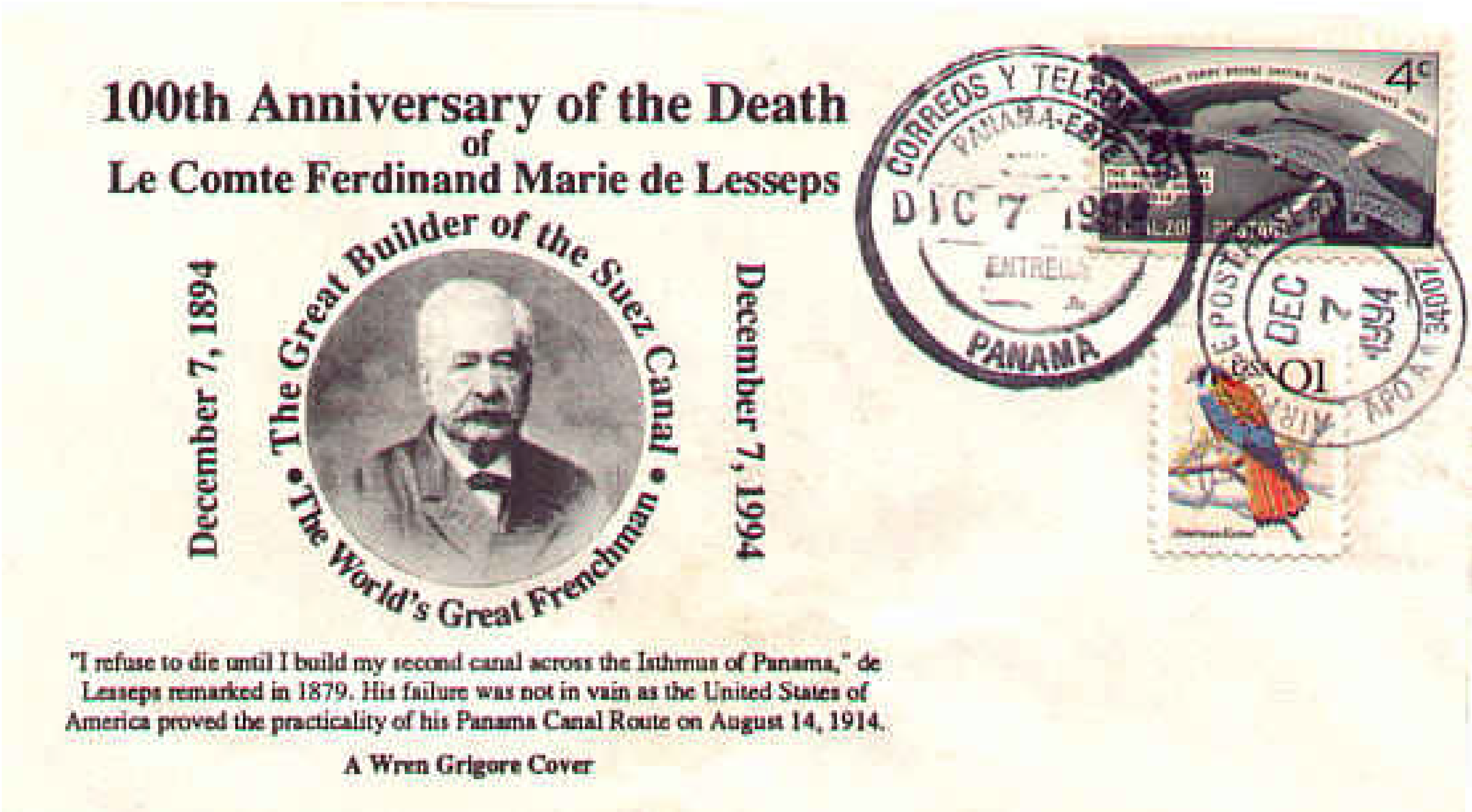
Above: excerpt from: "The New Panama Canal Company, Dec. 1898"

In May 1911 – seven years after the Americans took control of the canal from the French, the *Isthmian Canal Commission* made a careful official estimate of the value to the commission of the franchises, equipment, material, work done and property of various kinds for which the *United States* paid the French Canal Company $40 million. It placed the total value at over $42 million, broken-down as follows:

Excavation, useful to the Canal, 29,708,000 cubic yards	**$25,389,240.00**
Panama Railroad Stock	**9,644,320.00**
Plant and material, used, and sold for scrap	**2,112,063.00**
Buildings, used	**2,054,203.00**
Surveys, plans, maps, and records	**2,000,000.00**
Land	**1,000,000.00**
Clearings, roads, etc.	**100,000.00**
Ship channel in Panama Bay, four years' use	**500,000.00**
Total	**$42,799,826.00**

By the time the new canal company was established, *Ferdinand de Lesseps*' mental state was such that he understood little of what was going on and he remained sequestered at his home surrounded by his family. He died aged 89 on December 7th 1894. His son Charles lived until 1923, long enough to see the *Panama Canal* completed, his father's name restored to honor and his own reputation substantially cleared.

<u>Left</u>: 1894 portrait of *Le Comte Ferdinand Marie de Lesseps* from *Le Journal*


100th Anniversary of the Death
of
Le Comte Ferdinand Marie de Lesseps
December 7, 1894
The Great Builder of the Suez Canal
The World's Great Frenchman
December 7, 1994
"I refuse to die until I build my second canal across the Isthmus of Panama," de Lesseps remarked in 1879. His failure was not in vain as the United States of America proved the practicality of his Panama Canal Route on August 14, 1914.
A Wren Grigore Cover
CORREOS Y TELE
DIC 7
PANAMA
DEC
7
1994
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A La Memoire De Francais Morts

Many reasons can be given for the French failure, but it seems clear that the principal reason was de Lesseps' own stubbornness in insisting on and sticking to the original sea-level canal plan. His personal charm, charisma and powers of persuasion ultimately proved to be his worst enemy. People simply believed in him and the new religion of science and technology he professed. The devotion to duty and raw courage of the French in the face of impossible and deadly odds on the *Isthmus* is truly extraordinary.


CEMENTERIO
FRANCES
1880-1889.

***Plaza de Francia* was, originally, the main square of *Panama City* and is located at the very tip of the peninsula on which the city is situated. In the center stands an obelisk, topped by a rooster; a symbol of the French nation. The twelve surrounding slabs of marble outline the history of the *Panama Canal*. Memorial busts of *Ferdinand de Lesseps* and Panamanian engineer *Pero J. Sosa* stand nearby as well as tributes to other French nationals who were prominent in the attempt to construction a canal across the Isthmus. This monument honors the 22K who died trying to build the trans-oceanic canal for *France*.**

Part 3

Essayons

Nicaragua or Panama?

"…In 1899, the United States Congress created the Isthmian Canal Commission, to examine all practicable routes and to report which was the most practicable and feasible for a canal 'under the control, management and ownership of the United States.' The commission reported two alternative plans, one for a canal at Panama and the other across Nicaragua. It estimated the cost of a Panama Canal at $156,378,258 and of the Nicaragua Canal at $200,540,000. But because the route from New York to San Francisco would be several hundred miles shorter by way of Nicaragua, and considering existing French concessions in Panama, the commission gave it as its belief that the Nicaragua route was more desirable under the circumstances…"

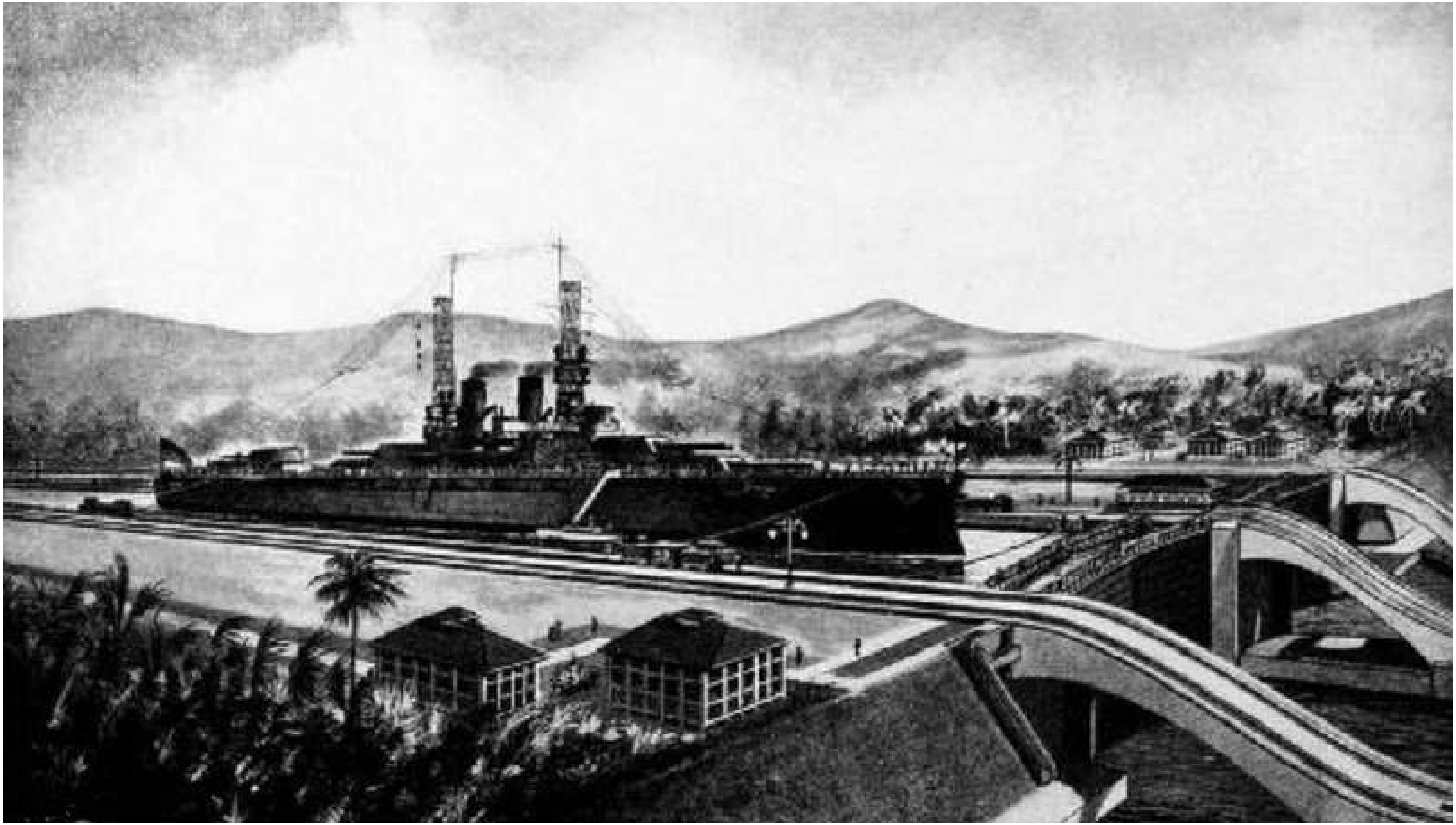
Popular Mechanics, **December 1913**

Following the failure of the French canal effort, *Panama* was in a state of confusion. The second *Walker Commission*; the *U.S. Isthmian Canal Commission of 1899-1902*, convened by President McKinley favored a *Nicaragua* route as did both popular and official U.S. support. Panama seemed clothed in defeat while Nicaragua was regarded as a clean slate for an all-American canal project. Following President McKinley's assassination, Vice President *Theodore Roosevelt* became POTUS. For TR, there was no romance about the project. The canal was practical, vital and indispensable to America's. destiny as a global power with supremacy over both its adjacent oceans. Roosevelt was a proponent of a doctrine proposed by U.S. naval officer and scholar *Thayer Mahan* who explained his theory in the 1890 book: *"Influence of Sea Power upon History."* The theory stipulated that supremacy at sea was an integral part of commercial and military prowess. For Roosevelt, this made a U.S. controlled canal an absolute necessity.

A timely incident clearly demonstrated this truth to Roosevelt and the world. A naval base had been established in *Cuba* as a result of the *Spanish-American War*. The Battleship *U.S.S*. *Maine*, which was stationed there, blew up on February 15th 1898 with a loss of 260 American lives. At the time, another Battleship; the *U.S.S. Oregon*, had been stationed in *San Francisco*. To save the day, the Oregon was ordered to proceed at once to the *Atlantic*, a 12K-mile course around *Cape Horn* at the southern tip of *South America*. Sixty-seven days later, the battleship arrived off the coast of *Florida,* just in time to participate in the *Battle of Santiago Bay*. The experience clearly demonstrated the military significance of an Isthmian canal. A trans-oceanic canal would have cut two weeks off the Oregon's voyage.

Left: the Battleship *U.S.S. Missouri* passing through the locks of the *Panama Canal* in 1945. It's extended forecastle was designed with the canal locks in mind. It passed through the 110-foot wide locks with mere inches to spare. The Missouri was selected to be the "Surrender Ship" by which *Japan* capitulated at the close of WWII.

The Flag in Two Oceans



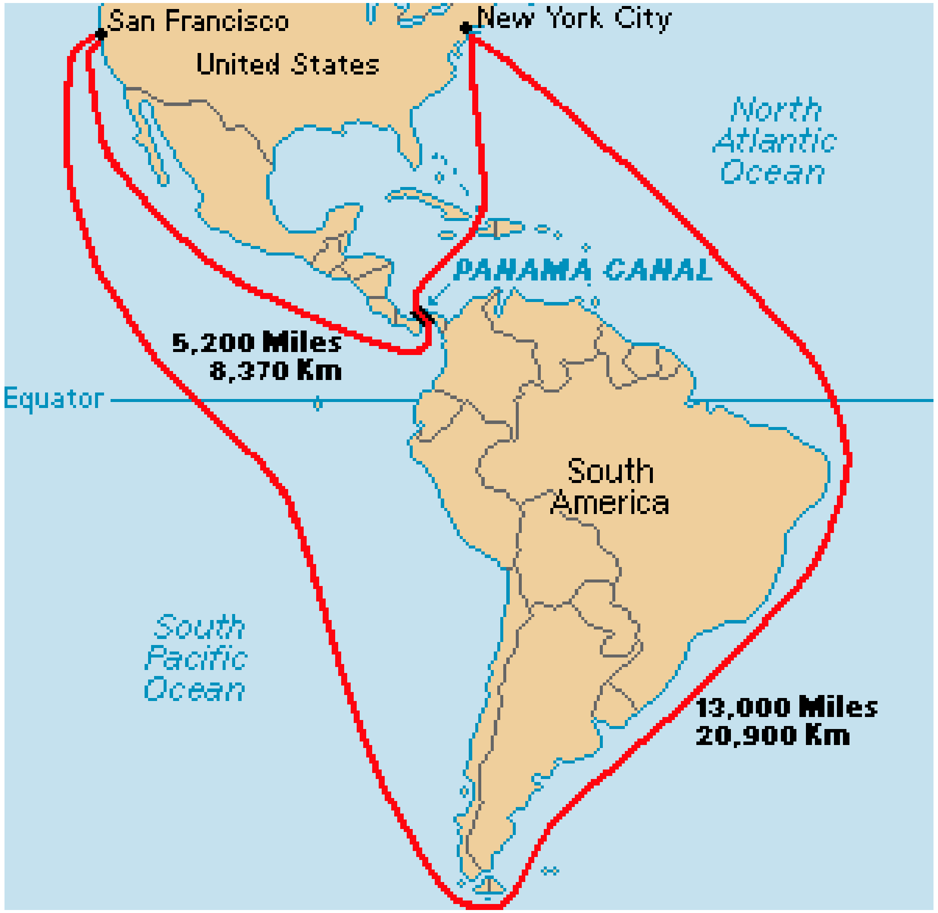
<u>Above</u>: caption: "'The Flag in Two Oceans.' The Oregon steamed 10,000 miles in 1898 to carry the flag from the Pacific to the theater of war in the Atlantic. Ten hours of steaming through 50 miles of canal will henceforth make our fleet available in either ocean."

"…The strategic value of the Panama canal to the United States, especially in a war with Japan or other western enemy, will unquestionably be great, but even in this respect exaggeration is easy and there are many American strategists who place a very low estimate on the importance of the canal. It will be impossible to move an American fleet from the Atlantic to the Pacific coast via the canal in less than about seventeen days, a much longer time than will be required for a Japanese fleet to cross the Pacific. The existence of the canal, therefore, will not relieve the United States of the necessity of maintaining a Pacific fleet, or greatly diminish the requisite naval strength…"

***Scientific American Supplement,* September 23rd 1911**

RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries"

Panama vs. Magellan



"…The success of the Panama route was assured from the start because of the enormous saving in mileage which makes it possible. From New York to San Francisco, via the Strait of Magellan, is 13,135 nautical miles, while the distance by the canal is 5,262, a saving of 7,873 miles. Among the benefits given the United States by the canal are reduced freight rates, quicker delivery of goods, closer relations with South America and a short cut for its fleet in war times as well as peace."

***H.H. Windsor, Jr.*, September 1st 1924**

DISTANCE SAVED BY THE PANAMA CUTOFF

COMPARATIVE DISTANCES (IN NAUTICAL MILES) IN THE WORLD'S SEA TRAFFIC AND DIFFERENCE IN DISTANCES VIA PANAMA CANAL AND OTHER PRINCIPAL ROUTES

To	Via	From: New York	New Orleans	Liverpool	Hamburg	Suez	Panama
Seattle	Magellan	13,953	14,369	14,320	14,701	15,397	
	Panama	6,080	5,501	8,654	9,173	10,447	4,063
Distance	saved	**7,873**	**8,868**	**5,666**	**5,528**	**4,950**	
San Francisco	Magellan	13,135	13,551	13,502	13,883	14,579	
	Panama	5,262	4,683	7,836	8,355	9,629	3,245
Distance	saved	**7,873**	**8,868**	**5,666**	**5,528**	**4,950**	
Honolulu	Magellan	13,312	13,728	13,679	14,060	14,756	
	Panama	6,702	6,123	9,276	9,795	11,069	4,685
Distance	saved	**6,610**	**7,605**	**4,403**	**4,265**	**3,687**	
Guayaquil	Magellan	10,215	10,631	10,582	10,963	11,659	
	Panama	2,810	2,231	5,384	5,903	9,192	793
Distance	saved	**7,405**	**8,400**	**5,198**	**5,060**	**2,467**	
Callao	Magellan	9,613	10,029	9,980	10,361	11,057	
	Panama	3,363	2,784	5,937	6,456	7,730	1,346
Distance	saved	**6,250**	**7,245**	**4,043**	**3,905**	**3,327**	
Valparaiso	Magellan	8,380	8,796	8,747	9,128	9,824	
	Panama	4,633	4,054	7,207	7,726	9,000	2,616
Distance	saved	**3,747**	**4,742**	**1,540**	**1,402**	**824**	
Wellington	Magellan	11,344	11,760		13,353	9,694	
	Suez			12,989			
	Panama	8,857	8,272	11,425	11,944	9,205	6,834
Distance	saved	**2,493**	**3,488**	**1,564**	**1,409**	**489**	
Melbourne	Cape Good Hope	13,162	14,095		11,845	8,186	
	Suez			11,654			
	Panama	10,392	9,813	12,966	13,452	10,713	8,342
Distance	saved	**2,770**	**4,282**	**1,312**	**1,607**	**2,527**	
Manila	Suez	11,589	12,943	9,701	9,892	6,233	
	Panama	11,548	10,969	14,122	14,608	11,869	9,370
Distance	saved	**41**	**1,974**	**4,421**	**4,716**	**5,636**	
Hongkong	Suez	11,673	13,031	9,785	9,976	6,317	
	Panama	11,691	11,112	13,957	14,443	11,704	9,173
Distance	saved	**18**	**1,919**	**4,172**	**4,467**	**5,387**	
Yokohama	Suez	13,566	14,924	11,678	11,869	8,210	
	Panama	9,798	9,219	12,372	13,858	11,119	7,660
Distance	saved	**3,768**	**5,705**	**694**	**1,989**	**2,909**	
Panama		2,017	1,438	4,591	5,110	6,387	

TABLE I.—DISTANCES AND TIME SAVED VIA THE PANAMA CANAL AS CONTRASTED WITH ROUTES VIA THE SUEZ CANAL, THE CAPE OF GOOD HOPE, AND THE STRAITS OF MAGELLAN BETWEEN THE ATLANTIC GULF SEABOARD OF THE UNITED STATES AND AUSTRALASIA

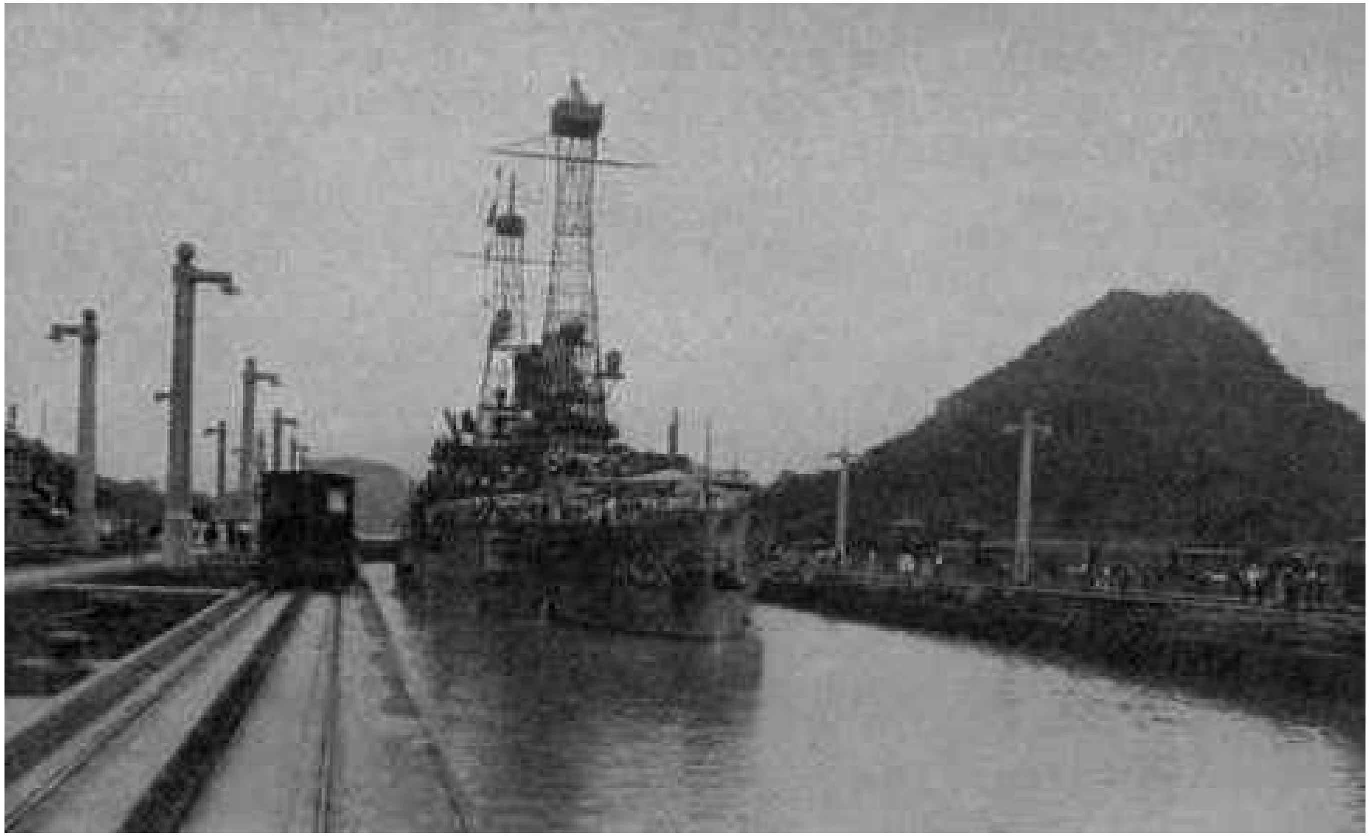
To	From New York						From New Orleans						Remarks
	Distance saved	Days saved for vessels of					Distance saved	Days saved for vessels of					
		9 knots	10 knots	12 knots	14 knots	16 knots		9 knots	10 knots	12 knots	14 knots	16 knots	
	Miles						Miles						
Adelaide...	1,746	7.5	6.7	5.6	4.6	4.0	3,258	14.6	13.1	10.8	9.2	8.0	Difference between routes via Panama, Tahiti, Sydney, and Melbourne, and via St. Vincent and Cape of Good Hope.
Melbourne.	2,770	12.3	11.0	9.1	7.7	6.7	4,282	19.3	17.3	14.3	12.2	10.7	Difference between routes via Panama, Tahiti, and Sydney and via St. Vincent, Cape of Good Hope, and Adelaide.
Sydney....	3,932	17.7	15.8	13.1	11.2	9.7	5,444	24.6	22.2	18.4	15.7	13.7	Difference between routes via Panama and Tahiti, and via St. Vincent, Cape of Good Hope, Adelaide, and Melbourne.
Wellington	2,493	11.0	9.9	8.1	6.9	6.0	3,488	15.6	14.0	11.6	9.9	8.6	Difference between routes via Panama and Tahiti and via Straits of Magellan.

TABLE II.—DISTANCES AND DAYS SAVED BY THE PANAMA OR THE SUEZ CANAL BETWEEN THE ATLANTIC GULF SEABOARD OF THE UNITED STATES AND JAPAN, CHINA, THE PHILIPPINES, AND SINGAPORE

To	Via	From New York						From New Orleans						Remarks
		Distance saved	Days saved for vessels of					Distance saved	Days saved for vessels of					
			9 knots	10 knots	12 knots	14 knots	16 knots		9 knots	10 knots	12 knots	14 knots	16 knots	
		Miles						Miles						
Yokohama...	Panama.	3,768	16.9	15.2	12.6	10.7	9.3	5,705	25.9	23.3	19.3	16.5	14.4	Via San Francisco.
	Suez....	...	...	...	...	...	...	...	...	...	...	...	...	Via Colombo, Singapore, Hongkong and Shanghai.
Shanghai	Panama.	1,876	8.1	7.3	6.0	5.1	4.4	3,813	17.1	15.4	12.7	10.8	9.4	Via San Francisco and Yokohama.
	Suez....	...	...	...	...	...	...	...	...	...	...	...	...	Via Colombo, Singapore and Hongkong.
Hongkong...	Panama.	...	...	...	...	...	...	1,919	8.4	7.5	6.2	5.2	4.5	Via San Francisco, Yokohama and Shanghai.
	Suez....	18	...	...	...	...	...	...	...	...	...	...	...	Via Colombo and Singapore.
Manila..	Panama.	41	...	...	...	...	...	1.978	8.6	7.7	6.4	5.4	4.7	Via San Francisco and Yokohama.
	Suez....	...	...	...	...	...	...	...	...	...	...	...	...	Via Colombo and Singapore.
Singapore...	Panama.	...	...	...	...	...	...	...	...	...	...	...	...	Via San Francisco and Yokohama.
	Suez....	2,484	11.0	9.8	8.4	6.9	5.9	547	2.0	1.7	1.4	1.1	0.9	Via Colombo.

“The first battleships to use the Panama Canal were the ‘Missouri,’ ‘Ohio,’ and Wisconsin,’ of the United State Navy, which passed through the canal on their way to San Francisco July 16, 1915. The battleship fleet, of which the ‘Missouri’ was the flagship, was engaged in the service of transporting the cadets from the Naval Academy at Annapolis, MD., to the Panama-Pacific Exposition…”

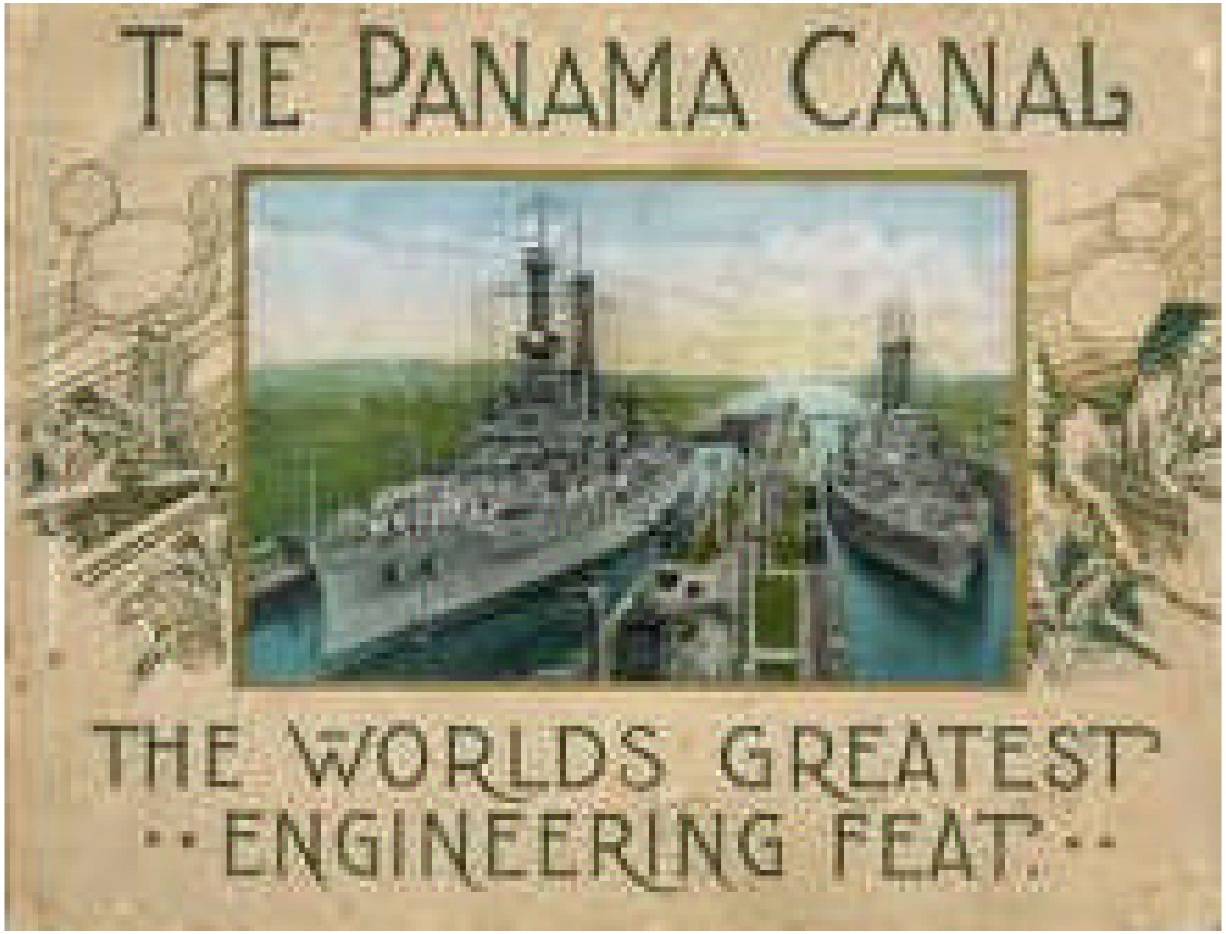
***Popular Mechanics,* October 1915**



"The recent passage of the United States Battleships through the Panama Canal, on their way to the Panama-Pacific Exposition, while impressive, was by no means sensational as the trip from the Atlantic to the Pacific was accomplished without particular incident or accident. The vessels entered the canal at Cristobal on Friday, July 16th, and the passage was made almost without a halt…The safe and rapid passage of these vessels, the first war fleet to make use of the canal, has probably added greatly to the appreciation by the public of the value of this great waterway."

***Scientific American Supplement,* August 21st 1915**

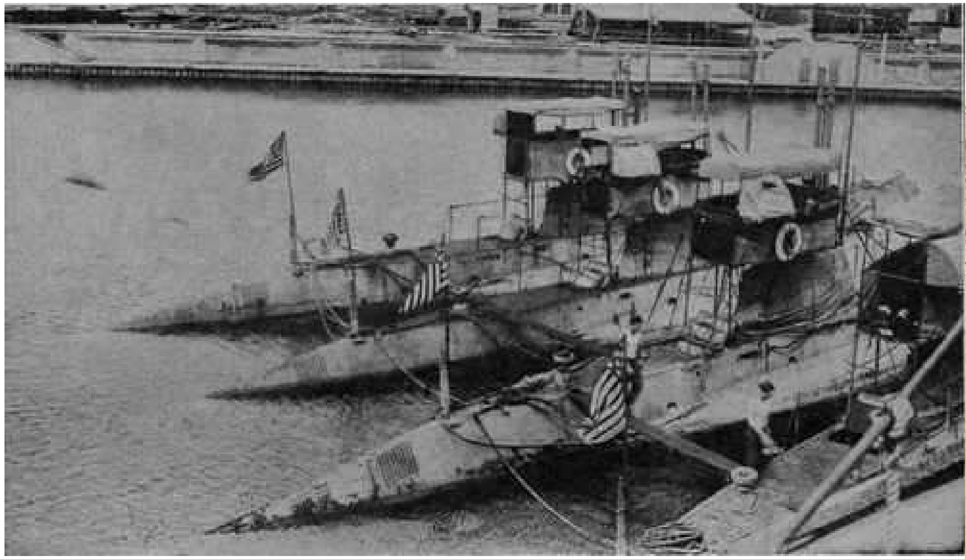
Above: caption: "The U.S.S. Ohio in the East Chamber of the Pedro Miguel Locks"

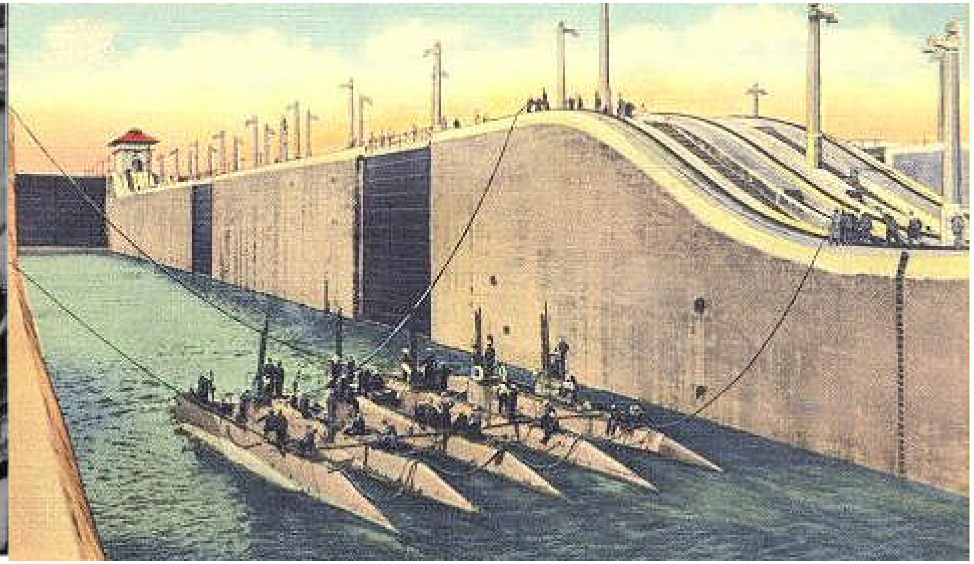

THE PANAMA CANAL
THE WORLDS GREATEST
ENGINEERING FEAT.

"…Moreover, the possibility of utilizing the canal in all circumstances in war is by no means assured, despite the great fortifications which the Americans are erecting at a cost of one hundred million dollars, in direct contravention of the Clayton-Bulwer treaty of 1850, which declared the unconditional neutrality of any future Isthmanian canal. Even if the ends of the canal are protected by impregnable fortifications and guarded by twelve thousand men, how can the fifty-mile long canal be protected from attack and destruction by a hostile force coming by way of the neutral territory which borders the narrow Canal Zone on both sides? David's Bay, near the island of Coiba, would afford a convenient landing place for Japanese troops, and the Japanese showed in 1904, on the Kwantung Peninsula, how coast fortifications, impregnable by sea, can be made useless by a land attack…"

Scientific American Supplement, **September 23rd 1911**

RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries"





"Charting of the sea floor in the Gulf of Panama and at the Pacific approach to the canal has been undertaken by the navy to make the underwater safe for the growing fleet of submarines based at the canal to protect it in the event of war. The surface of the gulf and the shoals that reach near enough to the surface to endanger shipping are well charted, but the underwater depths are not so well known, and the charts in many cases are incomplete and incorrect…"

***Popular Mechanics,* July 1927**

Left: caption: "The vessels here shown are used in defense of the Pacific side of the canal. They appear as anchored in the new concrete docks at Colon, preparatory to their passage through the canal, after having made the longest sea voyage then on record for submarines."

Right: (postcard) caption: "U.S. 'C' Class Submarines in Gatun Locks, Panama Canal"

Shall We Fortify the Panama Canal?

“Shall we fortify the Panama Canal? Seems a silly question, and yet some thin-skinned people profess to believe, at least they express a belief, that this water highway should be a high seas path. The canal will probably cost about four hundred million dollars, and should be as well worth the price as it is worth the doing. In time of peace, its tolls will doubtless be sufficient to make it at least self-supporting. In time of war, the value to the United States of this shortcut cannot be estimated...The right of the United States to erect and maintain suitable fortifications cannot be seriously questioned by the other powers…No comparison can be made with the Suez canal, which has no territorial rights, and is owned by an alien corporation. We have the same right and owe ourselves the same obligation to fortify the Panama canal that we have to fortify our home harbors and our island possessions.”

Popular Mechanics, **November 1910**

RE: editorial in favor of fortifying the ***Canal Zone***

Our Own Right and Might

“When other nations cease to increase their armaments by great strides, not only in ships and guns, but in men, in powder, and in aerial fleets, it will be safe for us to lay our Canal at the feet of the World and say ‘We have built it for you, and we can trust you to protect it for us – not before’…So let us hope that we will complete our great enterprise, not by the protection of promises, but by the strong, sure hand of government; that we will not leave it for years guarded only by an indulgent Providence as we have in the past left our coast cities; but that we will secure it in our own right and might for the benefit of our people for all time.”

Lieutenant General Nelson A. Miles, **1911**

A Matter of Insurance

“Having invested nearly $375,000,000 in the canal, the United States is intent upon safeguarding that tremendous outlay against the possibility of damage through foreign war. Fortification of the canal has been undertaken purely as an insurance matter. It is sought to make it impossible in time of war, for any enemy to take possession of the waterway, or to damage it to such an extent that the ships of the United States could not use it at will…”

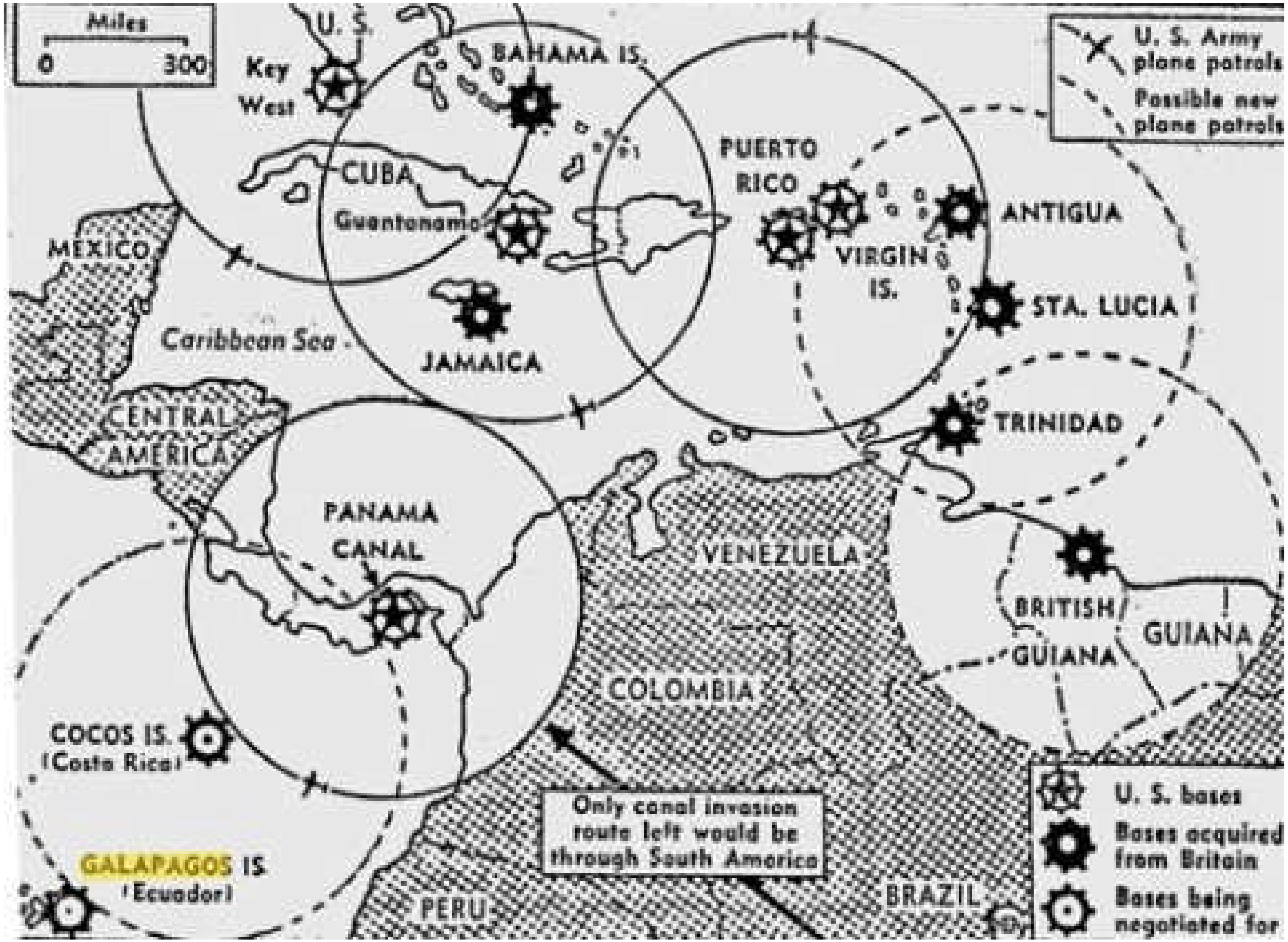
***Popular Mechanics,* March 1914**

<u>Above</u>: view of *U.S. Army Air Corps* planes on patrol, flying over *Fort Amador* at the *Pacific* entrance to the *Panama Canal* (ca. 1920s)

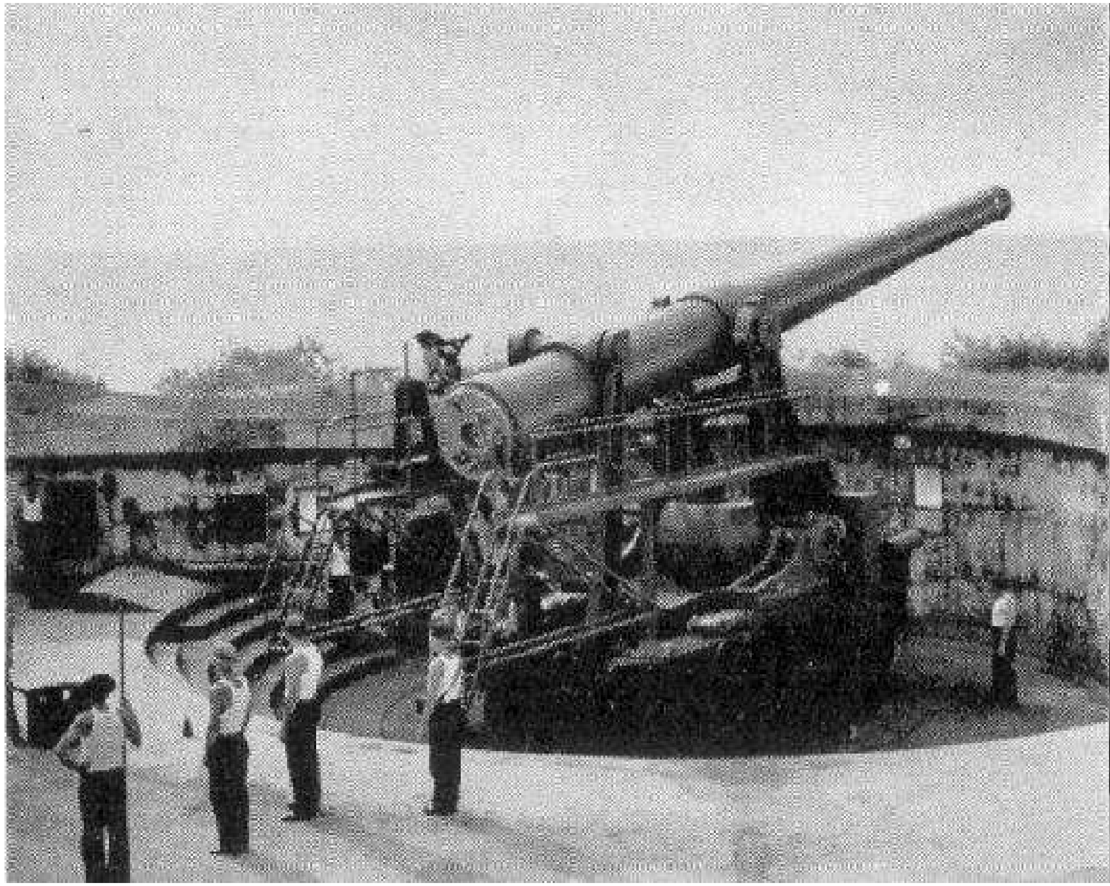
<u>Left</u>: caption: "'The Pacific Gateway." The gun points to canal entrance, high hills in the background are beyond the canal."

“…Guns of 14 and 16 in. caliber will be placed at forts guarding both the Pacific and Atlantic entrances, commanding a radius of 15 miles. The forts at the Pacific entrance are constructed on three islands in Panama Bay, at the very beginning of the canal, Flamenco, Perico, and Naos. These are huge masses of volcanic rock, behind which, safe from the fire of any ship, no matter how powerful, the forts stand. The great Miraflores Locks are seven miles inland from the forts, and no gun at the present time is powerful enough to send a shell the 22 miles intervening between the outside of the zone of fire from the forts and those locks which control the canal…The Canal Zone will be a military reservation, with ample guard always on duty, with field artillery, and wireless equipment which will be in touch with naval stations at all times, and instant alarm will be given of threatening attack from any source. Three regiments will be stationed at Culebra, a regiment of marines at Balboa, and a full force of artillerymen at the forts.”

***Popular Mechanics,* March 1914**



<u>Above</u>: caption: "Map shows how a shield against attack from both the Atlantic and Pacific will be formed around the Panama Canal by the new US and proposed bases on Cocos and Galapagos Islands"




<u>Left</u>: caption: “One of two 14-inch disappearing rifles of Battery Warren, Flamenco Island”
<u>Right</u>: caption: “12-nch coast defense mortars, Battery Merritt, Flamenco Island”

An American Monster

<u>Above</u>: **16"/ 50 (40.6 cm) Mark 3 Coastal Defense Gun on U.S. Army "Barbette" mounting; displayed at the *Aberdeen Proving Grounds Museum* in Maryland. The plaque reads;**

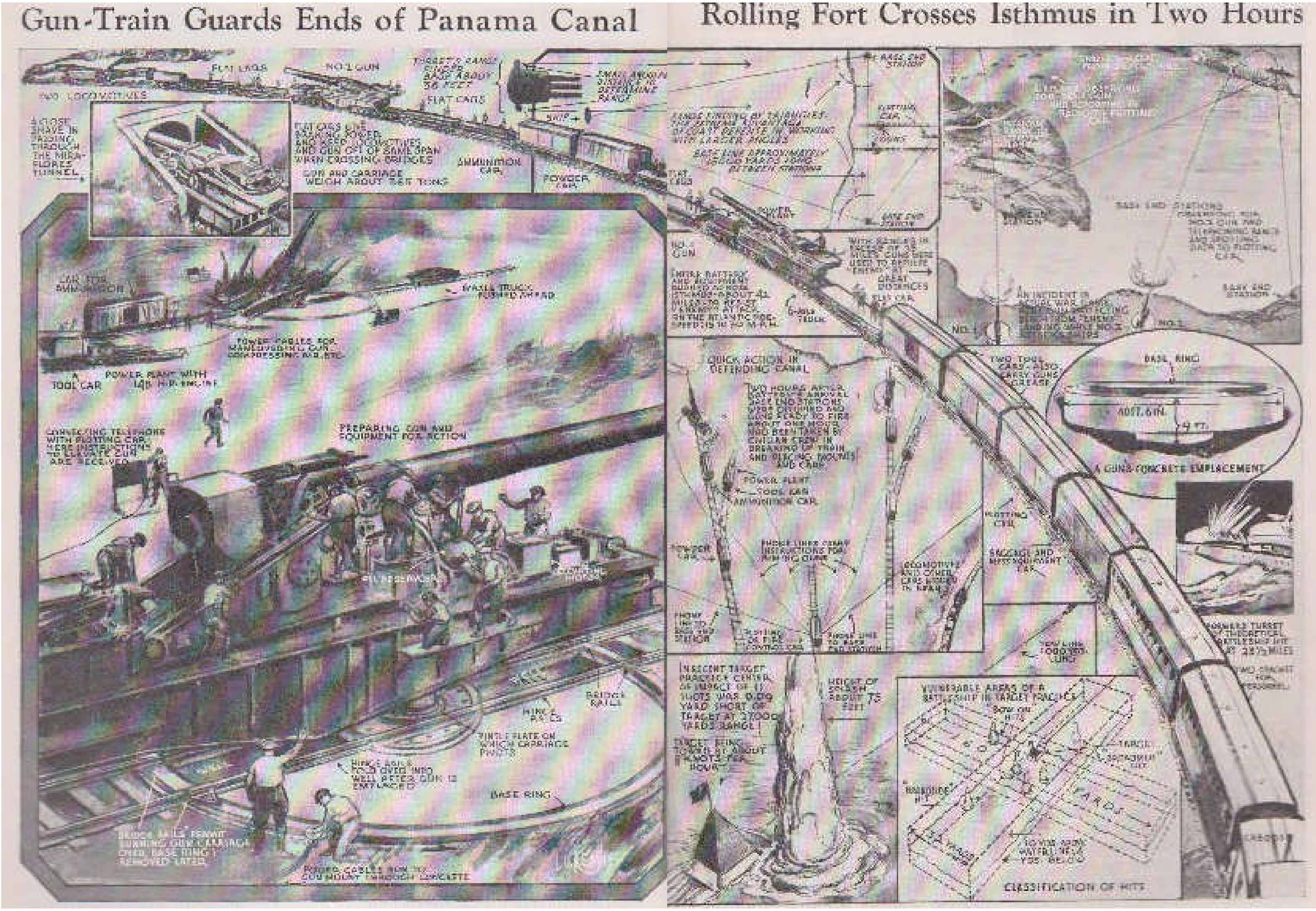
16 inch Coastal Defense Gun

This weapon represents the most powerful coastal defense gun built and is the last remaining example of its type. Originally designed as a naval weapon it is employed on an army barbette mount. The class of Battleships it was originally designed for were not built as a result of the Washington Treaty of 1922 and the weapons were transferred to the army for use in coast defense. This gun was brought to Aberdeen to test powder and projectiles.

"The biggest gun in the world was built primarily to guard the biggest canal in the world. This enormous engine of destruction is a 16-in. breech loading rifle, the newest weapon designed for the sea-coast defense of the United States and its insular possessions, the first one being completely intended for the Panama Canal. The total length of the gun is 49 ft. 2.9 in. It has a diameter of 60 in. at the breech, tapering to 28 in. at the muzzle. If smokeless powder is used, it is estimated that a full charge will throw a projectile weighing 2,400 lb. a distance of 22 miles. The projectile prepared for the monster is 5 ft. 4 in. long, and it has been calculated that it would go through a steel plate 42.3 in. thick, if the plate was placed at the muzzle…The total weight of this American monster is 130 tons…The greatest gun ever built by the Krupps had a range of 12.5 miles…It is expected that guns of the same type will be placed in the fortifications in the Philippines and in Hawaii. American ordnance experts are elated over the success of experiments with the gun."

Popular Mechanics, **November 1911**

Rolling Fort



"Mounted on a train for fast transportation from the Atlantic to the Pacific coast, large caliber guns guard both ends of the Panama Canal; drawings show how big gun is mounted after trip across Isthmus; manned by 200 men, the rifles fire from the rails; full turn permits all-round firing. Speeding from coast to coast, slightly more than forty miles, in twin mounts, the fort mounted on a train defies 'Enemies' at either end of the Panama Canal; Drawing shows some essential steps in hurling projectiles weighing nearly a ton; the Gun-Train has been tested in war-game maneuvers."

***Popular Mechanics,* December 1934**

<u>Above</u>: caption: "16 inch gun of 'Battery Murray' near the Pacific end of the Panama Canal in 1932. Note the complete lack of protection or concealment."
<u>Left</u>: caption: "A 16-inch gun used in the defense of the Panama Canal"

Fleet Problem IX

“Fleet Problem” was the term used by the *United States Navy* to describe each of twenty-one large-scale naval exercises conducted between 1923 and 1940. The Fleet Problem/s were annual exercises in which U.S. naval forces would engage in mock battles. One or more of the forces would play the part of a European or Asian navy. They were the culmination of the Navy’s annual training maneuvers. *Fleet Problem XXII*, scheduled for 1941, was canceled as a result of the *Pearl Harbor* attack (which was, ironically, simulated in *Fleet Problem XIX* held in April/May 1938). *Fleet Problem IX*, held in January 1929, studied the effects of an attack upon the *Panama Canal* and conducted the operations necessary to carry out such an eventuality. It pitted the *Battle Fleet* (less submarines and the aircraft carrier *Lexington*) against a combination of forces including the *Scouting Force* (augmented by *Lexington*) and local army defense forces. In a daring move, the carrier *Saratoga* was detached from the Battle Fleet with only a single cruiser as escort to make a wide, high-speed sweep to the south to simulate a pre-dawn aerial attack on the Panama Canal’s locks and airfields, which was defended by the Scouting Fleet and *Saratoga*’s sister ship *Lexington*. She successfully launched her strike on January 26th 1929 and, despite being “sunk” three times later in the day, proved the versatility of a carrier-based fast task-force and the vulnerability of the *Canal Zone* to air attack from carrier-borne aircraft.

“…Saratoga’s exploits during Fleet Problem IX marked the first step in the development of the Carrier Task Forces which were so effective in the Pacific. This operation convinced naval aviators - and some surface warriors, such as Admiral Pratt - that task forces built around carriers would be of importance in the future of naval warfare…”

***Albert A. Nofi*, Author**

“…The most important conclusion drawn from the Saratoga’s raid was the impossibility of stopping a determined air attack once it was launched. Unfortunately, in the years to come, this lesson would be forgotten, by certain members of the so-called Gun Club - the battleship men who were unwavering in their faith in the supremacy of the big gun. Their preoccupation with re-fighting the Battle of Jutland instead of ensuring the security of the fleet contributed greatly to the disaster at Pearl Harbor. Evident to Reeves and to the carrier commanders who followed in his footsteps, was the reality that in any future engagement involving aircraft carriers at sea, the first carrier to locate and bomb the other would determine the outcome...”

***Thomas Wildenberg*, Author**

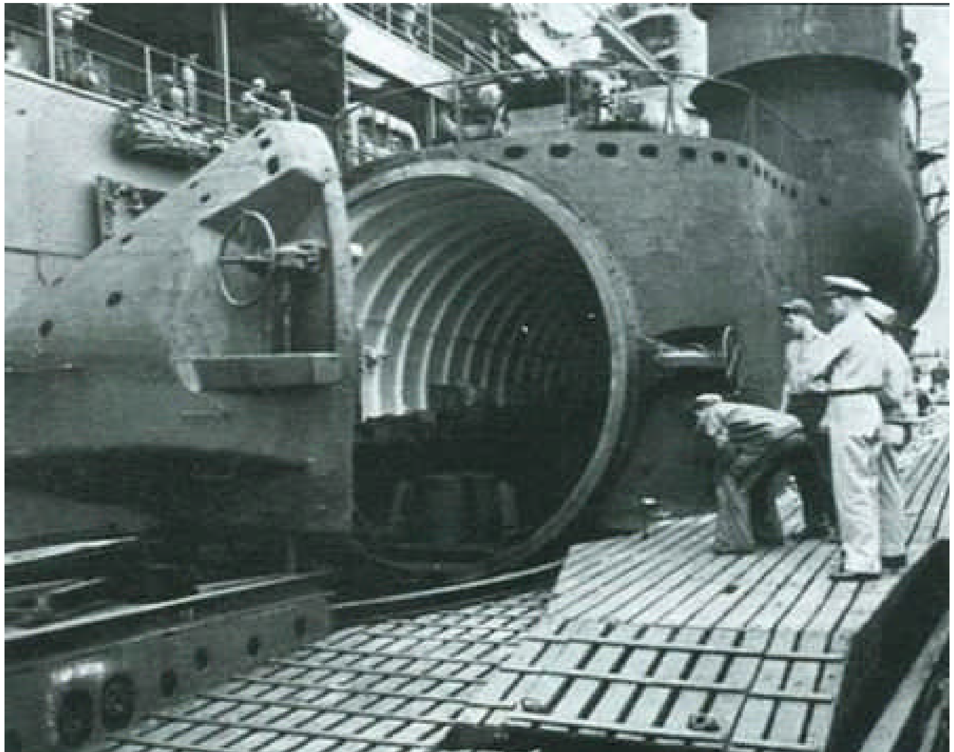
The Pacific Triangle

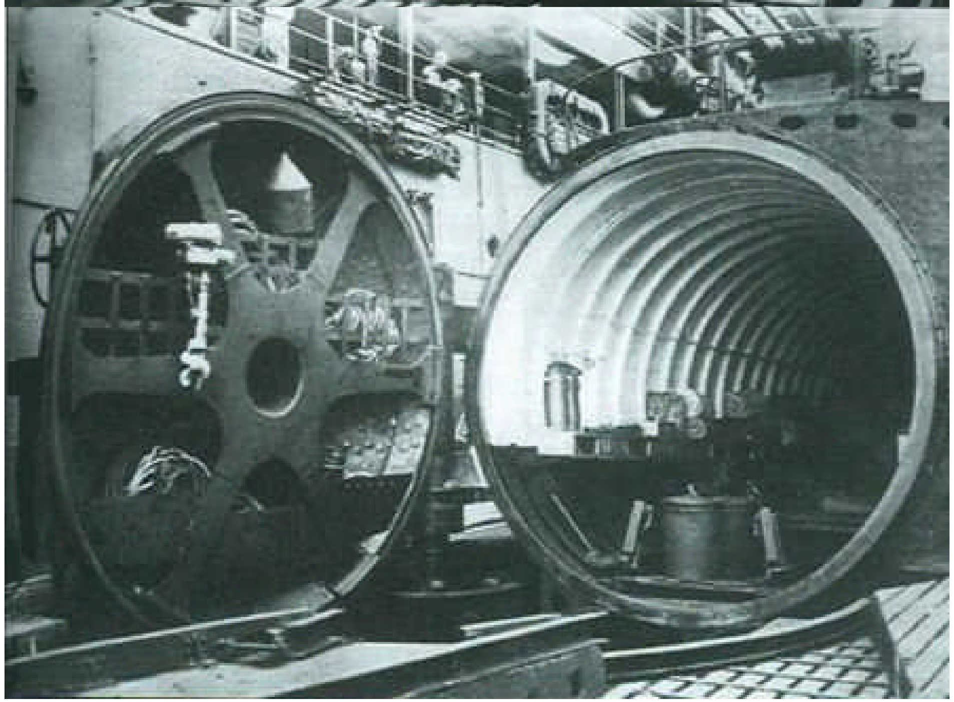
"The reason for the military emphasis on Oahu is that the island commands and protects the whole west coast. Together with Alaska and Panama it forms an invisible but deadly triangle through which an enemy would have to storm his way…Panama, the southern corner of the Pacific triangle, was long ago strongly prepared against assault. Now its zone of defense is being extended out into both oceans. Big guns on the hills and in the jungles can outshoot any battleship afloat. Elaborate precautions have been taken to prevent a foreign vessel from scuttling itself in the canal. Special counter-espionage and anti-sabotage measures are being enforced. Visitors who stray into forbidden areas are presumed to be violating the many 'restricted zone' signs and are to be fired upon by hidden guards. The Canal is too important to risk chances…"

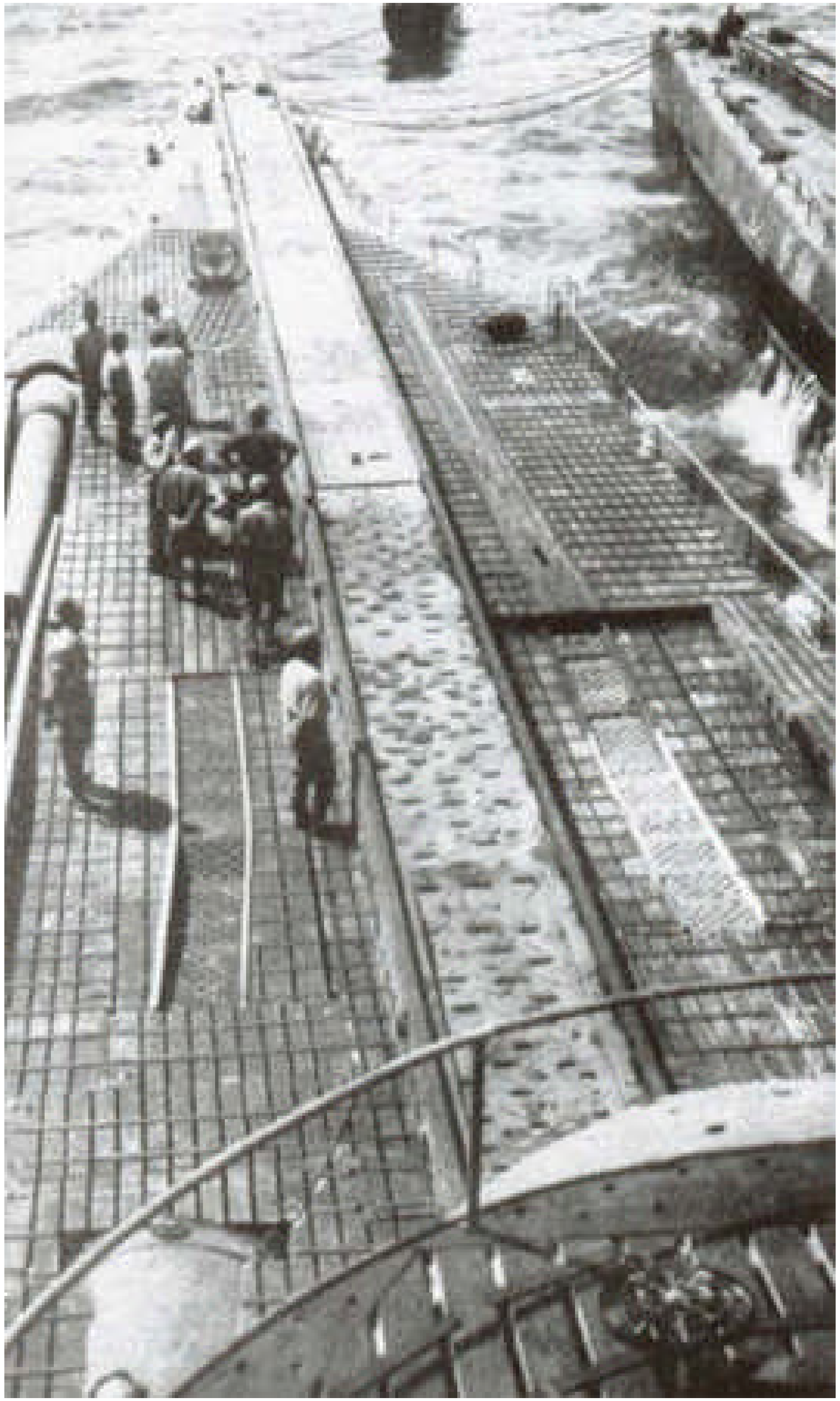
***Popular Mechanics*, April 1942**

Storm From a Clear Sky

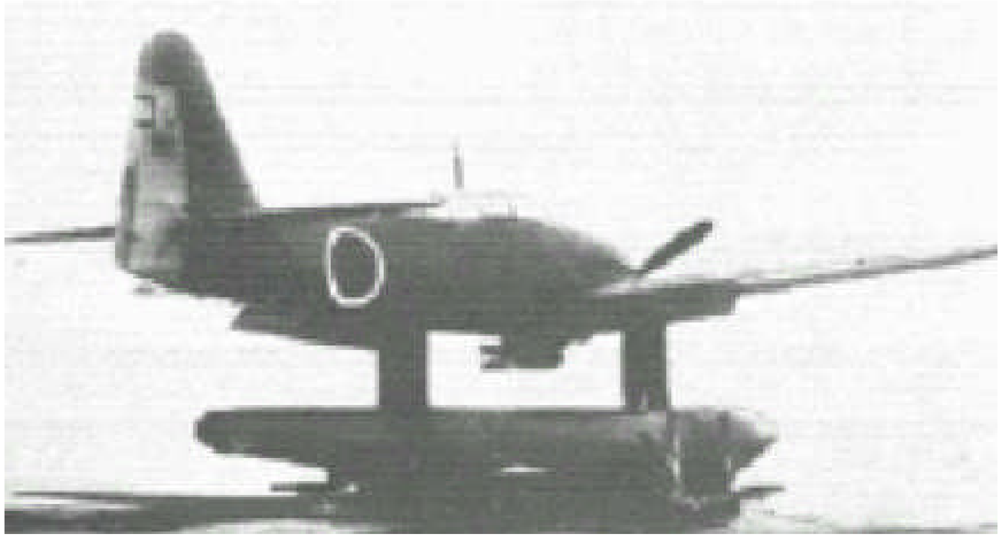
His Imperial Japanese Majesty's "Sensuikan Toku" (Special Submarines) was designed specifically to attack the ***Panama Canal***. In many ways, ***HIJMS I-400*** (Japan's sub-mersible aircraft carrier) was decades ahead of its time. It was the world's largest submarine with a length of 400-ft. and a surface displacement of 3,530 tons. Above her main deck rose a 115-ft. long, 12-ft. dia. hangar housing three torpedo-bombers. These float planes were rolled out through a massive hydraulic door onto an 85-ft. pneumatic catapult where they were rigged for flight, fueled, armed, launched and, after landing alongside, lifted back aboard with a powerful hydraulic crane. The I-400 was equipped with a snorkel, radar, radar detectors and capacious fuel tanks that gave her a range of 37,500 miles. She was armed with eight torpedo tubes, a 5.5-in 50-caliber deck gun, a bridge 25mm antiaircraft gun and three triple 25 mm AA mounts atop her hangar.







The I-400 had aircraft storage and catapult for three M6A1 “Seiran” (*Storm from a Clear Sky*) torpedo bombers. These specially designed float planes had a length of 35-ft., a wingspread of 40-ft., a range of 654 miles and a munitions payload of 1800-lbs. Additional fuel and bombs could be carried by jettisoning the floats on one-way missions where the pilots and planes were to be expended. The sleek Seiran bombers, built by *Aichi Kokuki* at *Nagoya*, were stowed in the hangar compartment with floats detached and wings and tails folded. Actually with the stabilizers folded down, and the top of the vertical stabilizer folded over, the overall profile of the aircraft was within the diameter of its single propeller.



A well-trained team could rig a *Seiran* floatplane (above) for launch with fuel and armament in as little as seven minutes. In fact, that same trained team could prepare all three planes and have them in the air in under 45 minutes. The planes were launched from a 120-foot catapult on the deck of the giant submarine. Accommodations for a crew of 145 were designed into the twin hulls, but on most occasions the crew compliment was much higher, somewhere in the 200-plus range. The reason for this was to facilitate expedited submarine and/or aviation operations at sea (more men was an assurance of that). Also the I-400 had great cruising range which enabled it to launch her three bombers within striking distance of targets as far from *Japan* as *San Francisco*, the *Panama Canal*, *Washington D.C.* and/or *New York*. All of these missions for the I-400s were considered by the *Tokyo* Naval Strategists.

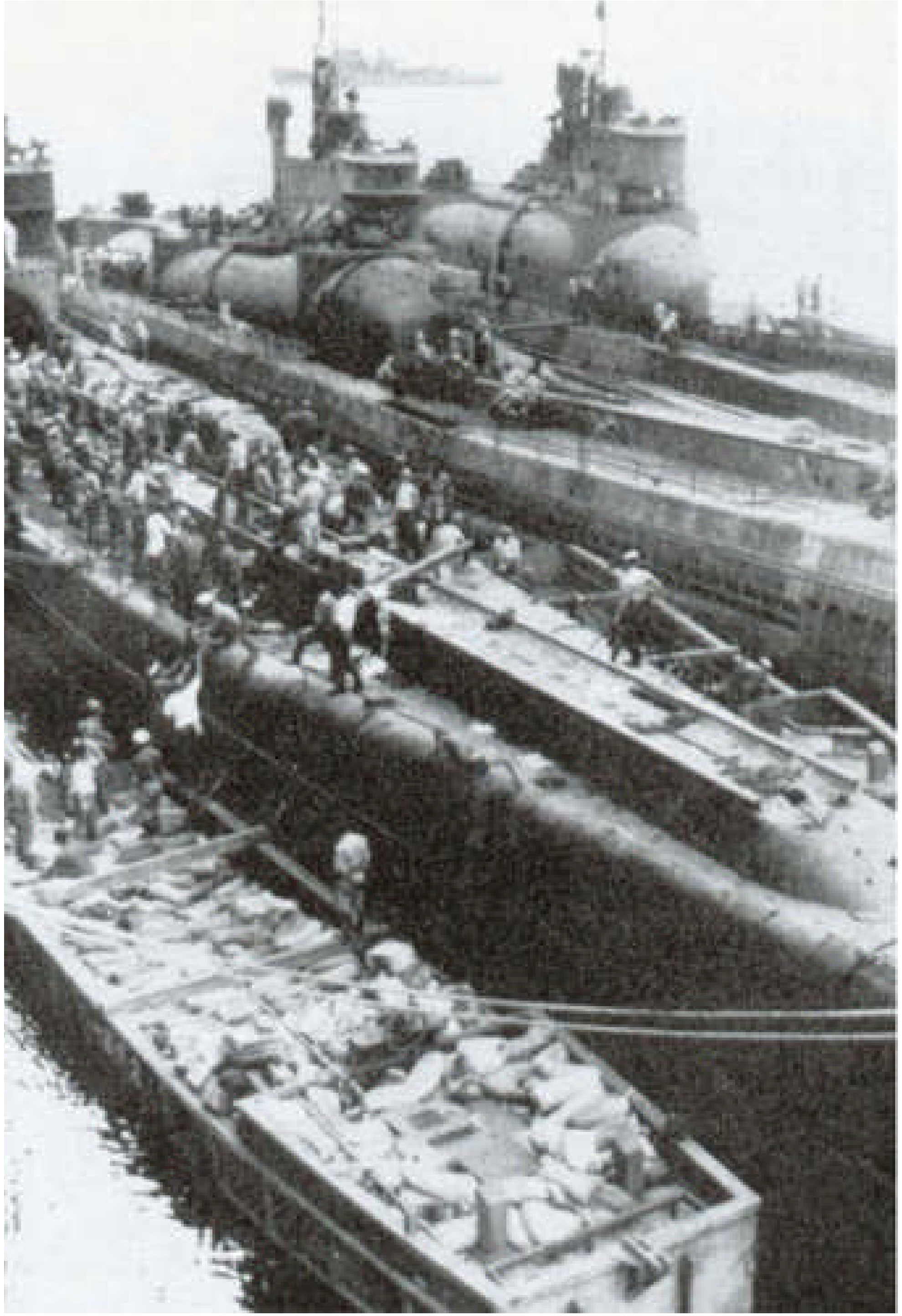
SubRon One

Several surviving Japanese submariners have described the hopes that accompanied the completion of the top secret subs in late 1944. As they became available, the four giant *I-400* submarines were assigned to a newly created *SubRon One*; a ten-bomber strike force. For their first mission Vice Admiral *Jisaburo Ozawa*, Vice Chief of the *Navy General Staff*, selected *Operation PX*, a top secret plan to use SubRon One's ten aircraft to unleash bacteriological warfare on populous areas of the American *West Coast* and *Pacific* Islands. Infected rats and insects would be dispersed to spread *Bubonic Plague, Cholera, Dengue Fever, Typhus* and other infectious diseases. General Ishii's infamous medical laboratory at *Harbin, Manchuria*, had developed the virulent germ warfare agents and confirmed their lethality by infecting Chinese and Caucasian prisoners. On March 26th 1945, this sinister mission was canceled by General *Yoshijiro Umezu*, Chief of the *Army General Staff*, who declared that, *"Germ warfare against the United States would escalate to war against all humanity."* As an alternate, the staff considered bombing *San Francisco, Panama, Washington* or *New York* and decided to launch a surprise air strike against the Panama Canal's *Gatun Locks*. Destroying these locks would empty *Gatun Lake* and block the passage of shipping for months. For the 17K-mile round trip to Panama, each submarine needed 1600-tons of diesel fuel, which was unavailable. *HIJMS I-401* was therefore dispatched to *Dairen, Manchuria,* to bring back the needed oil. On April 12th 1945 she grazed a B-29 laid mine off *Hime Shima Lighthouse* in the *Inland Sea* and had to return for repairs.

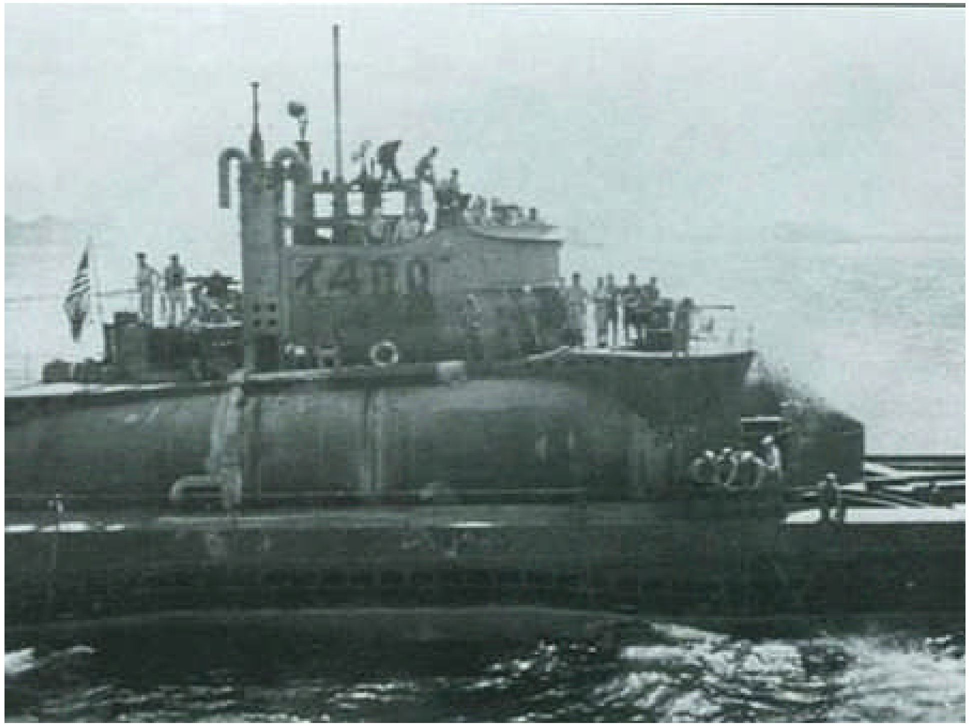
In her place, ***I-400*** **successfully carried out the undersea tanker mission. By early June 1945 all four boats were fueled, armed, equipped with new snorkels and disguised with false funnels. They sailed north through** ***Tsushima Strait*** **and the** ***Sea of Japan*** **to** ***Nanao Bay*** **on the west coast of** ***Honshu*** **near** ***Takaoka*****. Training there was hampered by B-29 laid mines and American submarines penetrating their training areas. Despite shortages,** ***SubRon One*** **managed to launch a number of simulated air strikes on a full-scale model of the** ***Gatun Locks*** **erected at** ***Tayama Bay*****. While the submersible carriers were perfecting their tactics to cripple the** ***Panama Canal*****, the position of the** ***Japanese Navy*** **was steadily deteriorating. Before the submarines could set sail for** ***Panama,*** **more than 3K allied warships and transports had reached the** ***Pacific*** **for** ***Operation Olympic*****, the forthcoming invasion of** ***Japan*****. This growing threat forced** ***Tokyo*** **strategists to reconsider the attack on distant Panama, which now appeared a questionable diversion. The** ***Sensuikan Toku*** **subs were ordered to abandon their carefully rehearsed canal strike and attack American naval forces at** ***Ulithi Atoll*****.**

In response to the new orders I-13 proceeded on July 4th 1945 to the *Ominato Naval Base* on the northern tip of *Honshu*. There she loaded two crated *Nakajima C6N2 "*Ayagumo" ("Colored Cloud") long range reconnaissance aircraft, then sailed into the *Pacific* through *Tsugaru Strait* bound for Japan's island stronghold of *Truk*. After repairing a hot propeller bearing, I-14 followed on July 14th 1945. On the 23rd, *I-400* and *I-401* departed Ominato on separate tracks far to the east for a rendezvous at sea southeast of *Ulithi* in three weeks. Suddenly, on August 15th 1945, *Emperor Hirohito* broadcast direct from the *Imperial Palace* his dramatic decree ending hostilities. The I-boat crews were mortified; their combat careers ended just as they reached the attack rendezvous. After a council of war at sea, the shattered *ComSubRon One* reluctantly carried out Tokyo's orders to cease hostilities, hoist a black flag, and return on the surface to home port. The captains of the I-boats were ordered to jettison all documents and munitions, fire all torpedoes, and catapult all aircraft into the sea. When I-401 surrendered to an American destroyer, the U.S. Crew was astounded at its size.

Operation Road's End

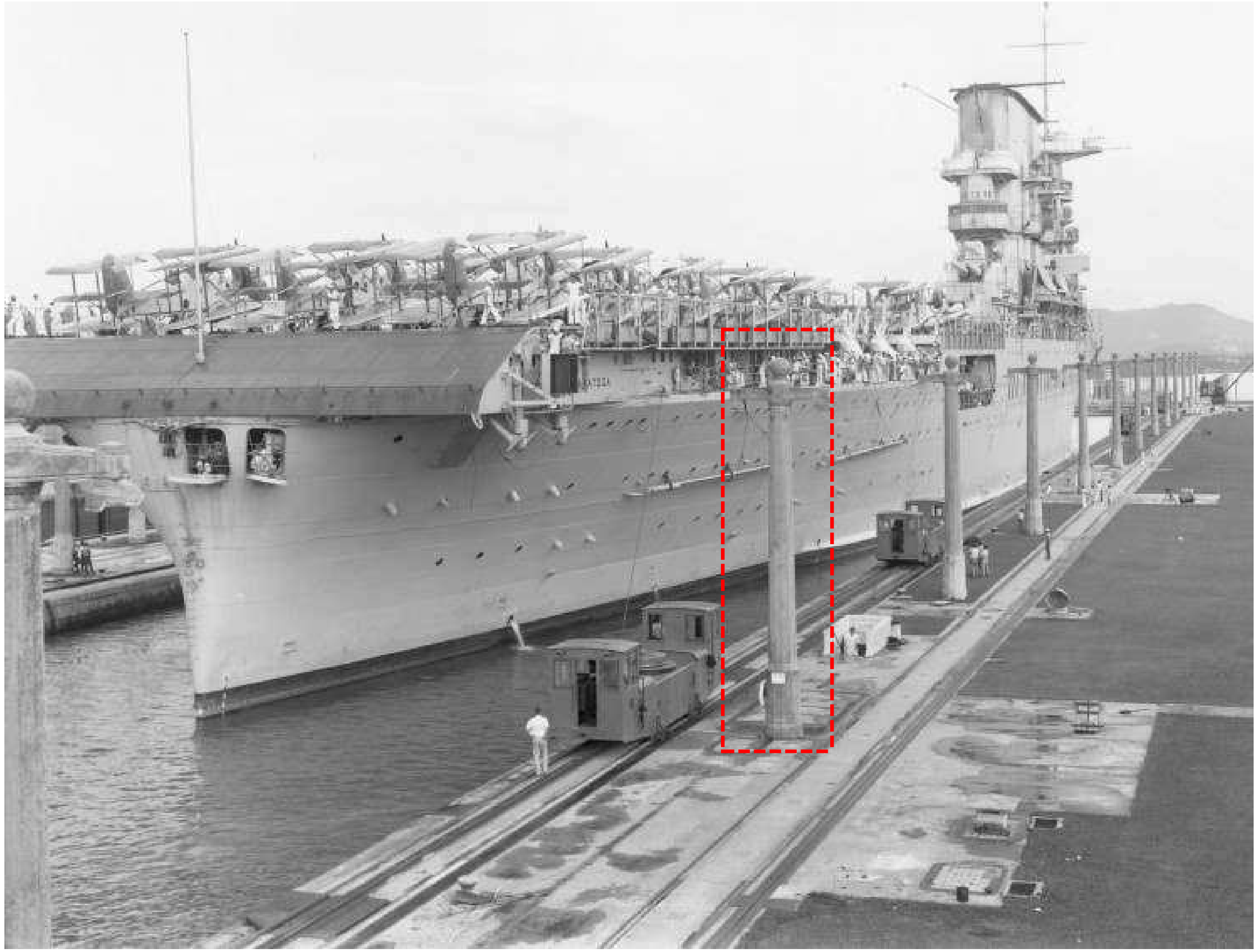


The commander of the submarine fleet; *Captain Ariizumi*, decided on suicide rather than surrender to the Americans. The *U.S. Navy* boarded and recovered twenty-four sub-marines including the four I-400 subs, taking them to *Sasebo Bay* to study them. While there, they received a message that the Russians were sending an inspection team to examine the submarines. To keep the technology out of the hands of the *Soviet Union*, *Operation Road's End* was instituted. Most of the submarines were taken to a position designated as *Point Deep Six*, about forty miles west from *Nagasaki* and off the island of *Goto-Retto*, were packed with charges of C-2 explosive and destroyed.



Four remaining submarines; *I-400, I-401, I-201* and *I-203,* which achieved speeds double those of American submarines, were sailed to *Hawaii* by *U.S. Navy* technicians for further inspection. Upon completion of the inspections, the submarines were scuttled in the waters off *Kalaeloa* near *Oahu* in *Hawaii* by torpedoes from the American submarine *USS Cabezon* on May 31st 1946. The reason for the scuttling was, apparently, the demands of Russian scientists for access to the submarines. The wreckage of I-401 was re-discovered by the *Pisces* deep-sea submarines of the *Hawaii Undersea Research Laboratory* in March 2005 at a depth of 820 meters.

Mahan Vindicated



The anticipated military significance of the canal was proven in *World War II*, when the *United States* used it to help restore their devastated *Pacific Fleet*. Some of the largest ships the *United States Navy* had to send through the canal were aircraft carriers, in particular the *Essex Class*. These were so large that, although the locks could hold them, the lamp-posts' brackets (alongside the locks) had to be removed (above).

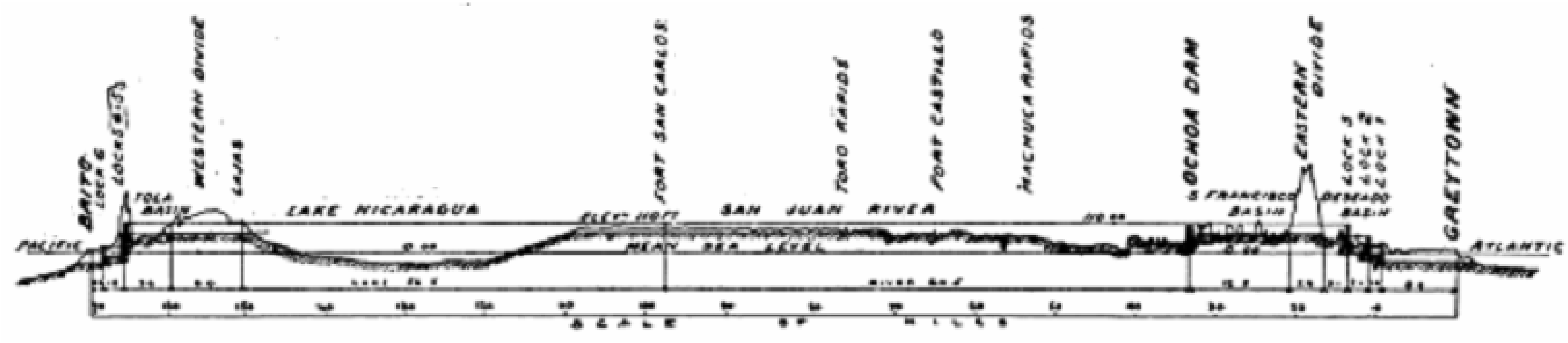
"…The building of the canal, however, is one of the best bargains or country ever made. How many millions of man-hours and ship hours were saved by the Panama Canal in World War II will never be calculated…Always well defended with giant coastal guns, the Canal Zone bristled during the war with anti-aircraft artillery. Barrage balloons were everywhere. A $20,000,000 fuel pipeline from Cristobal on the Atlantic side of the Isthmus to Balboa on the Pacific side was completed just before the Japs threw in the towel. Conceived as a secret alternate supply artery from one ocean to the other in case the canal was knocked out by enemy action, the pipe line – originally a single 20-inch line 46 miles long – proved so valuable that a duplicate pipeline was begun even before the first was completed. The daily capacity of the dual artery is 265,000 barrels of fuel oil, 60,000 barrels of gasoline and 47,000 barrels of Diesel oil…"

***Popular Mechanics,* June 1946**

<u>Left</u>: caption: “Building the $20,000,000 Panama fuel pipe line with a daily capacity of 265,000 barrels of fuel oil – a wartime project”

Land of Lakes and Volcanoes

In 1897 and 1899, two fact-finding commissions appointed by *Congress* recommended the *Nicaragua* route. What made Nicaragua so compelling was a massive lake in the middle of the country. The lake was 107-feet above sea-level, so no digging would be necessary. Since the lake drained to the *Caribbean Sea* via the *San Juan River*, all that need be done was to dredge out the river deep enough for ships to navigate. Ninety-percent of the route was easily traversed it seemed. Only the hills on the *Pacific*-side near *San Juan del Sur* would present any sort of problem. But since its lowest point was 184-feet above sea level, even this beat Panama's *Culebra Pass* (336-feet). On the other hand, *Panama* was the shorter route, but it had no lake to use for the "lake-and-lock" system typically used for canals through uneven terrain. Furthermore, its major river; the *Chagres*, was difficult to control while the San Juan was not. Both options were put on the table when President *Theodore Roosevelt* decided it was time to build a canal in 1901 with Nicaragua having the inside track. The French were panic-stricken. The only possible way to recoup some of their losses would be to persuade the Americans to change their mind about Nicaragua. France's new *Panama Canal Company* began a strong lobbying effort to influence the final verdict. The French offered to sell its equipment and license in Panama at a major discount. This offer put Panama back in the running. Yes, the Nicaragua route was superior, but the fact that the French had already dug out eleven of the fifty miles needed to finish the project definitely helped the Panama route's proponents.



Considering that popular sentiment and the second *Walker Commission* were in favor of a canal in *Nicaragua*, actions along those lines were moving swiftly through the U.S. *House of Representatives*. At about this same time, the Compagnie Nouvelle held a stockholders meeting in *Paris*, and, fearing to get left out in the cold with their proposed deal with the Americans, ascribed a new value to their *Panama* assets from $100 million to $40 million. This just happened to be the value put upon the French canal by the Americans. Admiral Walker was quoted as saying: *"It put things on a very different footing."* The House, however, passed the *Hepburn Bill* favoring Nicaragua, it was just two votes short of unanimous. Through all this, the *White House* had maintained silence; however, following the House vote, Roosevelt summoned the members of the Walker Commission for a closed-door meeting. There he let it be known that he wanted the French offer accepted and that the commission was to provide a supplementary report unanimously favoring the Panama route. The commission prepared the supplementary report reversing its original decision and coming out unanimously for Panama.

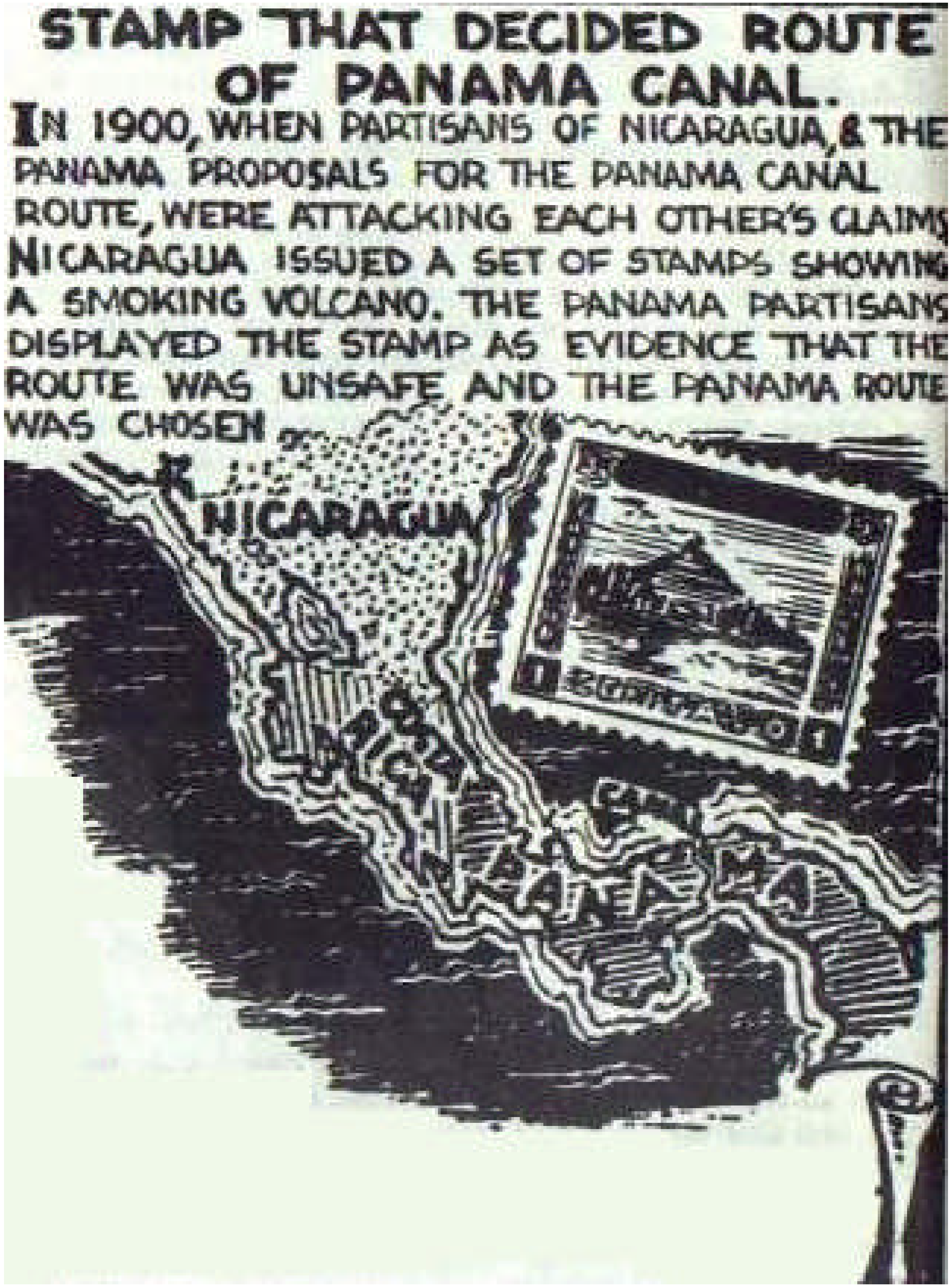
Above: caption: "Profile of the Nicaragua Canal as proposed by the Maritime Canal Company, 1893"

President Roosevelt submitted the supplementary report to *Congress* in January 1902. Wisconsin Senator *John Coit Spooner* introduced an amendment to the *Hepburn Bill* authorizing the president to acquire the French company's assets and concessions for a maximum price of $40 million. The bill stated that if arrangements could not be agreed upon between the *United States* and *Colombia* within "a reasonable time," the President would be authorized to seek an agreement for the alternate route through *Nicaragua*. Senator *John Tyler Morgan*, a long-time Nicaragua supporter, championed that route. On the other hand was the "Panama Lobby," led by *William Nelson Cromwell* and former French Director General *Philippe Bunau-Varilla*. As Bunau-Varilla personally held shares in the French company, his interest in seeing them bought out was self-serving. Cromwell; a lawyer who at the same time was a shareholder, a company director and represented the *Panama Railroad Company*, hoped to profit greatly from the deal and, indeed, he did, garnering an $800K fee for services rendered. Senator *Mark Hanna* was also in favor of the *Panama* route for technical reasons; reasons already provided in engineering reports. The Panama waterway would be shorter, straighter, take less time to transit, would require fewer locks, had better harbors, already had a railroad and would cost less to run.

Uncle Sam's next duty.—Minneapolis Tribune.

Known as the "Land of Lakes and Volcanoes," Nicaragua's detractors said its geology was simply too dangerous to risk this expensive and strategically important canal project on. A country the size of *New York State*, *Nicaragua* had a volatile geology that would prove to be its Achilles heel.

Mark Hanna's speech and support before the *Senate* were impressive, but not enough to alter the number of votes required. Not to go down in defeat, Bunau-Varilla mailed a letter to each Senator enclosing a one-centavo stamp (left) showing a Nicaraguan landscape. In the background, the famous *Momotombo Volcano* (right) was depicted in full eruption. The stamp highlighted the differences between the two countries; one with active volcanoes, the other without. On June 19th 1902, the Senate vote favored a *Panama* route by just eight votes. That it was the technical/engineering viewpoint that prevailed was significant. The most vociferous and articulate of the engineers favoring Panama was *George Shattuck Morison*. Morison is credited with changing many important minds about the canal route, including Walker, Hanna and even President Roosevelt to whom he wrote a letter on December 10th 1901 detailing the technical reasons and his own personal convictions for building the canal through *Panama*. TR would later credit "engineers" for helping make up his mind.


STAMP THAT DECIDED ROUTE OF PANAMA CANAL.
IN 1900, WHEN PARTISANS OF NICARAGUA, & THE PANAMA PROPOSALS FOR THE PANAMA CANAL ROUTE, WERE ATTACKING EACH OTHER'S CLAIMS NICARAGUA ISSUED A SET OF STAMPS SHOWING A SMOKING VOLCANO. THE PANAMA PARTISANS DISPLAYED THE STAMP AS EVIDENCE THAT THE ROUTE WAS UNSAFE AND THE PANAMA ROUTE WAS CHOSEN
NICARAGUA
PANAMA

Within the Limits of Possibility

"…There is another factor which, although it has not yet created any practical difficulty, may at any time destroy large sections of the canal in a few minutes. This is the circumstance that the Isthmus of Panama is not, like that of Suez, entirely immune to damage from earthquakes. It is true that the Panama region is comparatively free from the earthquakes which are of frequent occurrence in Central America and that the Panama canal is much more favorably situated in this respect than the projected Nicaragua canal, which would pass near twenty-five volcanoes, but the canal zone is not exempt from seismic disturbance. It experienced a slight shock in 1882 and in the past has been visited by violent and destructive earthquakes, the last of which occurred in 1621. The recurrence of such a visitation, though improbable, is quite within the limits of possibility, and the completed canal, with its insecure and sliding banks, might be utterly destroyed by a single violent shock…"

Scientific American Supplement, **September 23rd 1911**

RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries." In fact, an earthquake struck *Panama* on September 30th 1913 – just four days after the first successful trial of the *Gatun Locks*, knocking seismograph needles off the scale at *Ancon*. Although there were landslides in the interior and cracked walls in some *Panama City* buildings, Colonel Goethals reported: *"There has been no damage whatever to any part of the Canal."*

“Contrary to the popular impression, there is no evidence to substantiate the theory that the Panama Canal is in danger of eventually being ruined by earthquakes. The relation between geologic and topographic conditions and some of the engineering problems encountered in the construction of the waterway form the subject of a bulletin lately issued by the Bureau of Mines, in which this point is considered. Investigation has shown that during the last 300 years there have been but two seismic disturbances of consequence in the region, and that neither of these were of sufficient force to seriously damage the most delicate parts of the now existing canal. The tensile strength of the rocks in the zone is low and would prevent any accumulation of stress, it is believed. Outside the Isthmian shore waters the ocean bottom has been sinking for years. This has been the chief cause of the earthquakes, each of which has brought about a slight uprise of the land mass. There is a record of four oscillations and the beginning of another elevation, according to the government, but the average uplift for the past 1,000 years is estimated at less than .03 ft. annually, which is too slight to justify concern…”

Popular Mechanics, **May 1916**

The Competition

"…It has remained for the present administration to execute a very old idea. As long ago as the sixteenth century a survey for an Isthmus canal was made over the route of the present railroad, and from time to time in the succeeding years new plans and re-surveys have been made. Wars and changes in administration have always prevented the completion of any of them. Mexicans, Englishmen and Americans have in turn been granted concessions, all of which resulted in failure. In 1881 James B. Eads, the great American engineer, planned a ship railway by means of which loaded vessels were to be floated into a great cradle resting on wheels, and to be drawn by locomotives across the Isthmus on a railway of several rails, and again floated at the farther terminal. This would have obviated the transfer of the cargo as will now be done. Eads was very sanguine of success from an engineering standpoint, and was granted a concession. The magnitude and cost of the undertaking, however, discouraged financiers, and this plan, too, was finally abandoned after considerable money had been spent in preliminary work…"

***Popular Mechanics*, June 1905**

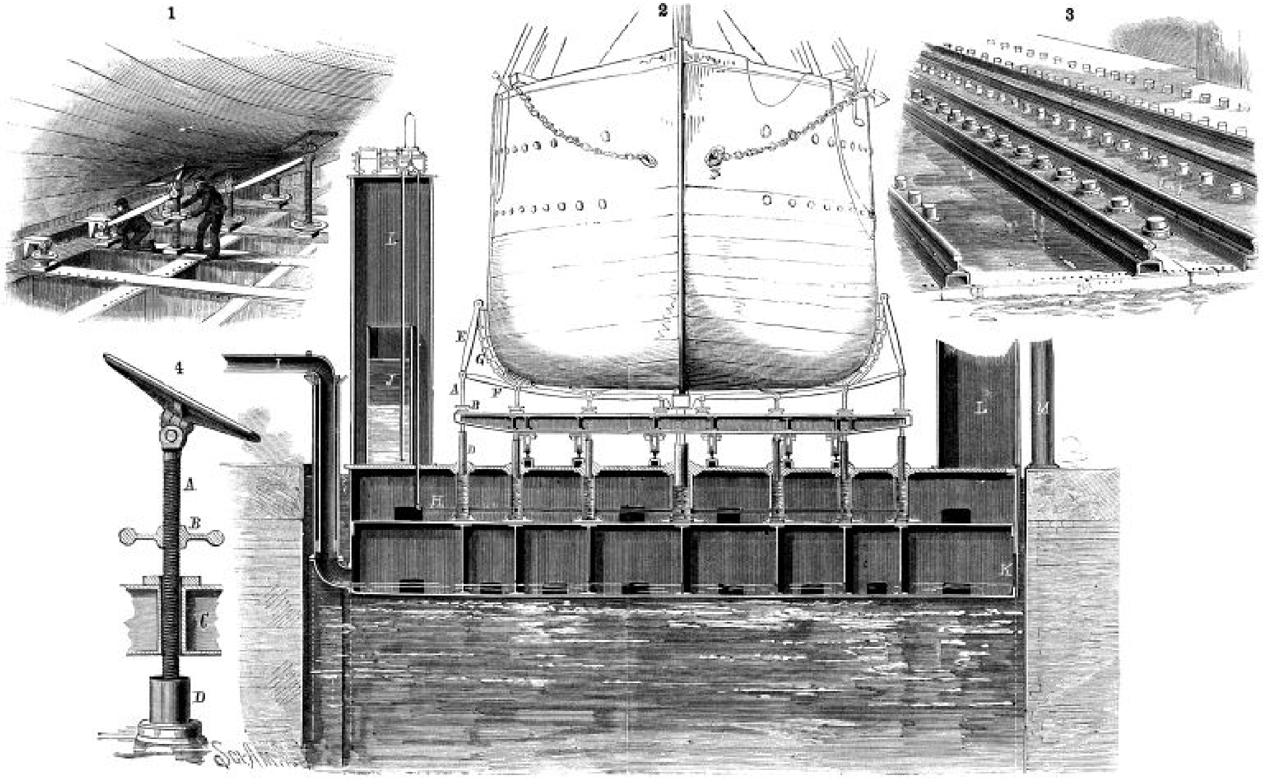


Fig. 2.—THE INTEROCEANIC SHIP CANAL—SECTIONAL ELEVATION OF PONTOON AND RAILWAY CRADLE.

"…The pontoon, or floating dock (see Figs.1 to 4), is of the same general construction as those in use all over the world, save in some important modifications rendered necessary to fit it for its special work. For it is not enough that the vessel should be docked and lifted out of the water, but that it shall be caused to rest upon a. cradle in such a manner that its weight shall be equalized fore and aft, and thus enable the carriage with its load to move easily and safely. This is effected by means of a system of hydraulic rams arranged along an intermediate deck about six feet below the upper deck of the pontoon (Fig. 2)…"

Scientific American, **December 27th 1884**

RE: excerpt from article entitled: "The Interoceanic Ship Railway"

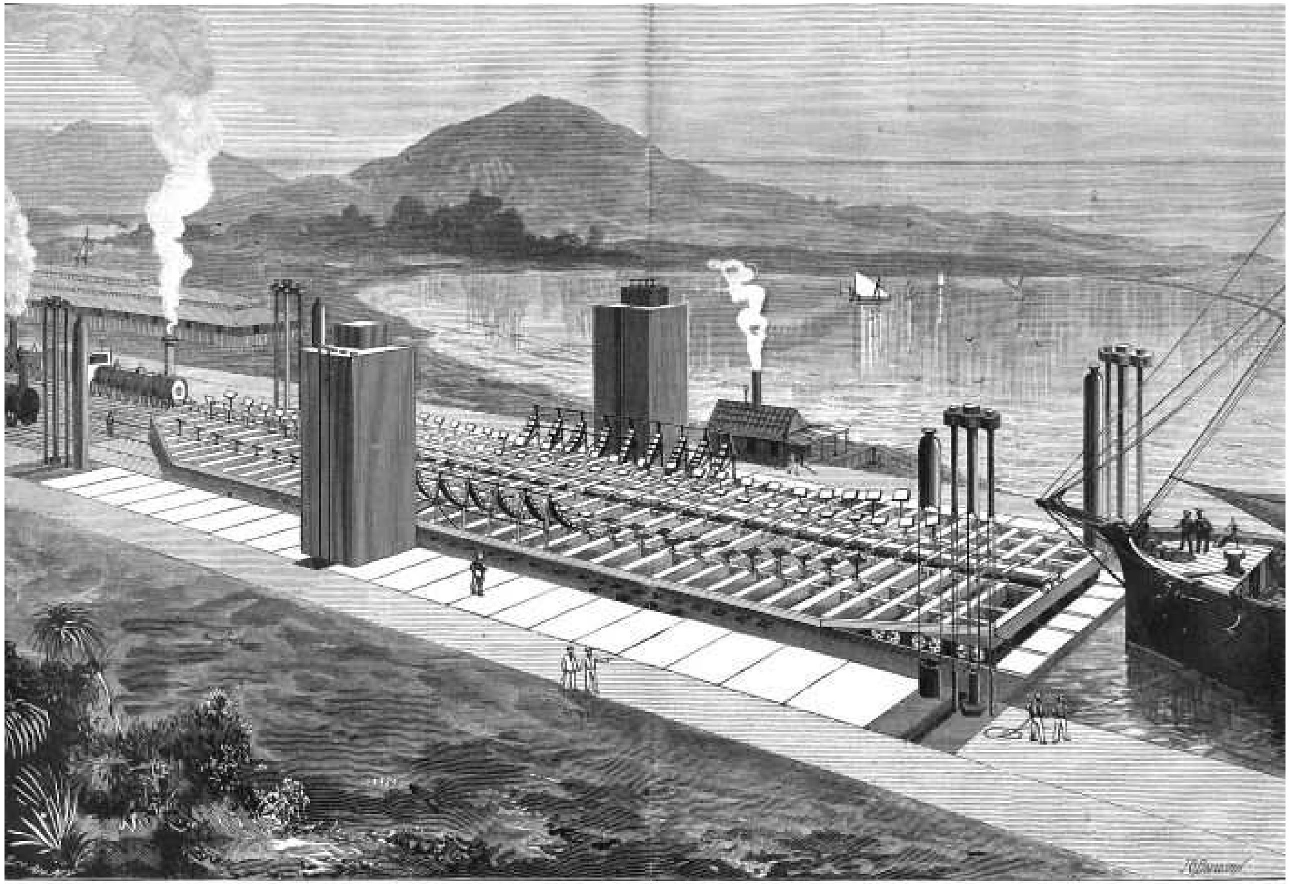
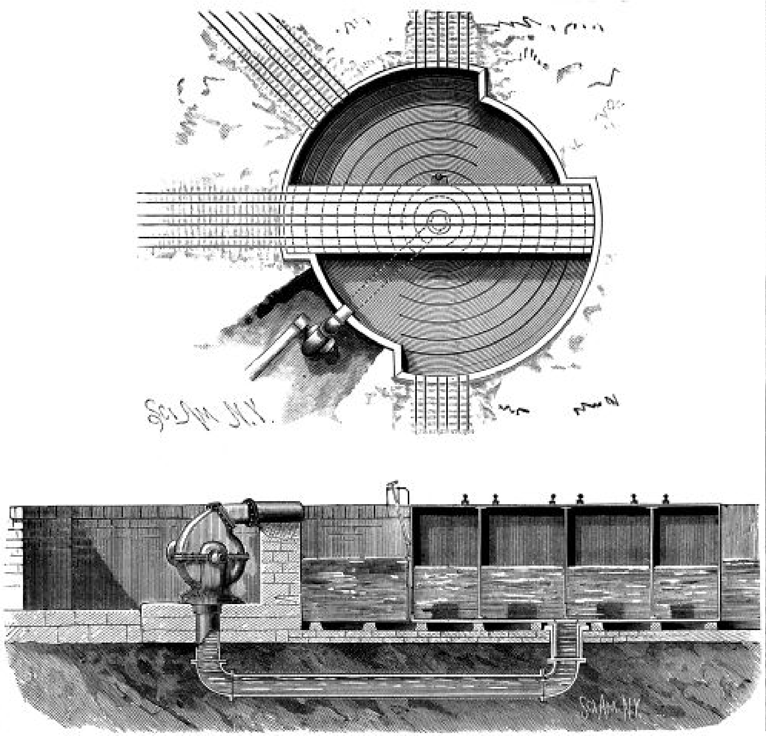


Fig. 3.—THE INTEROCEANIC SHIP RAILWAY.—THE LIFTING PONTOON AND RAILWAY CRADLE.

"…It is no part of the duty of these rams to lift the vessel. They are designed only to resist its weight as it gradually emerges from the basin. They get their power from a powerful hydraulic pump placed on a tower affixed to the side of the pontoon, and rising and sinking with it, but of such a height that, even when the pontoon rests upon the bottom of the dock, it is not entirely submerged. The pontoon itself is directed by powerful guides, which cause it to descend and emerge from the water always in the same position…"

Scientific American, **December 27th 1884**

RE: excerpt from article entitled: "The Interoceanic Ship Railway"



Figs. 5 & 6.—ILLUSTRATIONS OF THE TURNTABLE.

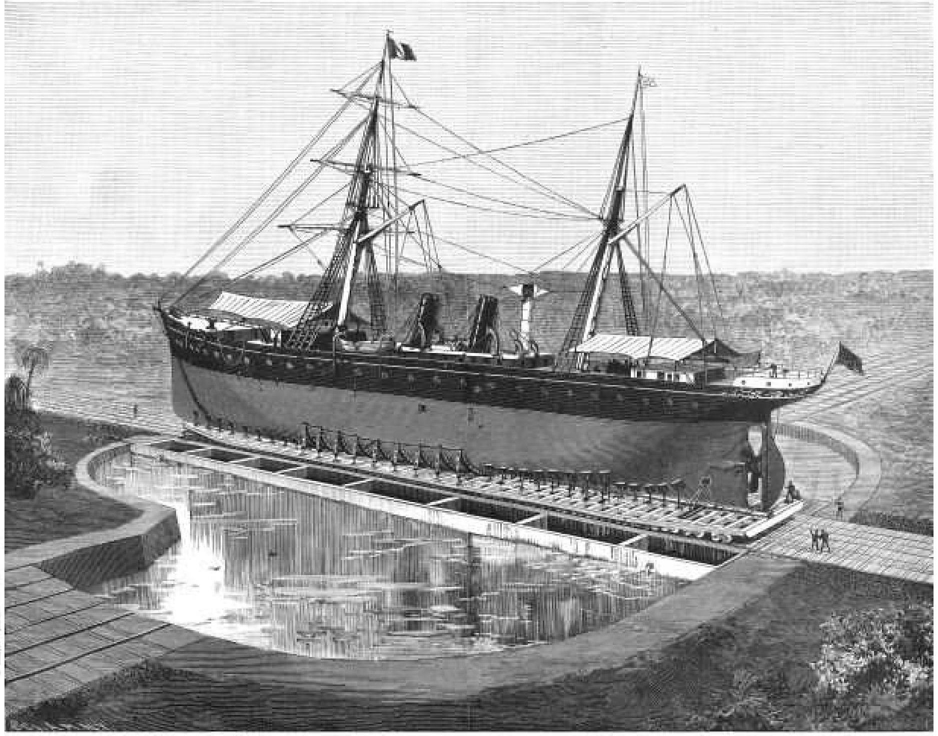


Fig. 7.—THE INTEROCEANIC SHIP RAILWAY.—THE FLOATING TURNTABLE.

"…the road is designed to be almost exactly straight, since there will be no curves having a radius of less than twenty miles, for the carriage is four hundred feet long, and rests upon wheels which, as already explained, are not set on trucks swinging to a common center. There are only five places in the whole line where it is necessary to deviate from a straight line, and at each of these places a floating turntable (see Fig. 5 to 7) will be built. These turntables in design resemble pontoons, for they rest upon water, and will be strong enough to receive the carriage and its burden. The turntable-pontoon will be firmly grounded, when the carriage is run upon it, by the weight of water upon the circular bearers of the basin. The water is pumped out by a powerful centrifugal pump, the water being emitted through an opening in the cylindrical pivot of the pontoon and discharged into the basin. Now, the pontoon has been made sufficiently buoyant to be turned easily upon its pivot by steam power, and the ship carriage is quickly pointed in its new direction. The valves then permit the water to enter once more, and the pontoon turntable again rests on its bearings…"

***Scientific American*, December 27th 1884**

RE: excerpt from article entitled: "The Interoceanic Ship Railway"

The Only Way

"…As the average freight steamer makes 250 miles a day there is about four days difference in favor of the Isthmus railway, allowing two days for unloading and re-loading on the railway and one day for passage of steamer through the Panama Canal. Of course there are many cargoes which it would be impractical to transfer, and it is assumed there will always be a waiting steamer at the farther terminal to receive the goods, and destined to the port of delivery. In the case of getting a warship or other vessel across the Isthmus of course the canal would be the only way. It is estimated the cost of canal tolls, say, $2,000, and four days' sailing, say, $8,000, for a 5,000-ton cargo would about equal the transfer and freight charges via the railway, but there would still be the saving of four days' time…"

***Scientific American,* December 27th 1884**

RE: excerpt from article entitled: "The Interoceanic Ship Railway"

“Mexico will compete with the Panama Canal, not with a water route, but with a steam railroad…already the track work is completed, and the terminal harbors are being constructed to equal any in the world. The road is 125 miles long, connecting Coatzacoalcos on the Atlantic side with Salina Cruz, the Pacific port. At both places enormous breakwaters are being built far out into the ocean, and great wharves, some of stone and others of steel are nearing completion. When the plans are worked out a great fleet of the largest ocean-going steamers can tie up and unload at the same time…”

***Popular Mechanics,* June 1905**

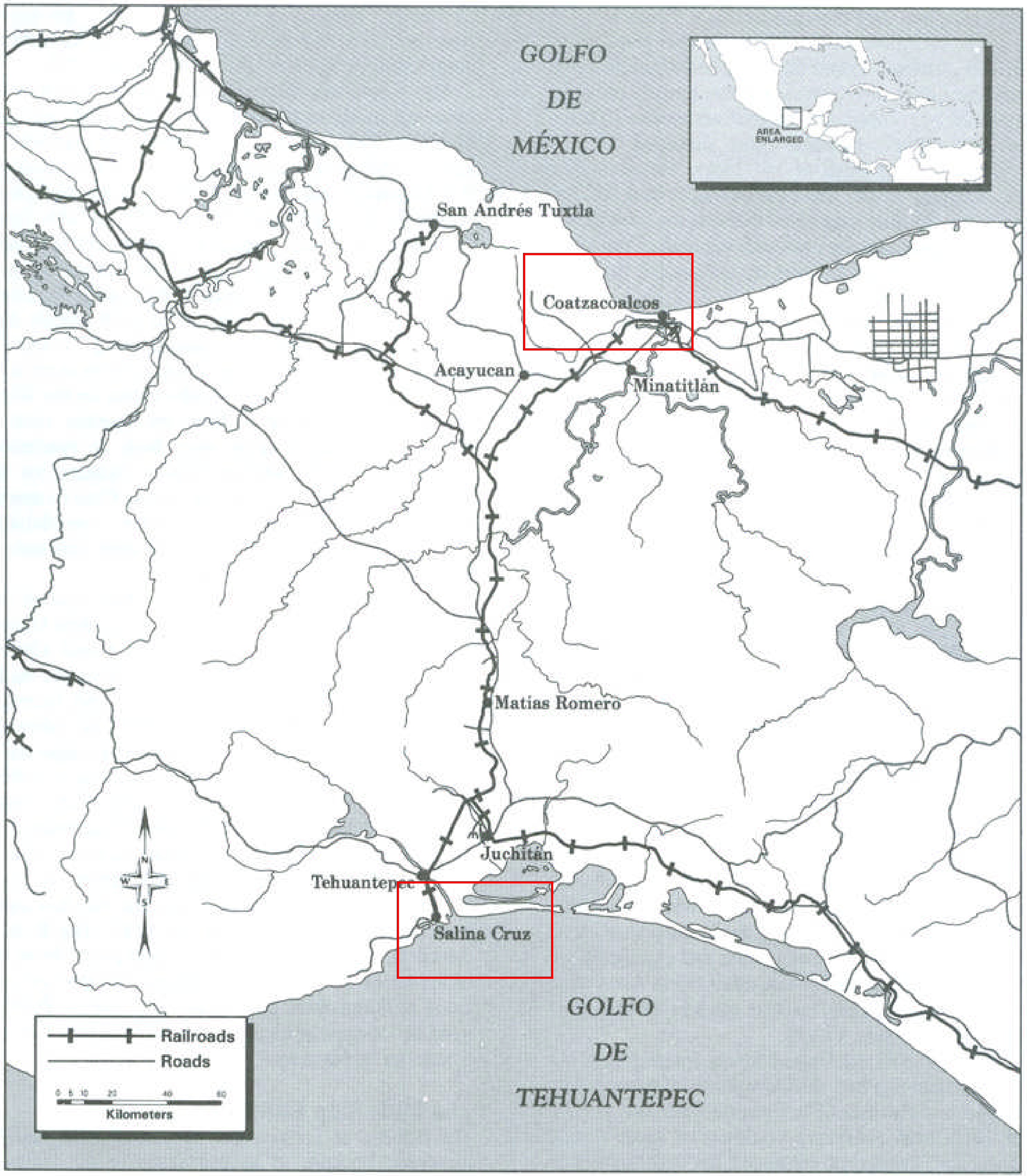


Fig. 1. The Isthmus of Tehuantepec, showing current railroad and highway routes. (Source: "Mexico Istmo: Carta Turistica," Instituto Nacional de Estadística, Geografía e Informática.)

"…Mexican 'Ship Railway.' Mexico is deeply interested in a plan for the overland movement of ocean-going steamers by means of a 185-mile 'ship railway' across the Isthmus of Tehuantepec for Puerto Mexico to Salina Cruz. The proposal, conceived some years ago, has been given new life since the war by Modesto C. Roland, Mexican civil engineer and head of the free ports department of the Treasury Department. Ships weighing up to 15,000 tons would be carried in mammoth structures resembling dry docks resting on some 300 wheels running on eight or ten rails abreast. Diesel motors would be enclosed in water-tight compartments so that the machine could roll down the rails into deep water to receive and discharge its amphibious cargoes. The estimated cost is 200 million dollars…"

***The Rotarian,* March 1949**

Avenging the Loss of Panama

"…Another cause of worry, which seems ludicrous but which is quite serious, is the lively agitation in Columbia for the construction of a rival canal connecting with the Atrato River which flows into the Gulf of Uraba. This apparently fantastic scheme is daily gaining in popularity and a Columbian engineer recently issued an impassioned appeal to his fellow-countrymen to avenge the loss of Panama by constructing a Columbian rival of the American canal. The importance attached to this project in the United States is shown by the fact that an official protest has already been sent from Washington to Bogata…"

***Scientific American Supplement,* September 23rd 1911**

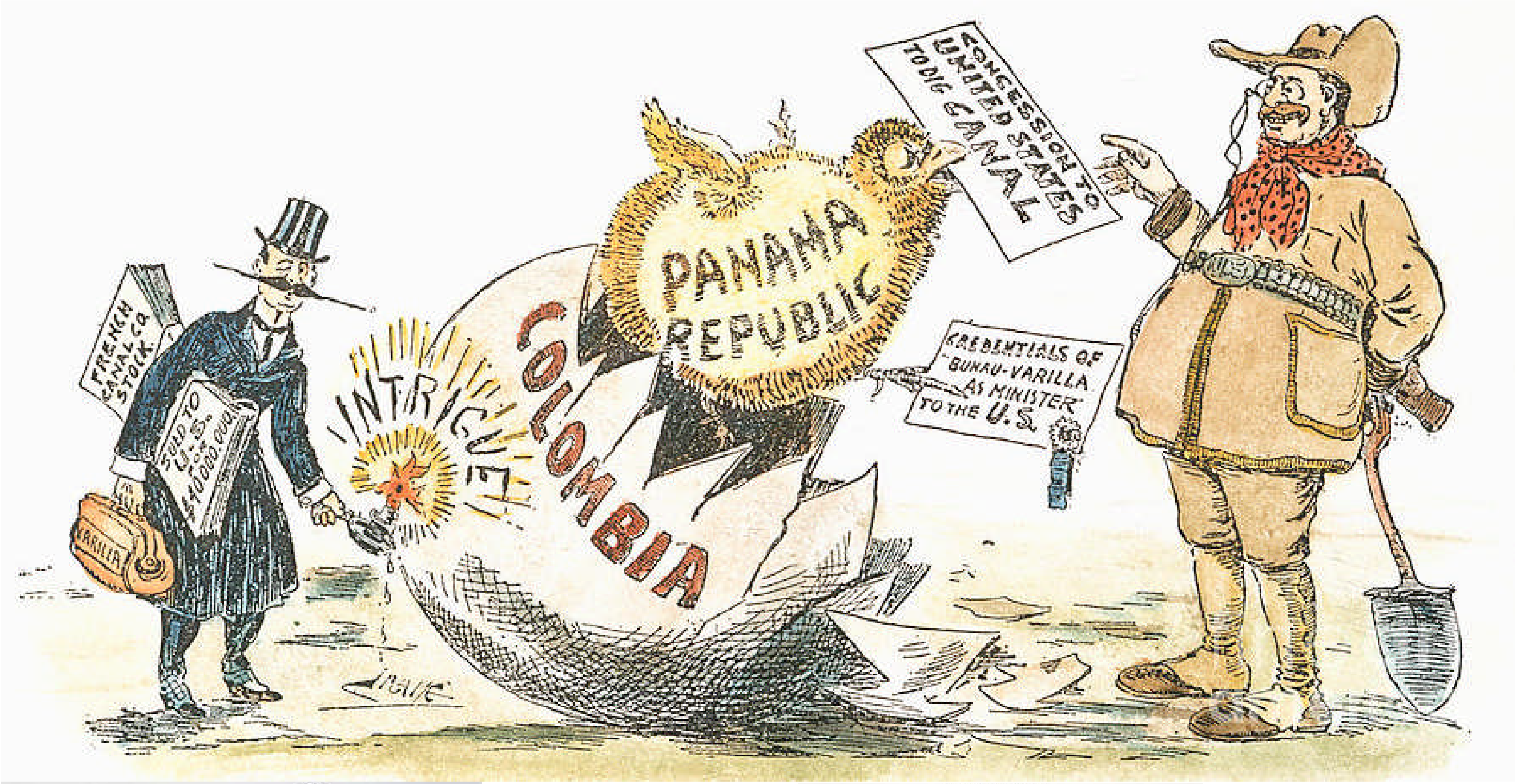
RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries"

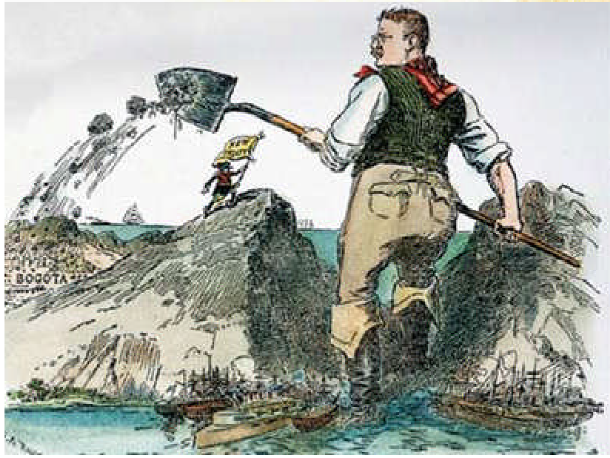
Daring Greatly

"…I took the isthmus, started the canal and then left Congress not to debate the canal, but to debate me."

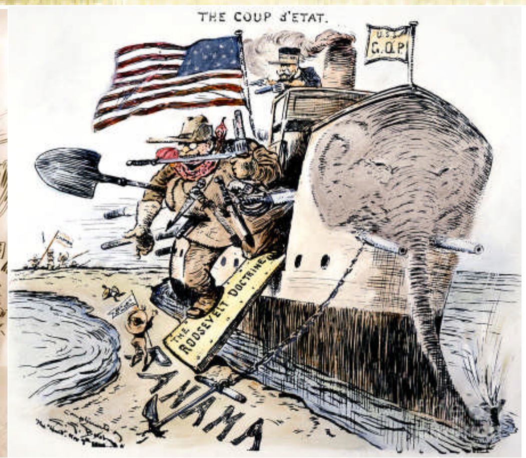
Theodore Roosevelt

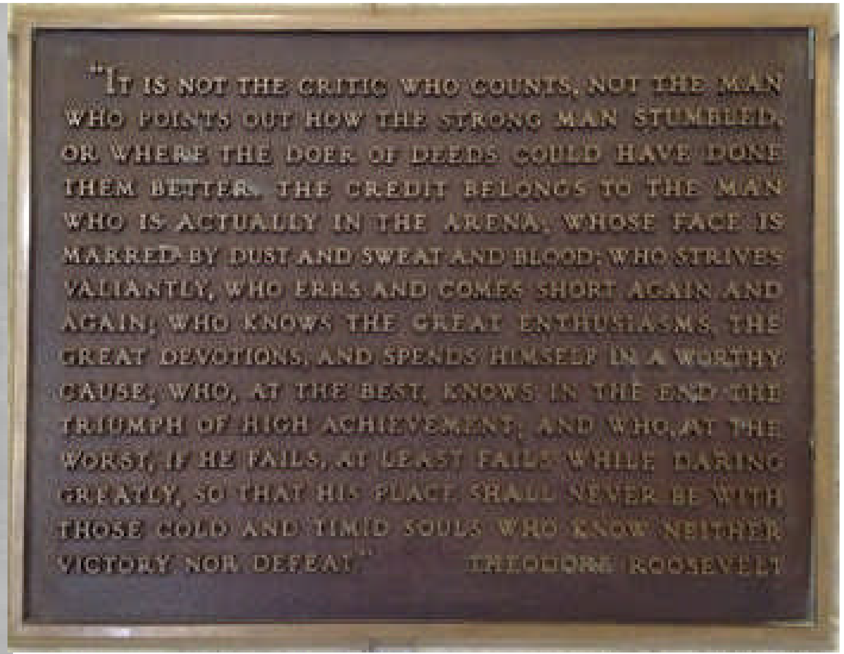
RE: with the route through the Panamanian Isthmus decided, it was now time to begin negotiations with *Colombia* for a concession to build a canal through the Colombian province of *Panama*. The resulting *Hay-Herran Treaty*, developed by Colombian charge d'affaires *Dr. Tomas Herran* and U.S. Secretary of State *John Hay*, was rejected by Colombia. Roosevelt was furious at the rejection thus he was not inclined to continue negotiations with the Columbian government. Impatient to build the canal, Roosevelt supported Panama's fledgling independence movement. As such, he was willing to put forth a show of military force, dispatching warships to both sides of the Isthmus thus effectively blocking Panama's sea approaches. Troops not only protected the railroad (per the 1846-48 treaty), but were also sent into the interior to block access from those areas. A land approach by a Colombian force of 2K was defeated by the *Darien* jungle and forced to turn back. Dropping all pretense during a speech, TR – man of action, boasted how he "took" the Isthmus and left *Congress* to debate his actions after-the-fact.


CONCESSION TO UNITED STATES TO DIG CANAL
PANAMA REPUBLIC
COLOMBIA
INTRIGUE!
FRENCH CANAL CO STOCK
SOLD TO U.S. FOR $40,000,000
VARILLA
CREDENTIALS OF "BUNAU-VARILLA" AS MINISTER TO THE U.S.


BOGOTA


CANAL


THE COUP D'ETAT.
U.S. G.O.P
THE ROOSEVELT DOCTRINE
PANAMA



"It is not the critic who counts, not the man who points out how the strong man stumbled, or when the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena; whose face is marred by dust and sweat and blood; who strives valiantly, who errs and comes short again and again; who knows the great enthusiasms, the great devotions, and spends himself in a worthy cause; who, at the best, knows in the end the triumph of high achievement; and who, at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who know neither victory nor defeat."

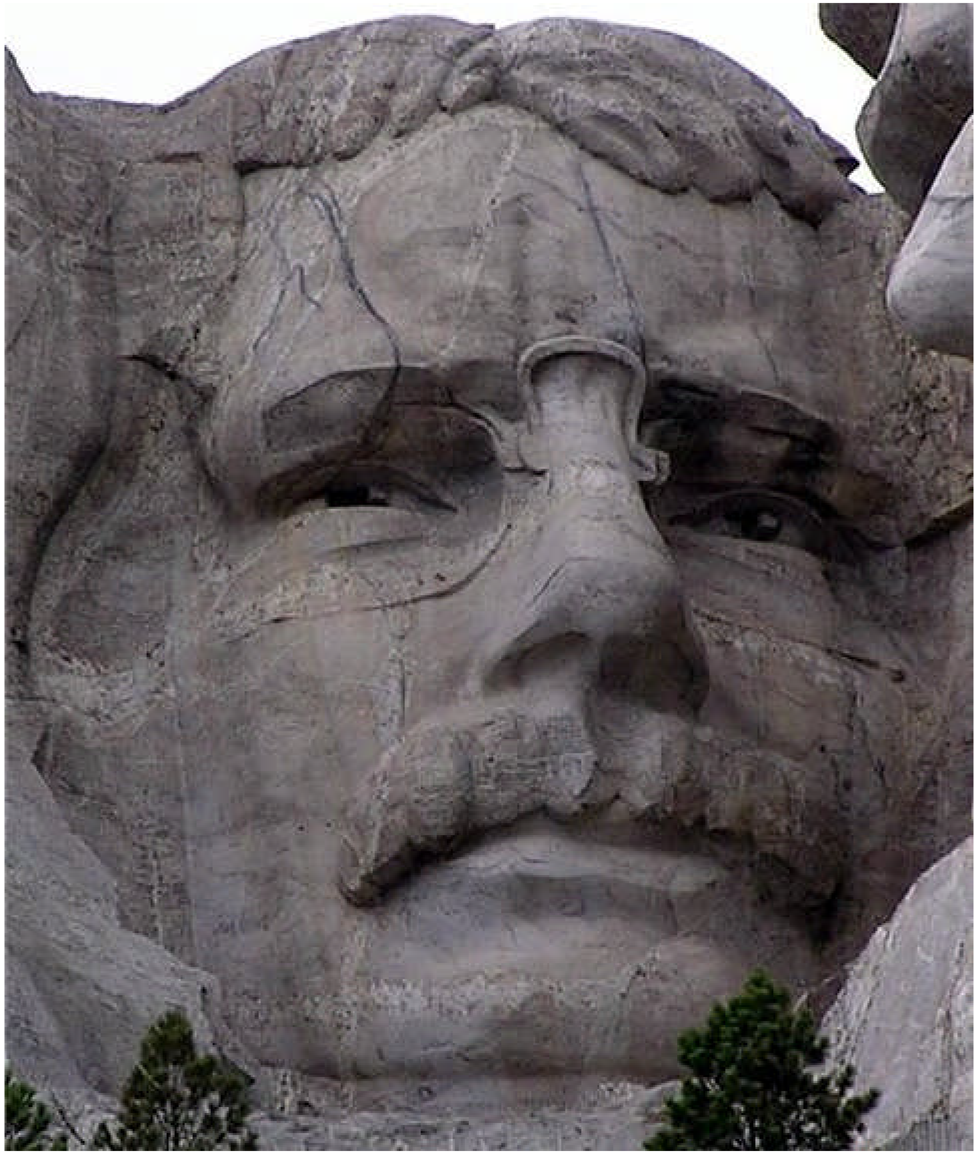
Theodore Roosevelt

A Passage to India

"On Mount Rushmore, in the Black Hills of South Dakota, Gutzon Borglam, the sculptor, is preparing to tell, in gigantic symbols, the story of the development of a nation. One side of the natural monument will bear the figures of Washington, 'the creator,' Jefferson, 'the expansionist,' Lincoln, 'the preserver,' and Roosevelt, who, in the words of Mr. Borglum, 'in completing the passage to India by building the Panama canal, fulfilled the prophecy of Columbus.'"

***Popular Mechanics,* March 1927**

<u>Above</u>: sculptor *Gutzon Borglam* working on a clay model of *Mount Rushmore*



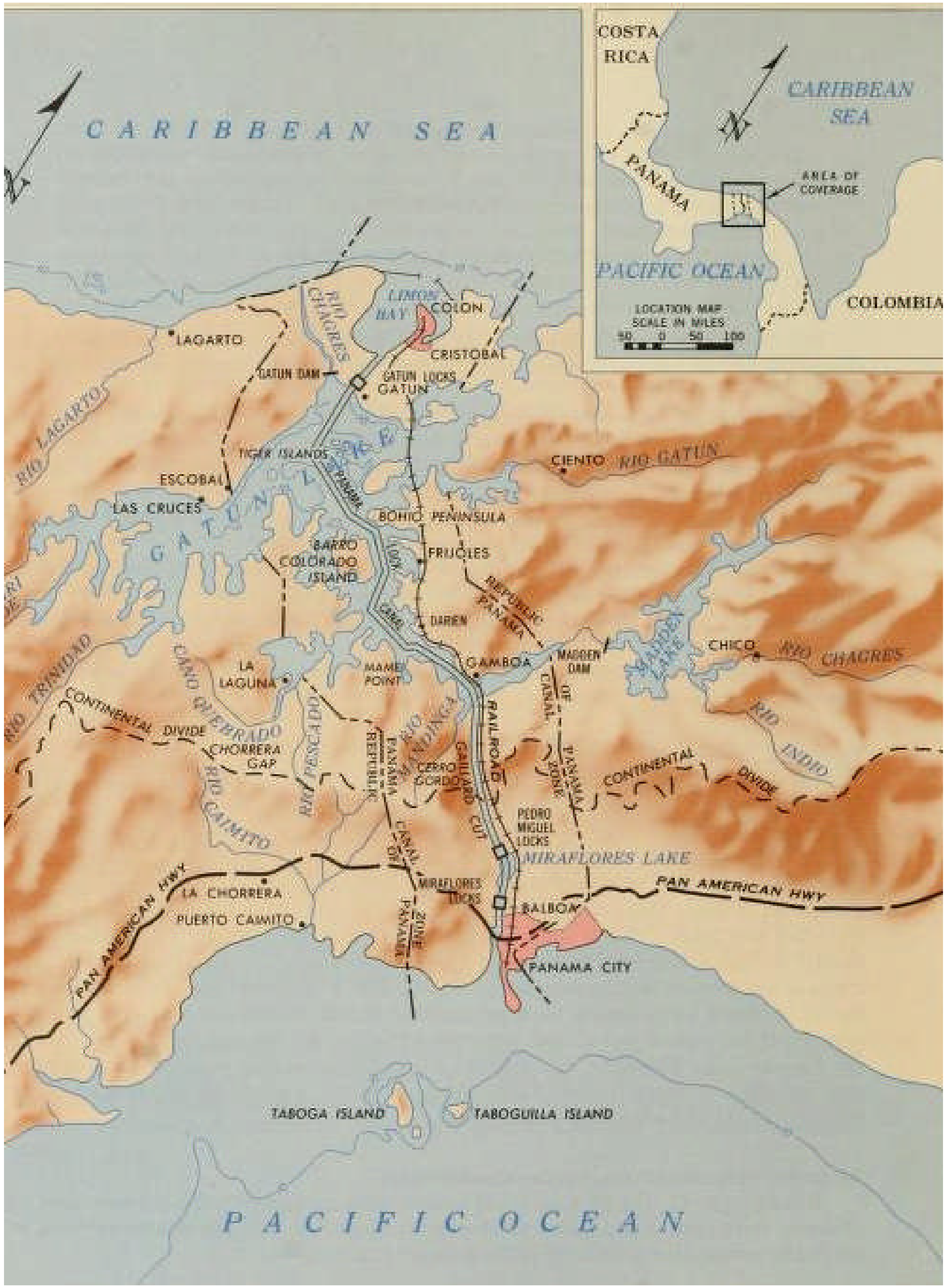
<u>Above</u>: mural from the *American Museum of Natural History's* "Theodore Roosevelt Rotunda" depicting the creation of the *Panama Canal*

The Real Builder of the Panama Canal

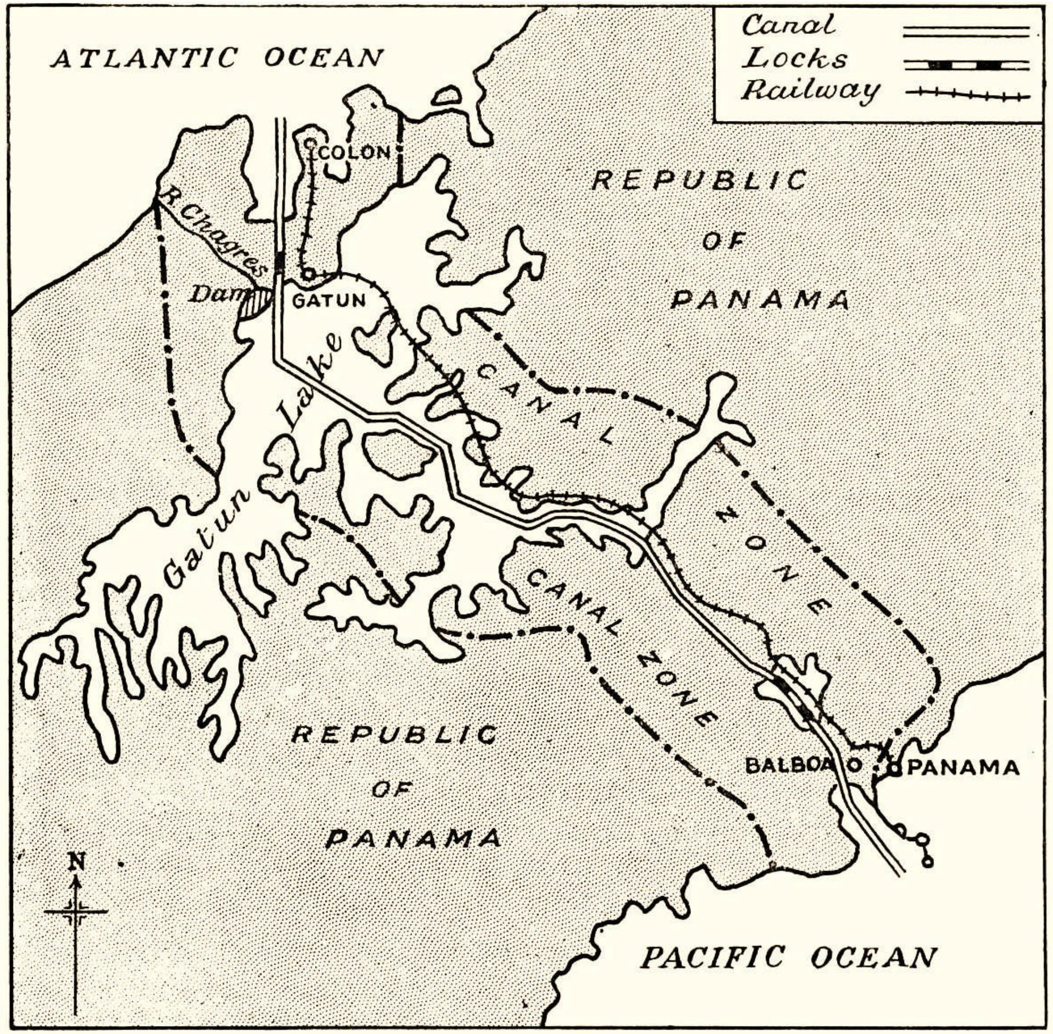
Theodore Roosevelt* is widely given credit for building the *Panama Canal.* However, of the three presidents whose terms coincided with canal's construction; TR, *Howard Taft* and *Woodrow Wilson* – it was Taft who provided the most active, hands-on participation over the longest period. Taft visited *Panama* five times as Roosevelt's Secretary *of War* and made two more trips while President. He also hired *John F. Stevens* and, when Stevens later resigned, recommended *George Goethals*. When Taft replaced Roosevelt as POTUS in 1909, canal construction was at the halfway mark. Colonel Goethals, however, was to write: *"The real builder of the Panama Canal was Theodore Roosevelt."


ROOSEVELT
CANAL ZONE
POSTAGE
2¢

The Canal Zone



Panama **declared independence from** ***Colombia*** **on November 3rd 1903. The** ***Hay-Bunau-Varilla Treaty*** **was negotiated by the new republic's "Envoy Extraordinary and Minister Plenipotentiary" –** ***Philippe-Jean Bunau-Varilla*****, along with Secretary of State** ***John Hay*****. The treaty granted to the** ***United States*** **(as if sovereign) a canal concession in perpetuity to a** ***Canal Zone*** **ten miles wide (five miles on either side of the canal prism line). Whether they liked it or not, the founders of** ***Panama*** **had little choice but to accede to the Americans demands. Refusal would have withdrawn all U.S. support for the young republic leaving it vulnerable to future dealings with** ***Colombia*****. It was this arrangement that gave the** ***United States*** **the control it needed to get the monumental job of a trans-oceanic canal commenced, completed, defended and maintained. The Hay-Bunau-Varilla Treaty was ratified in Panama on December 2nd 1903 and in the** ***United States*****, on February 23rd 1904. Roosevelt's audacious move had succeeded for the United States, but not without political repercussions in U.S./Latin American relations for years to come. Upon the treaty's ratification in the United States, Panama received a payment of $10 million. Three days later, Bunau-Varilla resigned and returned to** ***France*****, eminently successful in his efforts.**


ATLANTIC OCEAN
Canal
Locks
Railway
COLON
R. Chagres
Dam
GATUN
Gatun Lake
REPUBLIC OF PANAMA
CANAL ZONE
CANAL ZONE
REPUBLIC OF PANAMA
BALBOA
PANAMA
N
PACIFIC OCEAN

ARTICLE I

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

ARTICLE II

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

ARTICLE V

The Republic of Panama grants to the United States in perpetuity a monopoly for the construction, maintenance and operation of any system of communication by means of canal or railroad across its territory between the Caribbean Sea and the Pacific ocean.

RE: excerpts from the *Hay-Bunau-Varilla Treaty*

Native villages and towns in the *Canal Zone*, in accordance with *Articles VI* and *XV* of the 1903 treaty, were required to move. Legal owners thus required to vacate were compensated for their property. Many inhabitants were required to relocate with the filling of *Gatun Lake*. Many of these sites dated from early days of *Chagres River* navigation, when the route was a much used commercial route across the Isthmus. Such settlements included *Ahorca Lagarto, Barbacoas, Caimito, Matachin, Bailamonos, Santa Cruz, Cruz de Juan Gallego* and *Cruces*. Following canal completion, still other towns were no longer needed and were abandoned. These towns, some built on the sites of existing French era towns, such as *Emperador* (called "Empire" by the Americans) was the location of steam shovel repair shops and the *Central Division* engineering office in charge of the *Culebra Cut* excavation. On the other hand, *Culebra*, the American headquarters, was newly built. Many of these were company towns never intended to be permanent.

On Sound Business Principles

"Construction work on the Panama Canal will be actively pushed on the same business principles which characterize railroad operations. The President has reorganized the canal board and placed in charge an experienced railroad man, Theodore P. Shonts, who says 'Direct business methods, publicity, and absolutely no politics – this is the keynote of the policy of the Panama canal commission. We are all pitching in with our coats off, and there will be no time lost either now or in the future.' As a graceful compliment the government has sent an invitation to England, France and Germany to furnish each three engineers to assist our own engineering department in an advisory capacity."

***Popular Mechanics,* June 1905**

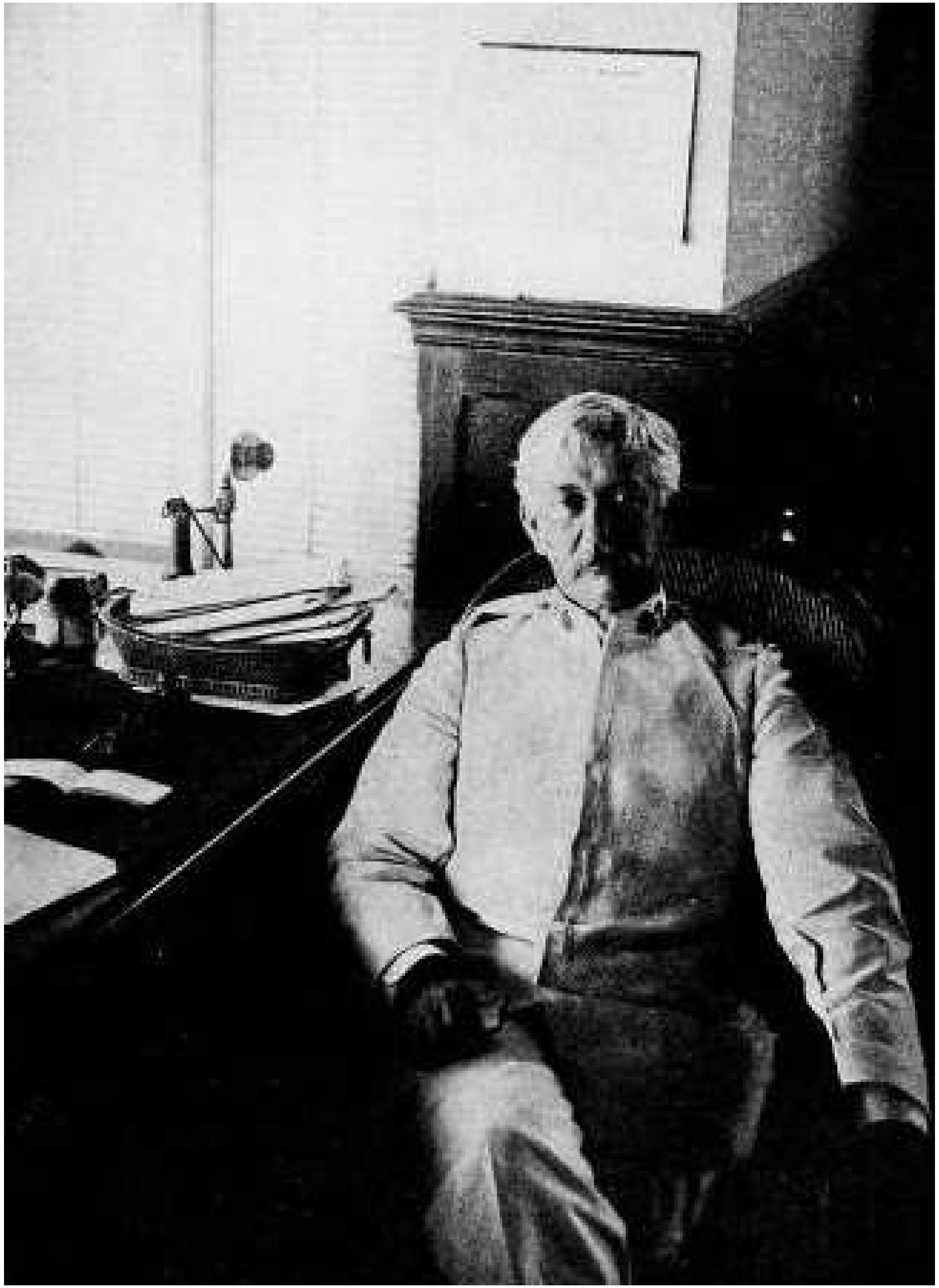
RE: one of the most amazing aspects of the American effort to build the canal was that this large, complex and unprecedented project was conducted and completed without any of the scandal and/or corruption that often plagues such efforts (as was the case of the French effort), nor has any hint of scandal ever come to light in subsequent years


14493
19 CANAL ZONE 49

Know Your Enemy

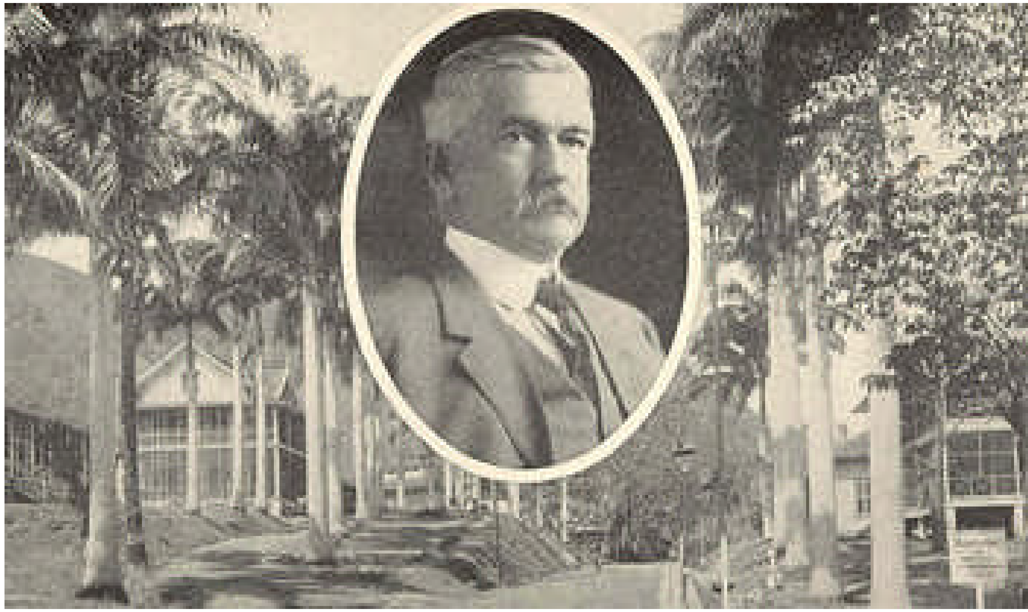
"…The greatest and most difficult problem which the American builders of the canal had to solve was not one of engineering, but of health. Under the French company's operations more than 60 percent of the workmen were continually incapacitated by disease. In one year the death rate among them reached 60 percent…"

Popular Mechanics, **December 1913**



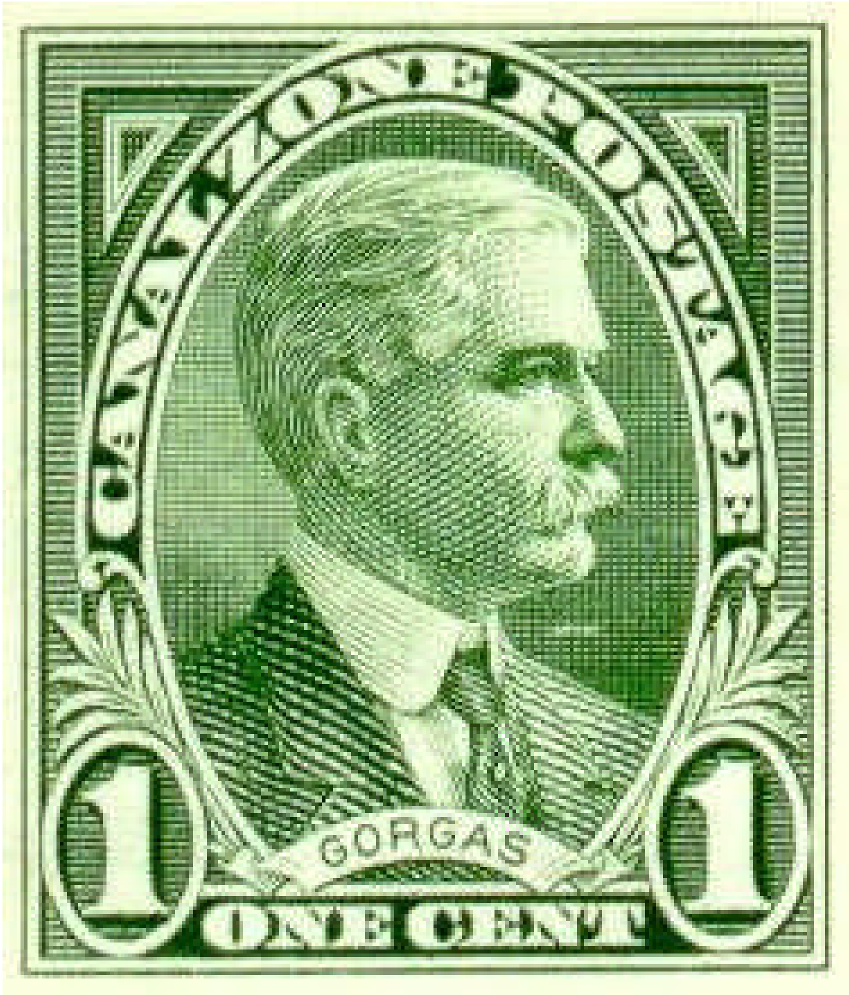
The beginning of the U.S. canal construction effort dates from May 4th 1904 when, in a brief ceremony, *U.S. Army Corps of Engineers* officer Lt. *Mark Brooke* received the keys to the storehouses and *Ancon Hospital*. Chief Sanitary Officer Colonel *William Crawford Gorgas* (left) and his staff were among the first to arrive and set up operations.

Medical researchers at the turn of the century were becoming more receptive to the idea of a relationship between mosquitoes and *Malaria* and *Yellow Fever*. *Dr. Carlos Juan Finlay*, as early as 1881, had become convinced that Yellow Fever was transmitted by a specific mosquito; the *Stegomyia Fasciata* (later to be named the *Aedes Aegypti*). The problem was that he couldn't prove what appeared, on the surface, to be an unreasonable theory. However, others would take their lead from Finlay. *Dr. Henry Rose Carter*, a researcher in *Mississippi,* discovered "extrinsic incubation" - the fact that a specific period of time was involved in the person-to-person transmission of the disease. However, the great Yellow Fever discoveries in *Cuba* in 1900 were the work of *Dr. Walter Reed* who happened, at the time, to be Dr. Gorgas' commanding officer. This proved that Stegomyia Fasciata was the carrier; debunking all previous theories including the belief that "fomites" - the term used for the soiled clothes or bedding of Yellow Fever victims, could spread the disease. Gorgas, himself a Yellow Fever survivor and thus immune to the disease, was a particularly valuable member of the medical team. Still skeptical, he suggested to Reed that, to prove the theory once and for all, *Havana* needed to be rid of the Stegomyia Fasciata and the results observed. Gorgas, with Reed's approval, began the work in February 1901. Results showed a dramatic reduction in yellow fever cases; from 1,400 known cases in 1900 to only 37 cases in 1901; none of them after October. The eradication procedures didn't just kill off the Stegomyia Fasciata, but reduced the *Anopheles* population as well, thus decreasing Malaria cases by more than half. Gorgas would bring these proven techniques with him to *Panama*.



The breeding habits of the *Stegomyia Fasciata,* which leads them to flourish in and around human habitations, made them much easier to kill than the *Malaria*-carrying *Anopheles*, which are found everywhere – jungles as well as back yards, making them very difficult to control. Besides, as Gorgas continually stressed, Malaria was far more dangerous than *Yellow Fever*, accounting for the largest loss of life during the French years. For Gorgas, it was urgent to get a jump on mosquito eradication before new, non-immune workers arrived and became infected. Unfortunately, Gorgas's superiors in the first *Isthmian Canal Commission* didn't take seriously the new scientific discoveries and thus did not support Gorgas' efforts. Even after a 1903 scientific congress in *Paris* reviewed Reed's Yellow Fever work and proclaimed it "scientifically determined fact," commission officials continued to believe Gorgas' efforts to be a waste of time and money.

<u>Above</u>: Colonel Gorgas on postacrd (left) / *Colon Hospital* (right)


CANAL ZONE POSTAGE
GORGAS
1
1
ONE CENT

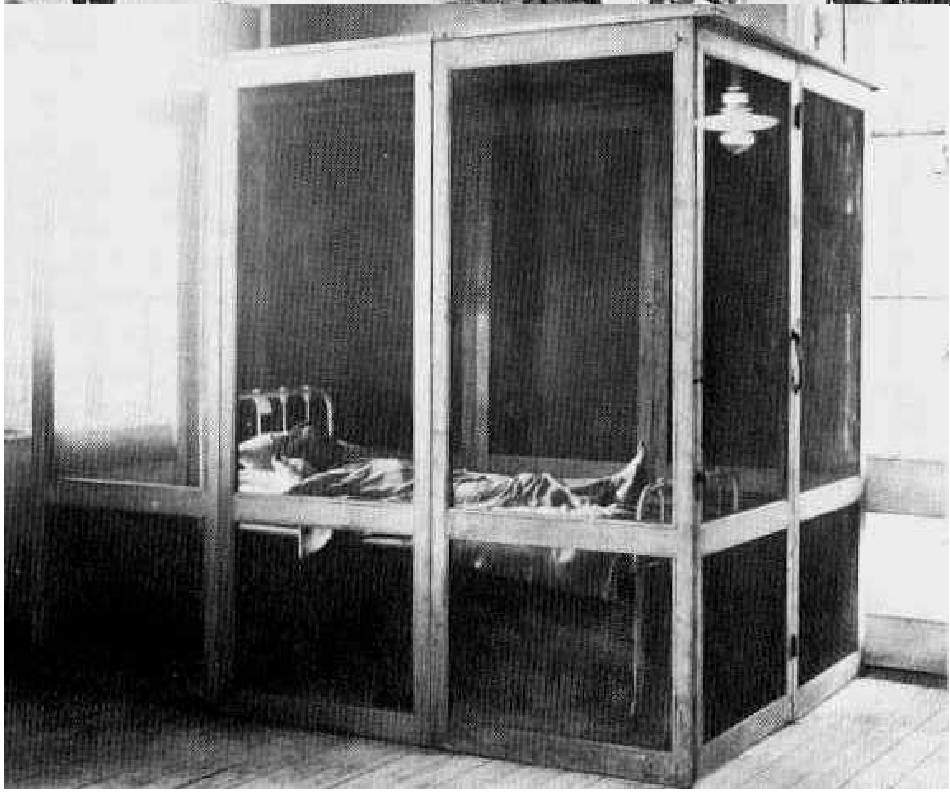
John Findlay Wallace **(above) was elected chief engineer of the** ***Panama Canal*** **on May 6th 1904 and immediately came under pressure to "make the dirt fly." However, the initial over-bureaucratic oversight from** ***Washington*** **stifled his efforts to get large forces of heavy equipment in place rapidly and caused a great deal of friction between Wallace and the commission. Both Wallace and the chief sanitary officer,** ***William C. Gorgas*****, determined to make great strides as rapidly as possible (though Wallace was unsupportive of Gorgas' mosquito eradication efforts), found themselves frustrated by delay and red tape at every turn. In 1905, Wallace resigned as chief engineer.**

“The moral effect of so high an official taking such a stand at this period was very great, and it is hard to estimate how much sanitation on the Isthmus owes to this gentleman for its subsequent success”

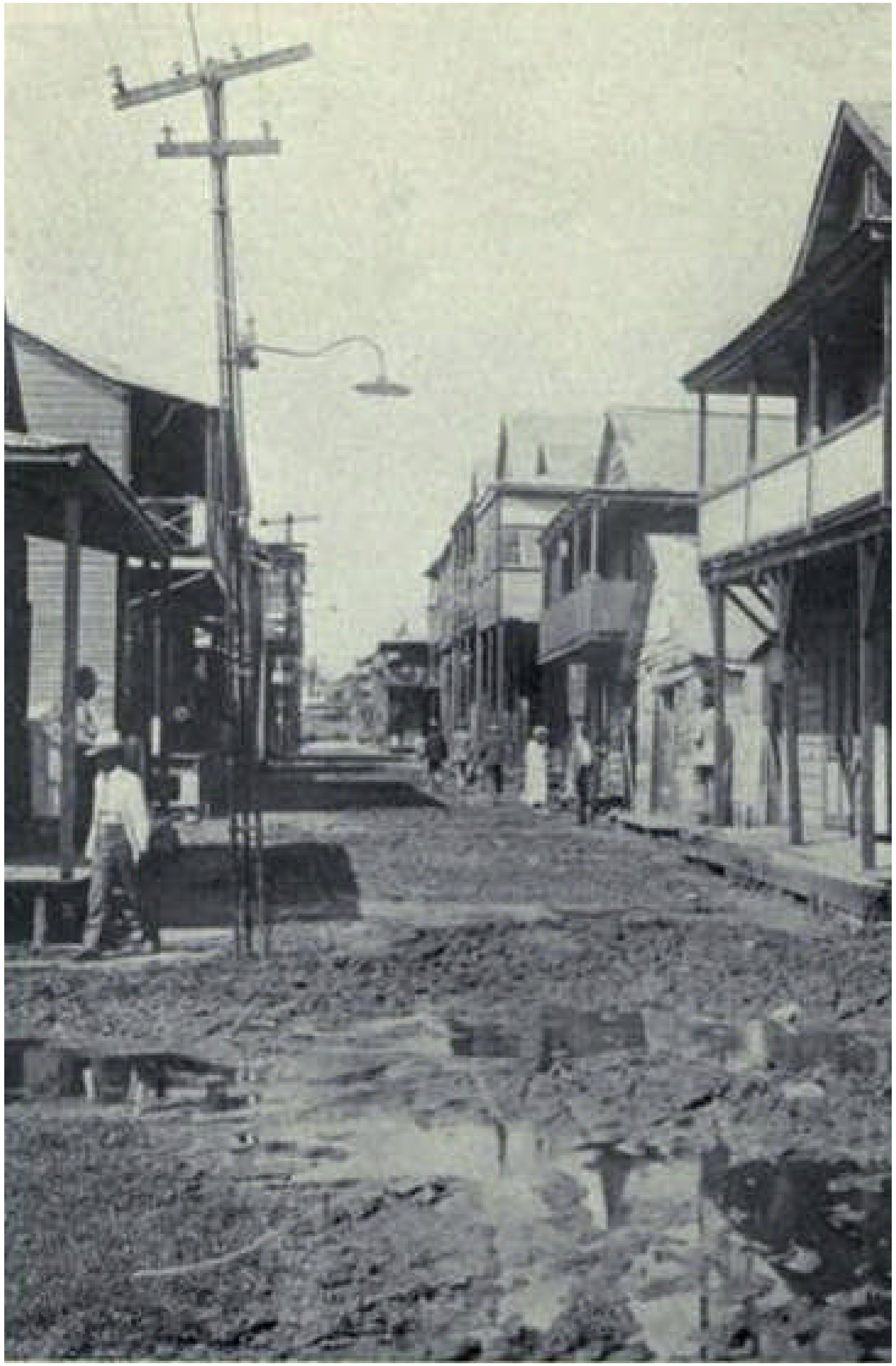
William C. Gorgas

RE: the *Isthmian Canal Commission’s* first chief Engineer, *John F. Wallace*, numbered among the nonbelievers. However, *John F. Stevens*, Wallace’s successor in 1905, provided Gorgas full support and funding. The work to combat *Yellow Fever* included screening windows and doors, house-by-house fumigation of *Panama City* and *Colon* and weekly oiling of cisterns and cesspools. A most important advance was providing running water to Panama City, *Colon* and other towns to do away with the need for the domestic water containers that served as perfect breeding sites for the Yellow Fever mosquito. As a result of Gorgas’s crusade, Yellow Fever was completely and permanently wiped out on the Isthmus, with the last case reported in Panama City on November 11th 1905.

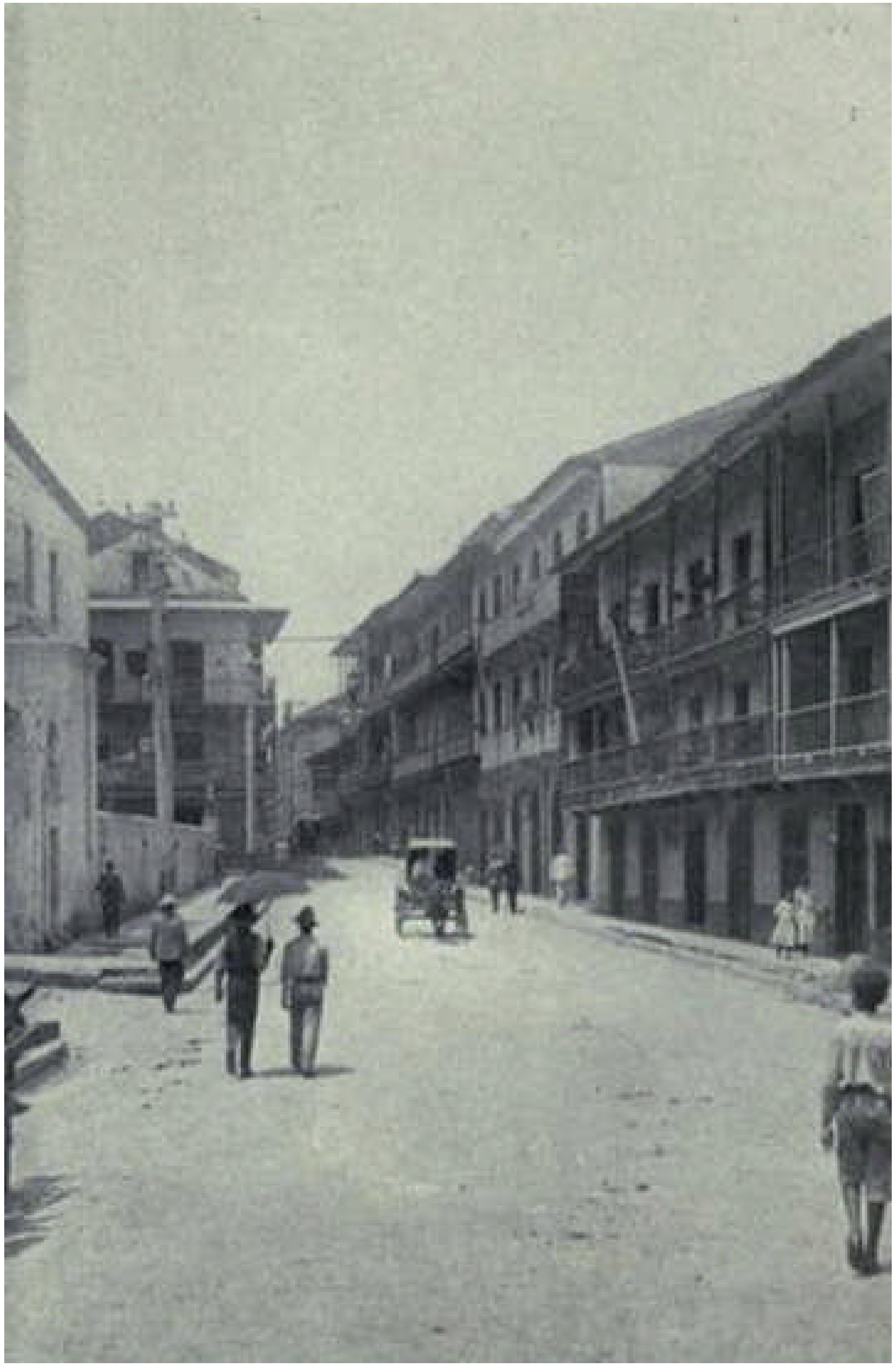
<u>Above</u>: caption: "Toro Point, showing labor quarters with self-closing garbage cans. July 1911"
<u>Left</u>: caption: "This man has a tank of oil on his back and he is spraying it into ditches to kill mosquitoes"



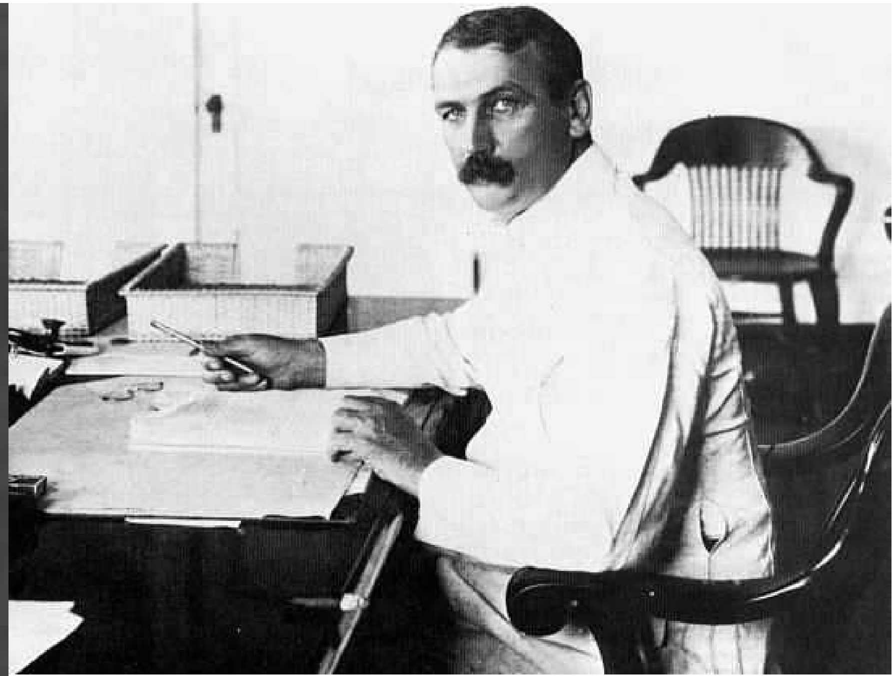
Top Left: fumigation brigades eradicating the mosquitoes (ca. 1905)
Top Right: fumigation car eradicating the mosquitoes (ca. 1905)
Left: Yellow Fever Quarantine Station



Left: caption: "The kind of thing formerly made the Canal Zone uninhabitable for foreigners. It was malaria and yellow fever that caused the failure of the French Company."



<u>Left</u>: caption: "One of the most noticeable effects of the American occupation – clean, paved streets and modern sewerage. These are the methods that wiped out yellow fever."



"Like probably many others I had gained some little idea of the mosquito theory, but, like most laymen, I had little faith in its effectiveness, or even dreamed of its tremendous importance."

John Frank Stevens

The Lazy Bug

“The Lazy Bug…is now recognized as an actual, serious proposition, and one which quite as much as yellow fever must be reckoned with in building the Panama canal. The lazy bug is the discovery of Capt. Bailey K. Ashford, assistant surgeon in the United States Army. The vindication of his investigations is seen in the appropriation of $50,000 to carry on his work in Porto Rico, and the sending of a government officer to that island in the effort to secure native immunes for work on the Panama canal. The lazy bug is a microscopic parasite in the form of a small worm, which attaches itself to the walls of the small intestines and absorbs the nutritious cycle before it passes into the blood; in a short time the blood is so impoverished the victim loses strength and becomes dizzy and light headed. None are exempt; the parasite attacks children and people of all ages. Capt. Ashford not only solved the question of what caused this universal debility, but discovered an antidote in the form of a serum…The treatment will be established in the canal zone for the benefit of laborers on the canal.”

Popular Mechanics, **May 1906**

Fighting all the Beasts of the Jungle

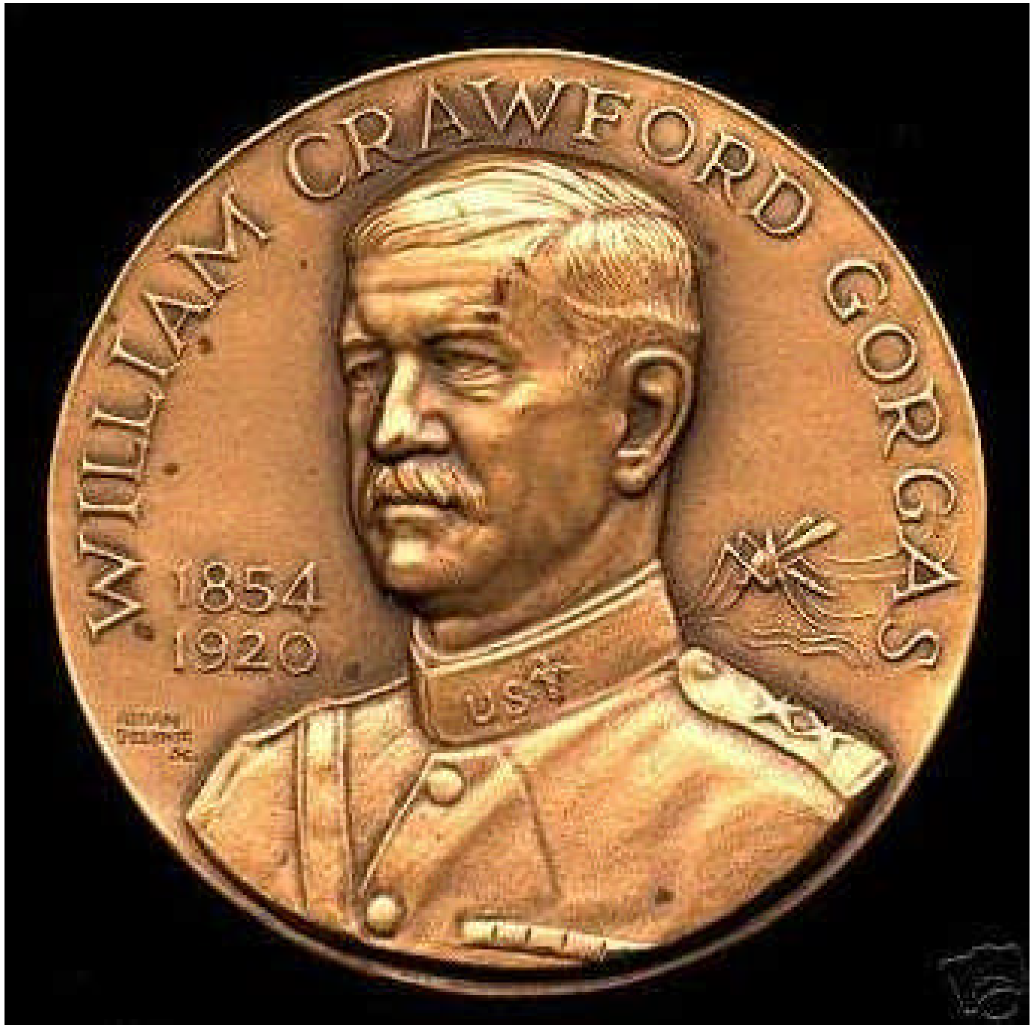
"If we can control malaria, I feel very little anxiety about other diseases. If we do not control malaria our mortality is going to be heavy"
William C. Gorgas

RE: *Malaria*, unlike *Yellow Fever*, does not confer immunity. With the disease endemic on the Isthmus, there were repeated opportunities to lay its victims low by debilitation or death. It actually was the cause of more deaths during the French and U.S. construction periods than was Yellow Fever. During the first full year of the American effort (1905), nearly all of the American force, including Gorgas, had contracted Malaria after only a month on the Isthmus. A comparison between eradicating the two kinds of mosquitoes likened getting rid of the Yellow Fever carrier to: *"making war on the family cat,"* while a campaign against the Malaria-carrying mosquito was *"like fighting all the beasts of the jungle."*

Reducing and eradicating the swarms of malarial mosquitoes was a huge task. Research, however, revealed valuable information. Knowing that the *Anopheles* mosquito cannot fly far without lighting on some sort of vegetation, 200-yard-wide areas were cleared around where people lived and worked. Sanitation teams drained more than 100 square-miles of swamp, built nearly a thousand miles of earthen ditching, 300 miles of concrete ditch, 200 miles of rock-filled trench, nearly 200 miles of tile drain, cut hundreds of acres of wild vegetation, sprayed standing water with thousands of gallons of oil, hatched and released thousands of minnows to eat the Anopheles larvae and bred spiders, ants, lizards to feed on adult insects. To keep vegetation such as grass and algae from preventing the free spread of the larvae-smothering oil, some 200 barrels of poison (a mixture of *Carbolic Acid*, *Resin* and *Caustic Soda*) were applied monthly around the edges of water pools and streams. While these efforts covered only a small fraction of the *Canal Zone* area, they efficiently reduced *Malaria* incidence in populated areas. Two hundred and eleven employees died of *Malaria* during fiscal year 1906-1907, declining significantly from a peak of 7.45 per 1,000 in 1906 to 0.30 per 1,000 in 1913. This achievement greatly increased American chances of canal-building success. A 1941 report stated that, during the past twenty years, there were only seven deaths from Malaria among employees.[287]

"…Truly the work accomplished since the army engineers took charge is stupendous and awe-inspiring, but the fore-runners who prepared the way under overwhelming obstacles and drove the mosquito and the yellow fever from the canal zone must not be forgotten. Because of their work the whole force can now put its shoulders to the wheel and defy the climate, which 10 years ago was death to the white man…"

***Popular Mechanics,* June 1908**


WILLIAM CRAWFORD GORGAS
1854
1920
U S

Mobilization

“This is no reflection on the French, but I cannot conceive how they did the work they did with the plant they had.”

John F. Stevens

RE: many problems had to be confronted immediately and solved by *John F. Stevens*, chief engineer between July 1st 1905 and April 1st 1907. As *Panama* was insufficiently developed and/or equipped to support the additional population created by the growing labor force, a great deal of planning went into providing proper housing and an adequate food supply. Virtually everything that was needed for canal construction; from equipment and building supplies to a labor force and food, would have to be brought to the Isthmus and distributed efficiently along the line of the canal. The *Panama Railroad*, which Stevens saw at once to be the lifeline of canal construction, was completely overhauled. The lightweight, inadequate and mismatched equipment of the French was replaced with the best and toughest available for this railroad would not only distribute workers, materials and supplies but also haul away the dirt and rock excavated from the channel. Heavier track, engines, freight cars, dump cars and refrigerator cars were ordered and bridges, signals and sidings were upgraded and improved. Also required and recruited from the *United States* was a phalanx of trained engineers, switchmen, operators, mechanics, yard masters, train masters, dispatchers, superintendents and conductors to first put together the railroad (all components were shipped “knocked-down”) and then operate it efficiently. All other kinds of equipment were rehabilitated or replaced as well. Communications were improved with new telegraph and telephone systems. The size of the labor force was tripled in six months under Stevens and whole communities, including housing, mess halls, hospitals, hotels, schools churches, cold storage, clubhouses and laundries were built to accommodate them. Streets were paved in *Colon* and *Panama City* and water and sewage systems installed. At one time, nearly half of the twenty-four thousand man work force was employed at constructing buildings.

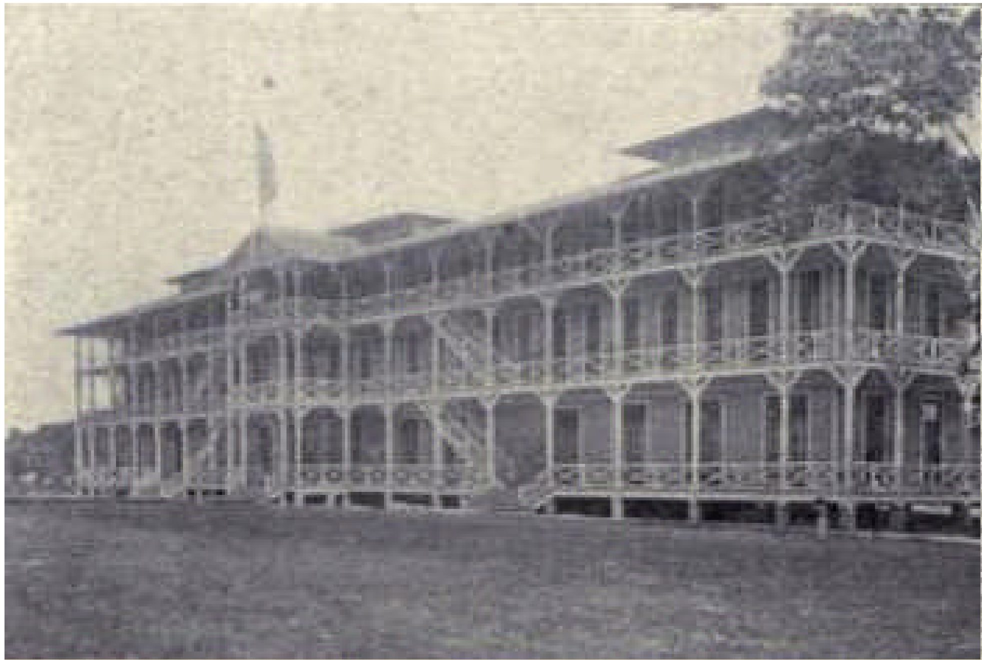
SHOPS AND TERMINAL FACILITIES

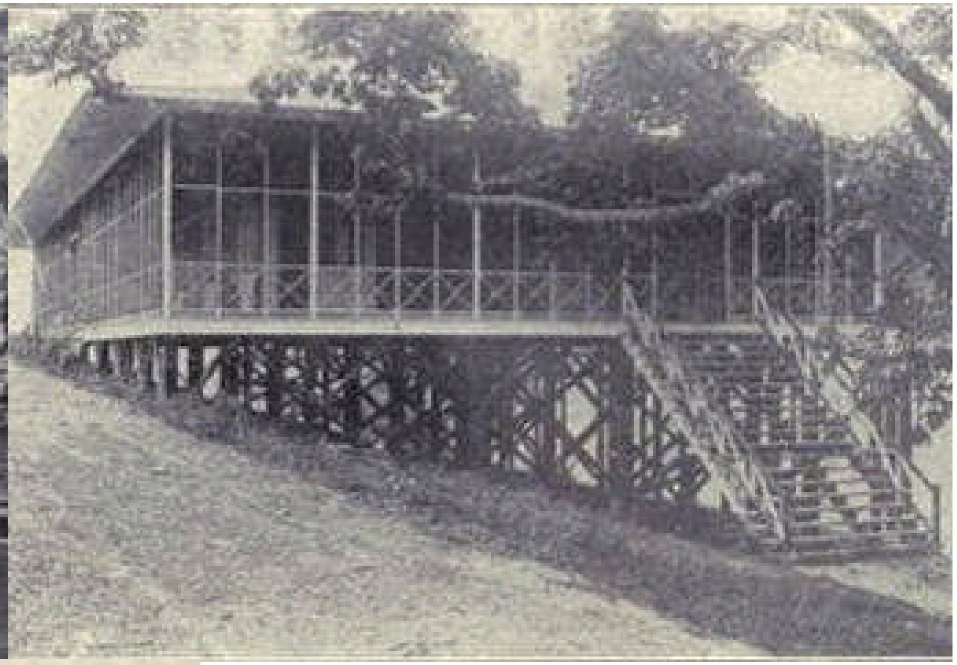
Building	Floor Area *Square Feet*
Machine, erecting, and tool shops	67,420
Forge, pipefitters', tinsmiths', and copper shop	31,650
Steel storage shed	18,080
Boiler and shopfitters' shop	45,940
General storehouse	89.920
Paint shop	12,760
Car shop	38,800
Joiner, carpenter, and pattern shop	48,240
Galvanizing shop	5,620
Lumber and equipment store shed	67,060
Steel, iron, and brass foundry	37,060
Coke shed	3,070
Boiler house	2,380
Pattern storage building	13,870
Office building	9,500
Total	491,370

"…Having made the Canal Zone a safe place in which to work, the commission went farther and made it a comfortable place in which to live. Quarters for the working force were constructed at a number of convenient points and for the married men comfortable houses were provided, and the commission's commissary department arranged for regular shipments of food supplies, which were sold to the employees at cost. Nor was the social life of the workers overlooked. Club houses were built and furnished at the principal settlements along the route of the canal, mostly operated under the direction of the Y.M.C.A., and a little later, women's clubs were organized in principal towns…"

***Popular Mechanics,* December 1913**

<u>Top Left</u>: Recreation Building, *Culebra*
<u>Top Right</u>: Disbursing Office and Quarters, *Empire*
<u>Left</u>: Commission School at *Cristobal*





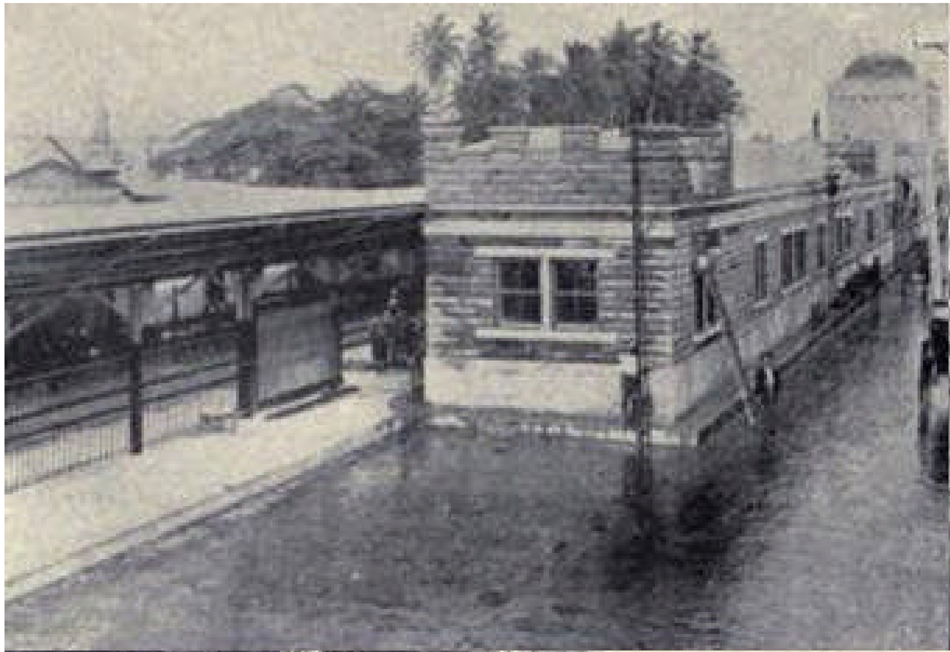
<u>Top Left</u>: Commission Hotel at *Corozal*
<u>Top Right</u>: Public School at *Ancon*
<u>Left</u>: Fire Station, *Cristobal*

“Proximity to the equator, and a high degree of humidity, combine to give the Panama Canal Zone a climate somewhat enervating to persons accustomed to more temperate regions. As a matter of efficiency as well as comfort for Canal Zone workers, a committee of officials is conducting a search for a convenient vacation spot of cooler climate. Change of altitude rather than latitude is relied upon for the success of the experiment, and it is likely that some high point in Costa Rica or the Chiriqui Province of Panama will be selected.”

***Popular Mechanics,* January 1921**

A Matter of Efficiency and Comfort

Providing food to more than 40K employees and their families in a country with little capacity for food production and a few shops was a tremendous task at first. With the goal in mind to maintain a healthy and happy workforce, the *Isthmian Canal Commission* brought food on board the steamers of the *Panama Railroad*. Farms also began to grow fruits and vegetables and even plants and flowers, as well as farms to produce milk and eggs. This was a difficult task at first, but every effort was made to ensure adequate living standards for workers in the *Canal Zone* following standards of the time. Refrigerated warehouses were built to store food and ice and a bakery and an ice cream plant were established. The Panama RR had refrigerated trucks to deliver the goods to the villages located along the canal. Hotels and restaurants were built for American singles. Canteens were built for European workers in which meals were served at $0.40/day. Separate kitchens were built for negro workers where food was served for $0.30/day.



<u>Top Left</u>: new Panama Railroad station, *Colon* (ca. 1909)
<u>Top Right</u>: Kitchen for Negro laborers
<u>Left</u>: ice delivery wagon in front of Cold Storage Plant, *Cristobal*

<u>Above L&R</u>: crowds of men gather around the *Panama RR* pay car on pay-day
<u>Left</u>: interior of pay car



<u>Top Left</u>: Americans celebrating the *Fourth of July* in *Panama*, despite the torrential rain

<u>Top Right</u>: "Automobile Railway Bus" (owned by the U.S. Gov't. in Panama)

<u>Left</u>: *Canal Zone* paramilitary policeman on horseback (most were *Spanish-American War* veterans)

<u>Top Left</u>: view of *Panama City* from *Ancon Hill*
<u>Top Right</u>: Sunday open-air market
<u>Left</u>: a dozen nationalities worked on the canal. Here they are shopping for fruits and vegetables

“The Government is to make a test of Chinese labor for digging the Panama canal. In the test 2,500 Chinese will be employed. The work is said to be too hard for the large number of Jamaicans now employed, and a sufficient number of Spaniards cannot be secured immediately.”

***Popular Mechanics,* November 1906**

RE: recruitment of a labor force was a big problem at the beginning of canal construction. With Panama’s relatively sparse population, there was no surplus labor anywhere in the republic. It was recognized early on that all classes of labor would have to be recruited from outside and that most of the higher grades of skilled labor would have to be recruited from the *United States*.

Date	Workforce
May 1904	1,000 (Approx.)
November 1904	3,500
November 1905	17,000
December 1906	23,901
October 1907	31,967
April 1908	33,170
October 1909	35,495
March 1910	38,676
December 1911	37,826
June 1912	38,174
August 1913	39,962
June 1914	33,270

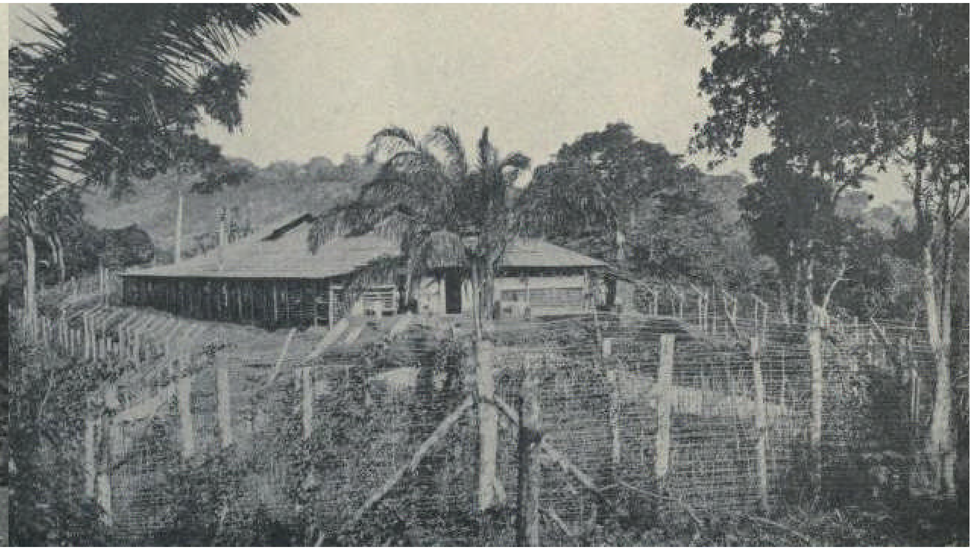
"…The largest number of men employed by the French at one time was 10,854. A recent report of the Canal Commission gave the number employed at 42,885, of whom about 4,000 were white Americans…"

***Popular Mechanics,* December 1913**

Above: table indicating the size of the labor force employed during construction of the *Panama Canal.* The average number of Americans working for the canal during the construction period was +5K.

“Large public works are usually built by contractors, and the question is often asked why an exception should be made in the construction of the Panama Canal. The explanation given is that the location and conditions are such that contractors would necessarily have so large an element of uncertainty as to the work, they would be obliged to bid at prohibitive figures, in order to be on the safe side. The problem of sanitation is so closely interwoven with the construction work as to be difficult of separation, and yet this is a feature which the government alone can handle.”

Popular Mechanics, **April 1906**

"…The plan of having the canal built by contract was considered, but none of the bids was satisfactory, and President Roosevelt decided to place the work under the control of the Engineer Corps of the Army…in April 1907, work was begun under the plan which proved successful…"

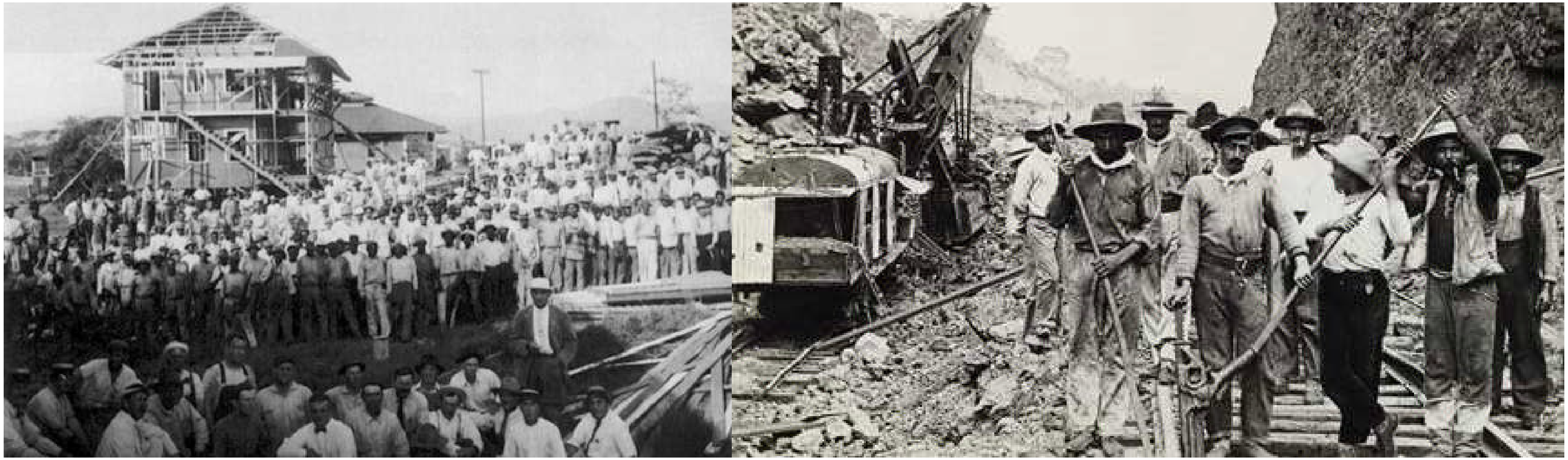
***Popular Mechanics,* December 1913**

RE: contractors were not used during the American canal construction period except for special projects such as lock gate construction which required specially experienced workers. The *McClintic-Marshall Company*, which built the gates, at one time had more than 5K men at work. Taking this force into consideration, the maximum effective force was reached on March 26th 1913, with a total number of men actually on the job at 44,733, not including the sick, those on leave and other absentees. Taking these into consideration would add an additional twenty percent to the total number on the rolls for any given period.

Left: caption: "Empire-Chorrera 16-foot Macadam Road under construction with Zone prison labor, as it appeared August 29, 1912"

Right: caption: "Mandingo stockade for Zone convicts engaged in road building, August 1912"

<u>Top Left</u>: caption: "Typical camp for European workers, Juan Grande"
<u>Top Right</u>: caption: "A room in Bachelor Quarters at Culebra. This shows a typical room such as is provided for bachelor Americans. The government has taken great pains to provide good food, clothing and living conditions, including amusements for its employees."
<u>Left</u>: West Indian Mess Hall

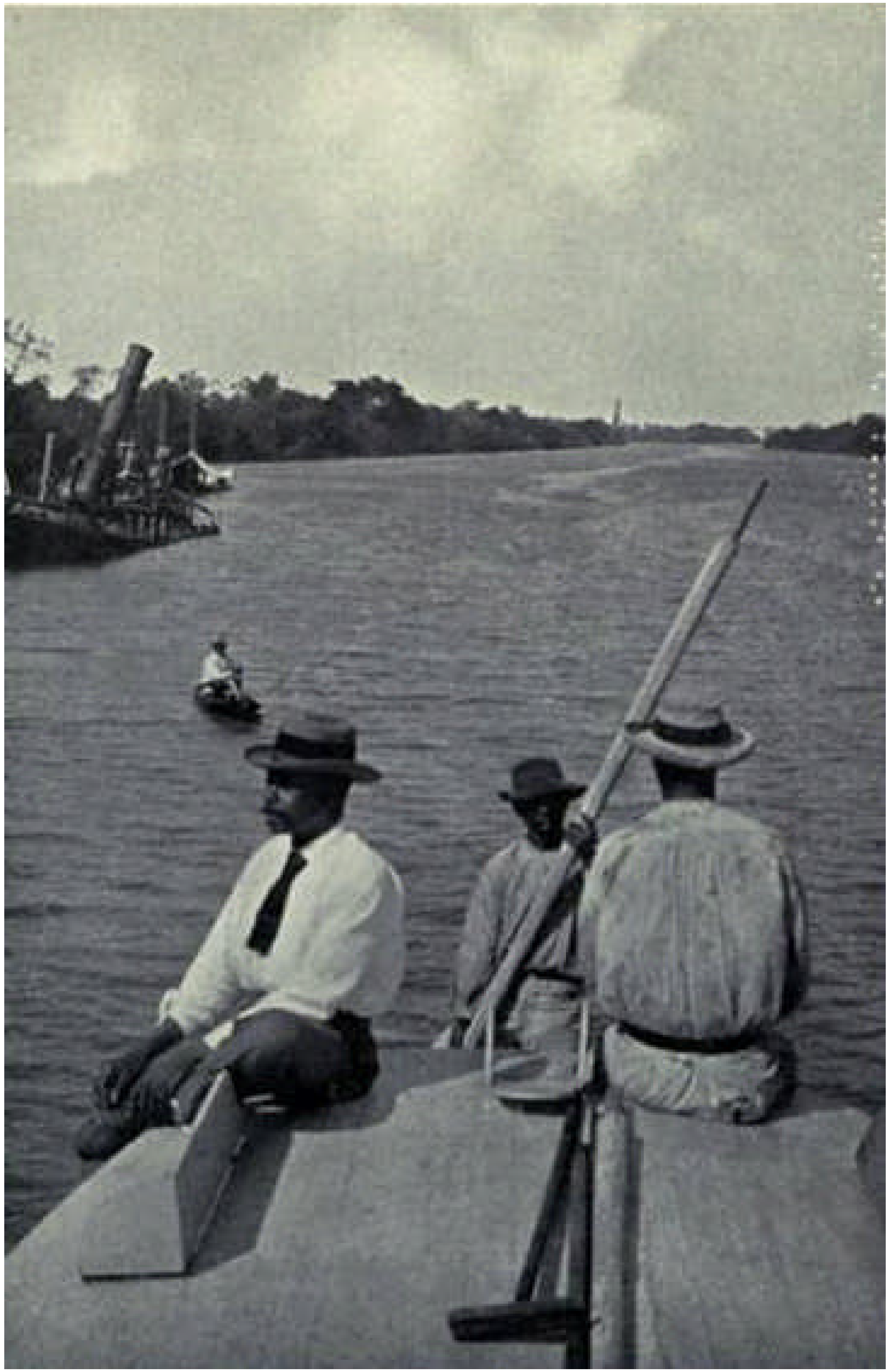


The islands of the *Caribbean* were the logical place to seek a labor force as the French had done some years before. However, when the French canal effort failed, many *West Indian* laborers, about 20K of them, were left stranded in *Panama*, to be repatriated at their governments' expense. This experience left both governments and laborers themselves loath to participate in the American effort. Authorities on the Island of *Barbados* finally authorized large-scale recruitment leading to a total recruitment of 19,900 laborers, reportedly approximately ten percent of the population and between thirty to forty percent of the adult males. When restrictions were withdrawn in 1907, some 7,500 men were recruited from the French islands of *Martinique* and *Guadeloupe*. Actually, the largest recruitment of contracted workers occurred in 1907 when nearly 15K men were brought to the Isthmus. When news got out of the high wages and good living conditions, there was no longer a need to recruit and all agents were withdrawn in 1909.

Above L&R: West Indian laborers

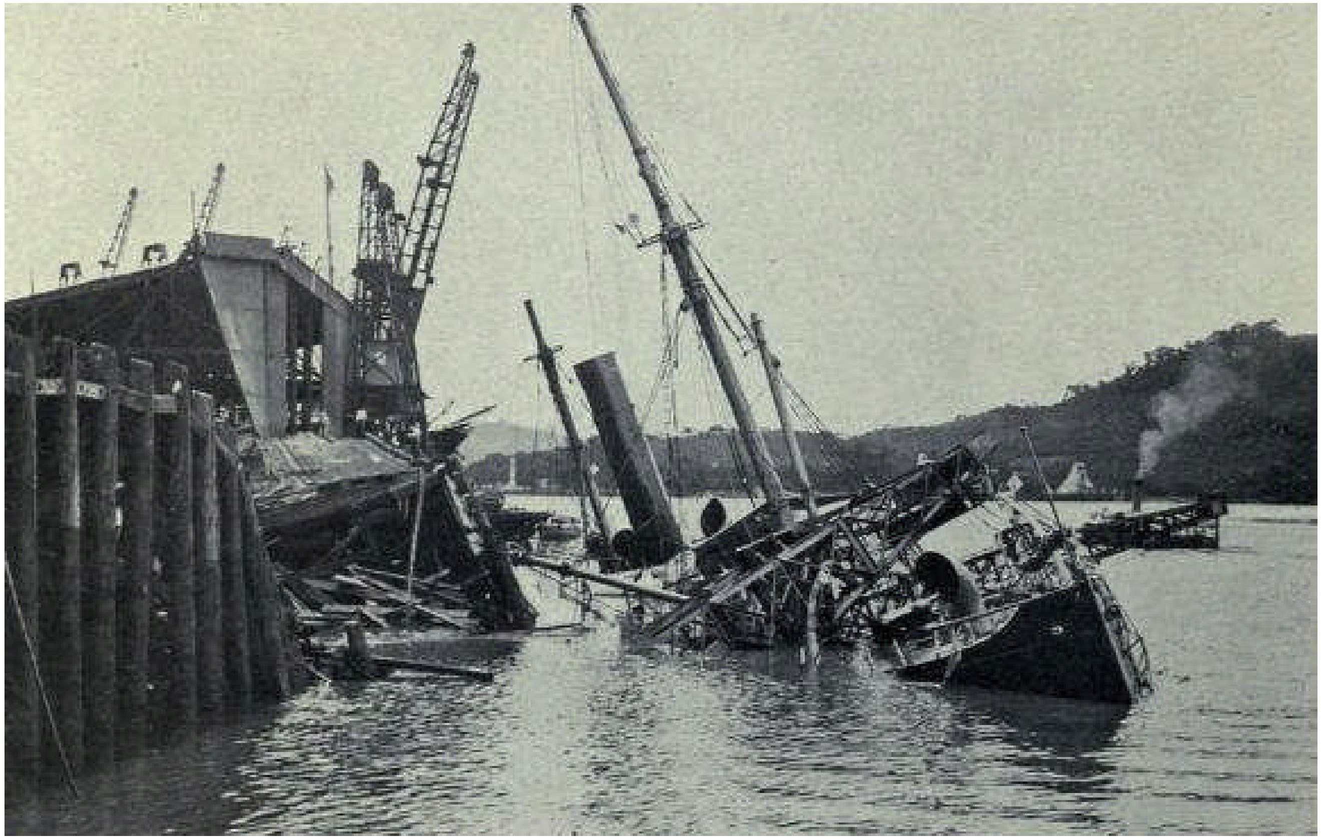
<u>Above</u>: caption: "S.S. Ancon coming into Cristobol with 1,500 laborers from Barbados, Sept. 2, 1909"

<u>Left</u>: caption: "Arrival at Cristobol of S.S. Ancon with 1500 laborers from Barbados, deck scene, Sept. 2, 1909"



It is often, erroneously, believed that Jamaican labor built the *Panama Canal*. Actually, *Jamaica*, the largest, nearest and most populous of the *British West Indies*, would have been a logical place to recruit unskilled labor. However, throughout the construction period, island authorities consistently refused to allow recruiting, placing a tax of one pound sterling on anyone wishing to leave to work in Panama. For unskilled laborers who made a maximum of about $0.30 per day, to pay the tax and the passage was prohibitive. The large Jamaican immigration to the Isthmus consisted mostly of artisans, not laborers.

Left: caption: "The northern or Atlantic end of the Canal, approaching the Gatun Locks. Types of Jamaica negroes employed on the Canal. Wrecked steamers left by the French."



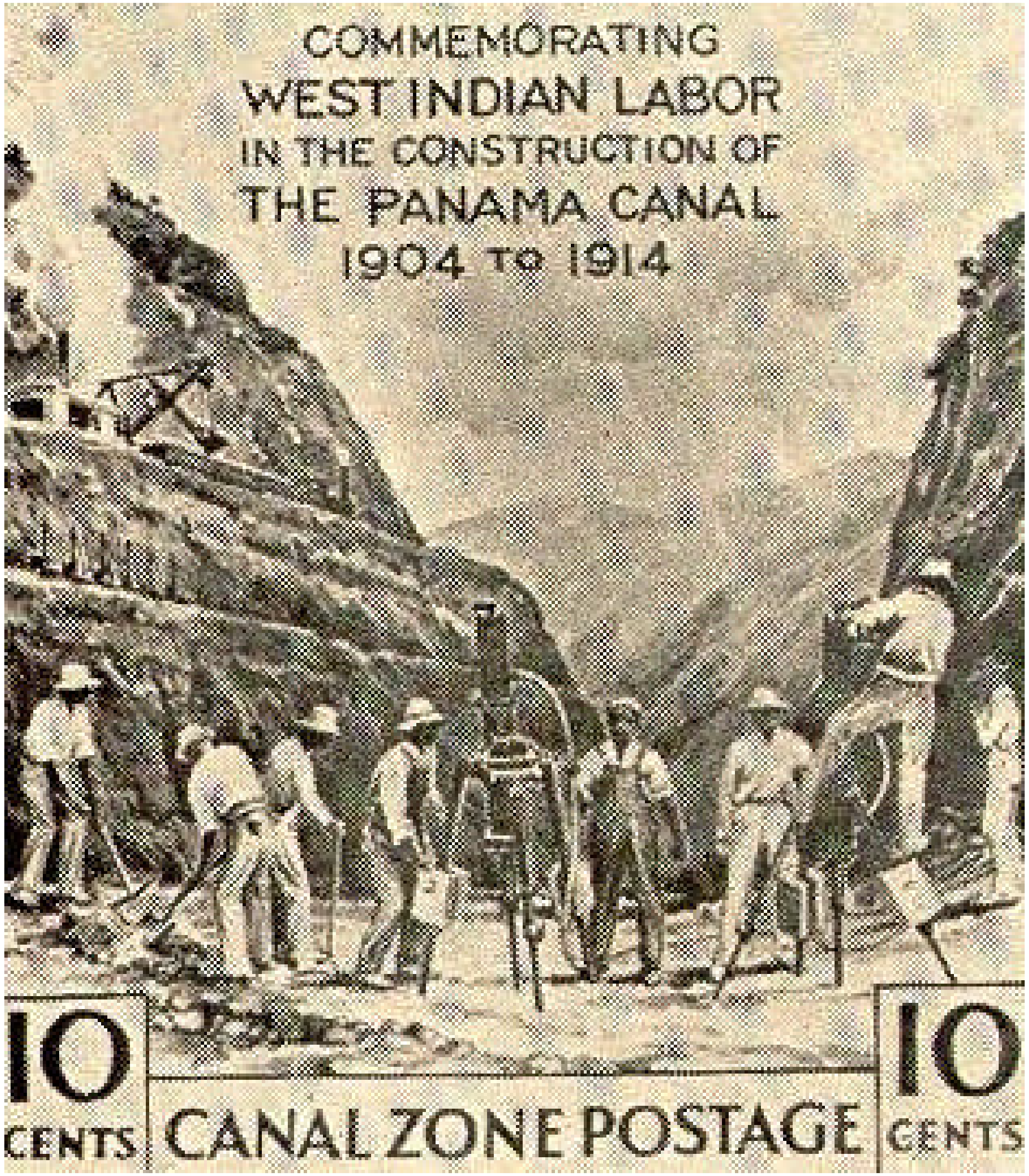
Silver Men

The black laborers, who were generally *West Indian*, would remember their *Panama Canal* experience for the rest of their lives; if they survived. They recalled the tremendous physical exertion and the constant fear of being killed. In fact, *Panama* was four time more deadly for the black man than it was for the white man. Violent death was more feared than disease since, particularly during the French Period, train derailments, falls from trains, being crushed under land and/or mud slides and suffocation from noxious gases was commonplace. With the coming of the Americans in 1904, the reliance on dynamite to quickly blast away layers of soil and rock from the *Culebra Cut* presented the ever-present possibility of being blown to pieces at any time. The “powder men” - those who transported the thousands of fifty-pound boxes of dynamite on their heads and/or shoulders, along with the men who drilled the charge holes into the side of rocky precipices, were often the victims of accidental or premature explosions. Even the “sweat” produced by dynamite - an unpredictable material, was liable to set off an explosion if not handled delicately. Most of the men who actually handled the dynamite and the charge boxes were, in fact, black West Indians. There were also horrible rail accidents. Even Dr. Gorgas himself, at one point, was preoccupied with the number of violent fatalities; they were “very excessive,” he acknowledged, particularly since so many were caused by railroad accidents. Hundreds of black men lost their life and limb in falls from moving dirt cars and other rail transport, particularly in moving spoil and men to and from Culebra Cut. Many descendants of the original “Silver Men” consider the cut to be a large scale burial ground: *Un Campo Santo*.

<u>Top Left</u>: caption: "A crew of West Indian 'Powder Men' transporting fifty pound boxes of dynamite on their heads"
<u>Top Right</u>: caption: "Upper Miraflores Locks - Tripod drills at work, April 1910"
<u>Left</u>: caption: "Men building the Panama Canal"

“From Colon the Panama Railroad ran regular funeral trains out to Monkey Hill each morning. Over to Panama, S.W. Plume would recall in his memorable testimony, it was the same way - bury, bury, bury, running two, three, and four trains a day with dead Jamaica negroes all the time…It did not matter any difference whether they were black or white, to see the way they died there. They died like animals...The accusation that black workers were sometimes disposed of in the dumping grounds - simply rolled down an embankment, then buried beneath several tons of spoil, appears in several accounts and is undoubtedly based on fact.”

RE: excerpts from: “The Path Between the Seas” by *David McCullough.* The “funerary trains” became legendary during the canal construction years. The routine passage of these trains loaded with the bodies of dead; mostly West Indian workmen killed on the job, was a sorry sight for the survivors who looked on with somber acknowledgement of their fallen comrades fate. The funeral trains carried the deceased to *Colon* on their pick-up rounds out of *Empire*.

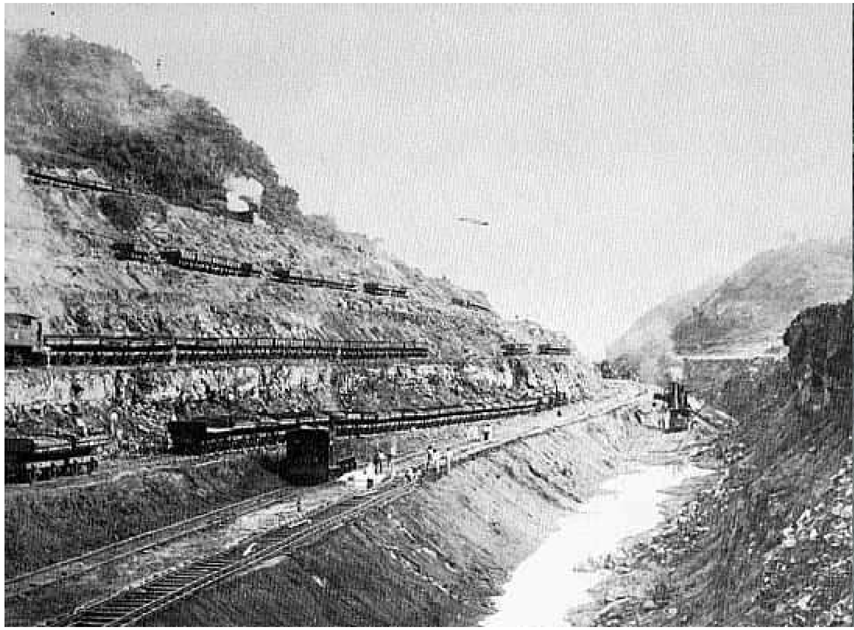
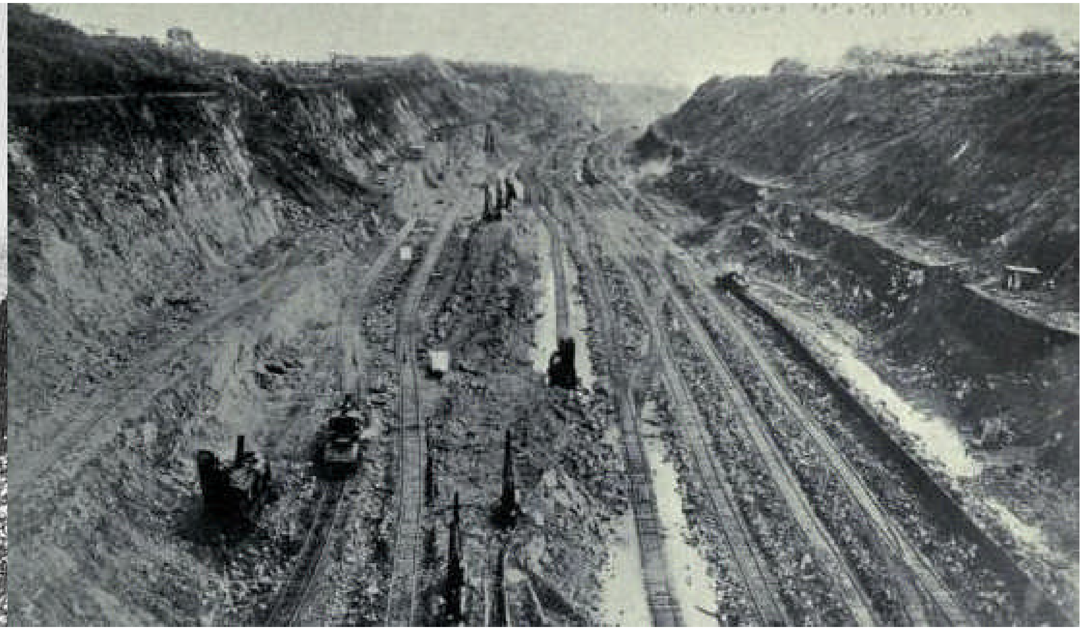

COMMEMORATING
WEST INDIAN LABOR
IN THE CONSTRUCTION OF
THE PANAMA CANAL
1904 TO 1914
10
CENTS
CANAL ZONE POSTAGE
10
CENTS

"A farm for the benefit of 'silver' or unskilled workmen thrown out of employment by the completion of the Panama Canal has been established by the government on the Canal Zone. There are now about 100 men on this farm, all of whom are earning a comfortable living for themselves. Nearly all these farmers are crippled, some having lost an arm or a leg or having been incapacitated in some other way for hard work. The farm grows bananas, oranges, cocoanuts and other tropical products and is stocked with cows, chickens, ducks and pigs. It is managed by the medical corps of the United States Army. Each workman is to have a life job on the farm."

***Popular Mechanics,* December 1914**

RE: according to hospital records, 5,609 lives were lost from disease and accidents during the American construction era. Adding the deaths during the French era would likely bring the total deaths to about 25K, based on an estimate by Dr. Gorgas. However, the true number will never be known, since the French only recorded the deaths that occurred in their hospitals.

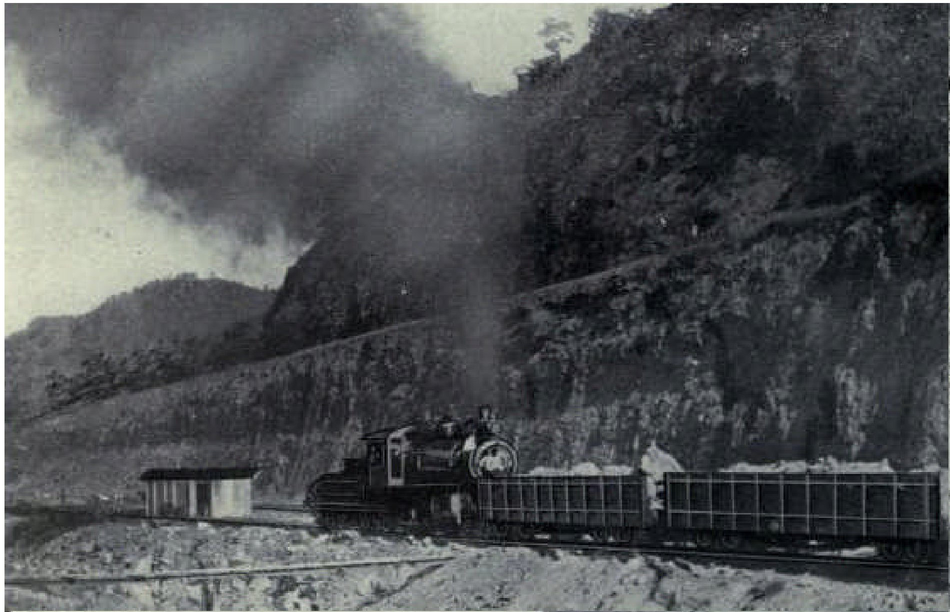
Spoil Trains

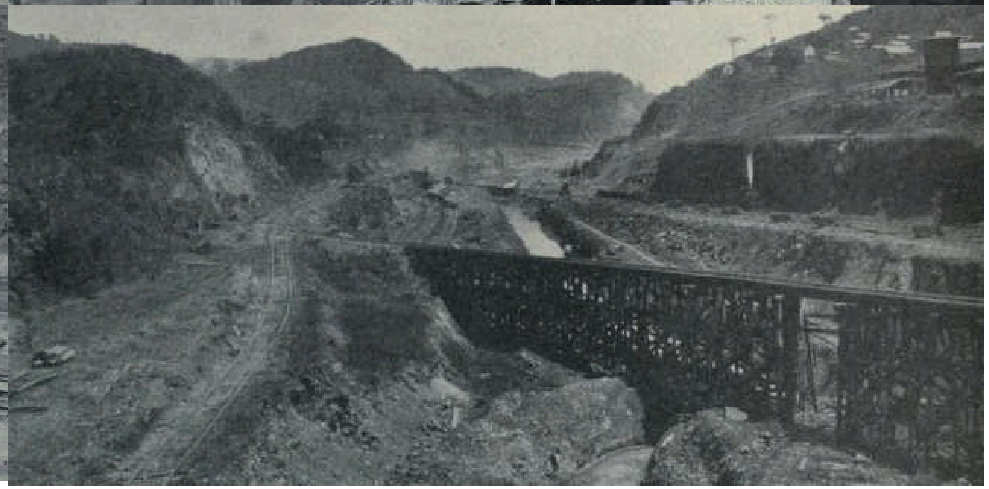
 

With a background in railroads and well aware that removing excavated material from the site was critical, Stevens developed an ingenious system of canal excavation and disposal of rock and soil (a.k.a. "spoil'). He devised a complex but very workable and efficient system of railroad tracks at different levels within the Cut. Spoil train schedules were coordinated to the level where the excavation work was being done. Spoil train capacity kept pace with the excavation work, keeping both trains and steam shovels efficiently employed at all times.

<u>Left</u>: *Culebra Cut*, at the start of U.S. operations in 1904. Note the spoil trains at various levels

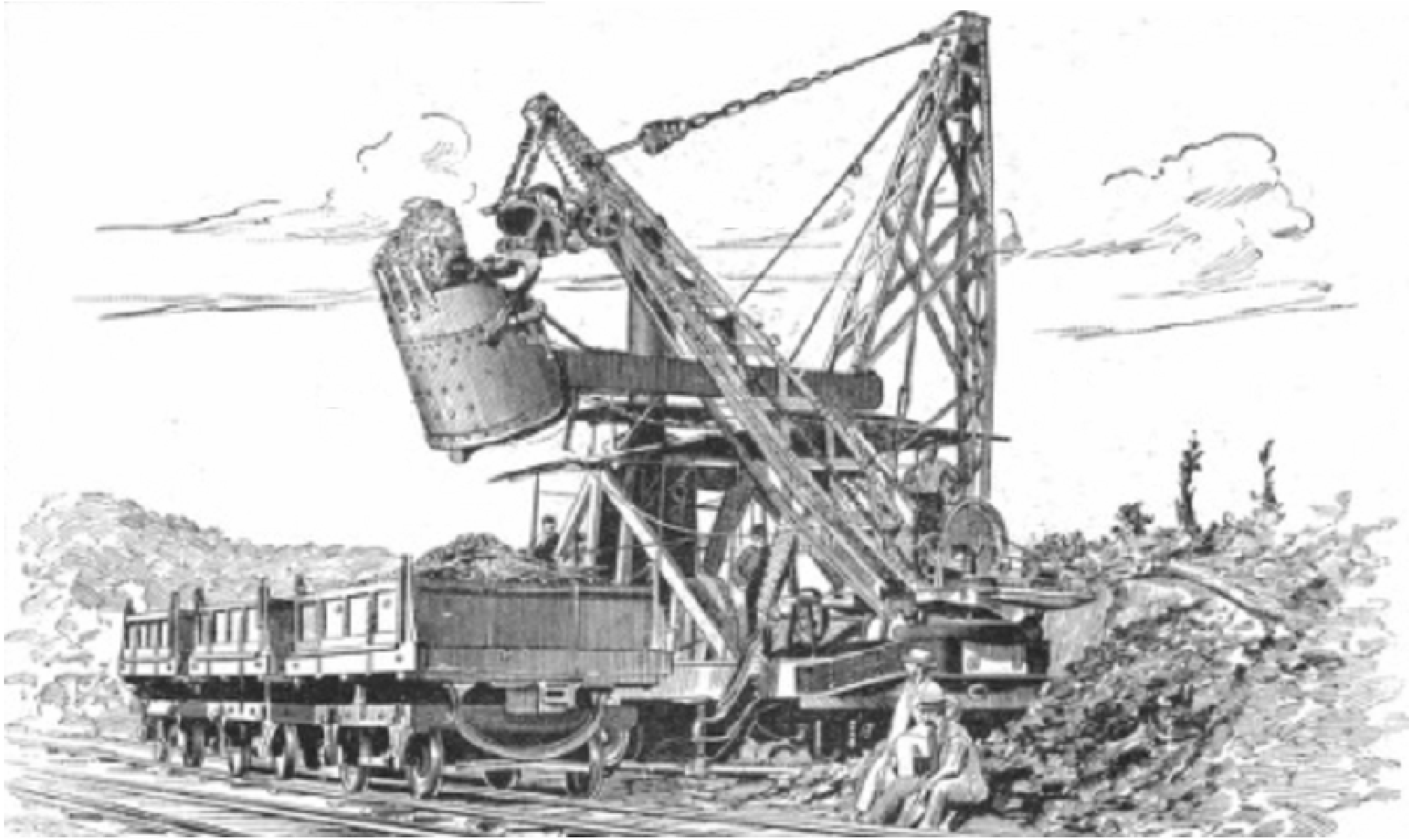
<u>Right</u>: caption: "Nine railroad tracks side-by-side in Culebra Cut. View from the Empire Suspension Bridge"





<u>Top Left</u>: caption: “As the shovels load a car, the locomotive pushes the train along slowly until the whole train is full. Then off to the dump and back for another load.”
<u>Top Right</u>: caption: ‘One of the great steam shovels loads a train car. Two men handle one of these monsters easily”
<u>Bottom Left</u>: caption: “Steam shovels are working away at the “toe” and loading the material on trains to be hauled away”
<u>Bottom Right</u>: caption: “Culebra Cut Trestle RR Bridge, June 1912”

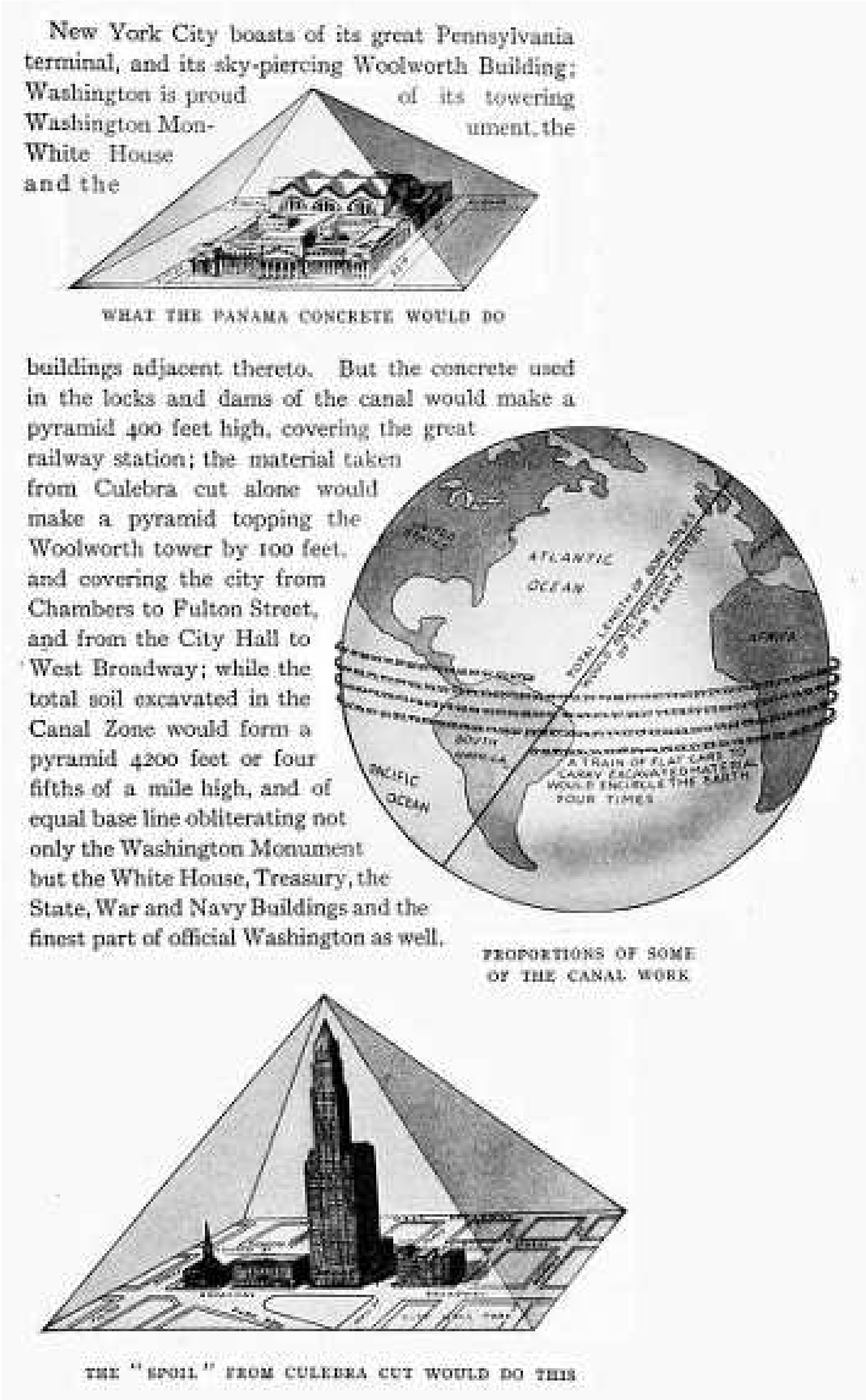
Making the Dirt Fly



"Spread in any city of the Union the earth which was taken from the canal during a single month would have buried 10 city blocks under 40 solid feet of earth"

***The Philadelphia North American,* 1908**

<u>Above</u>: caption: "Excavation Plant at Panama – Osgood American Excavator"



New York City boasts of its great Pennsylvania terminal, and its sky-piercing Woolworth Building; Washington is proud of its towering Washington Monument, the White House and the

WHAT THE PANAMA CONCRETE WOULD DO

buildings adjacent thereto. But the concrete used in the locks and dams of the canal would make a pyramid 400 feet high, covering the great railway station; the material taken from Culebra cut alone would make a pyramid topping the Woolworth tower by 100 feet, and covering the city from Chambers to Fulton Street, and from the City Hall to West Broadway; while the total soil excavated in the Canal Zone would form a pyramid 4200 feet or four fifths of a mile high, and of equal base line obliterating not only the Washington Monument but the White House, Treasury, the State, War and Navy Buildings and the finest part of official Washington as well.

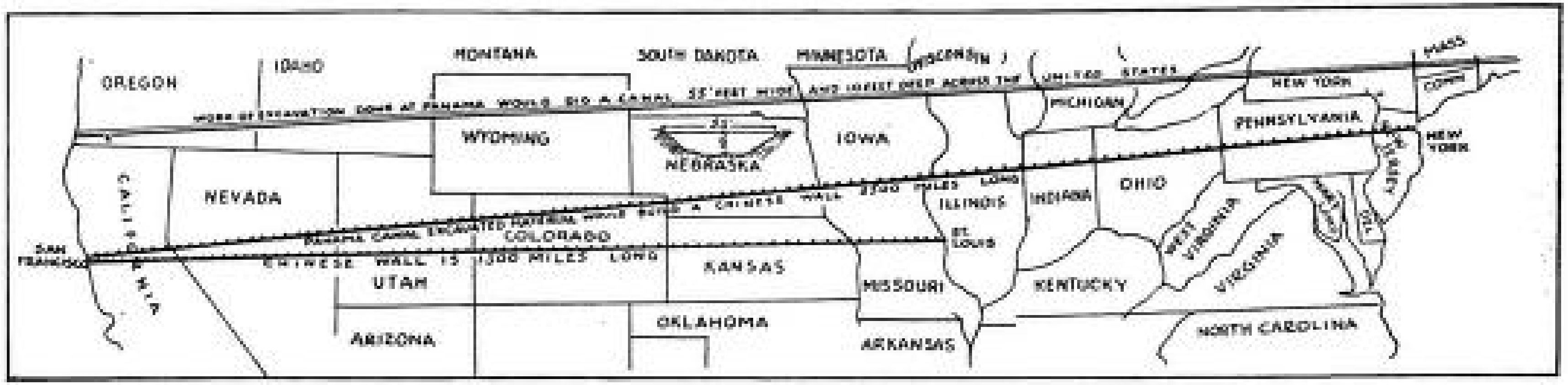
PROPORTIONS OF SOME OF THE CANAL WORK

THE "SPOIL" FROM CULEBRA CUT WOULD DO THIS

"Every 50 working days the toilers who are digging the Panama canal are removing an amount of material equal to the great Pyramid of Cheops, which consumed the labor of 100,000 men for 20 years in the building, and the services of the same number for 10 years in constructing the road connecting the work with the quarries…"

Popular Mechanics, **June 1908**

High Water Mark



WHAT THE WORK EXPENDED ON THE CANAL MIGHT HAVE DONE

Build a Chinese wall from San Francisco to New York, or dig a ditch 10 feet deep and 55 feet wide across the United States at its widest part

"…The high water mark was reached during February, when a daily average of 122,742 cu. yd. of material was excavated. February had but 24 working days of 8 hours each, but all records were broken by a total excavation of 2,945,880 cu. yd. For this work 64 steam shovels were used. Thirty-five more immense steam shovels are now being used, or en route to the canal zone…The real work of excavation began in 1906, and in the two years ended since then 21,600,565 cu. yd. were removed. During 1907 the record went up in bounds from 815,270 cu. yd. in March to 1,868,729 in October, but even the latter figure, which so amazed the American public when reported, has been dwarfed to insignificance by the 2,709,290 cu. yd. of January and the 2,945,880 cu. yd. of February, 1908…"

Popular Mechanics, **June 1908**

RE: by July 1st 1914, a total of 238,845,587 cubic yards had been excavated during the American construction era. Together with about 30 million cubic yards excavated by the French, this gives a total of around 268 million cubic yards, or more than four times the volume originally estimated for de Lesseps' sea level canal.

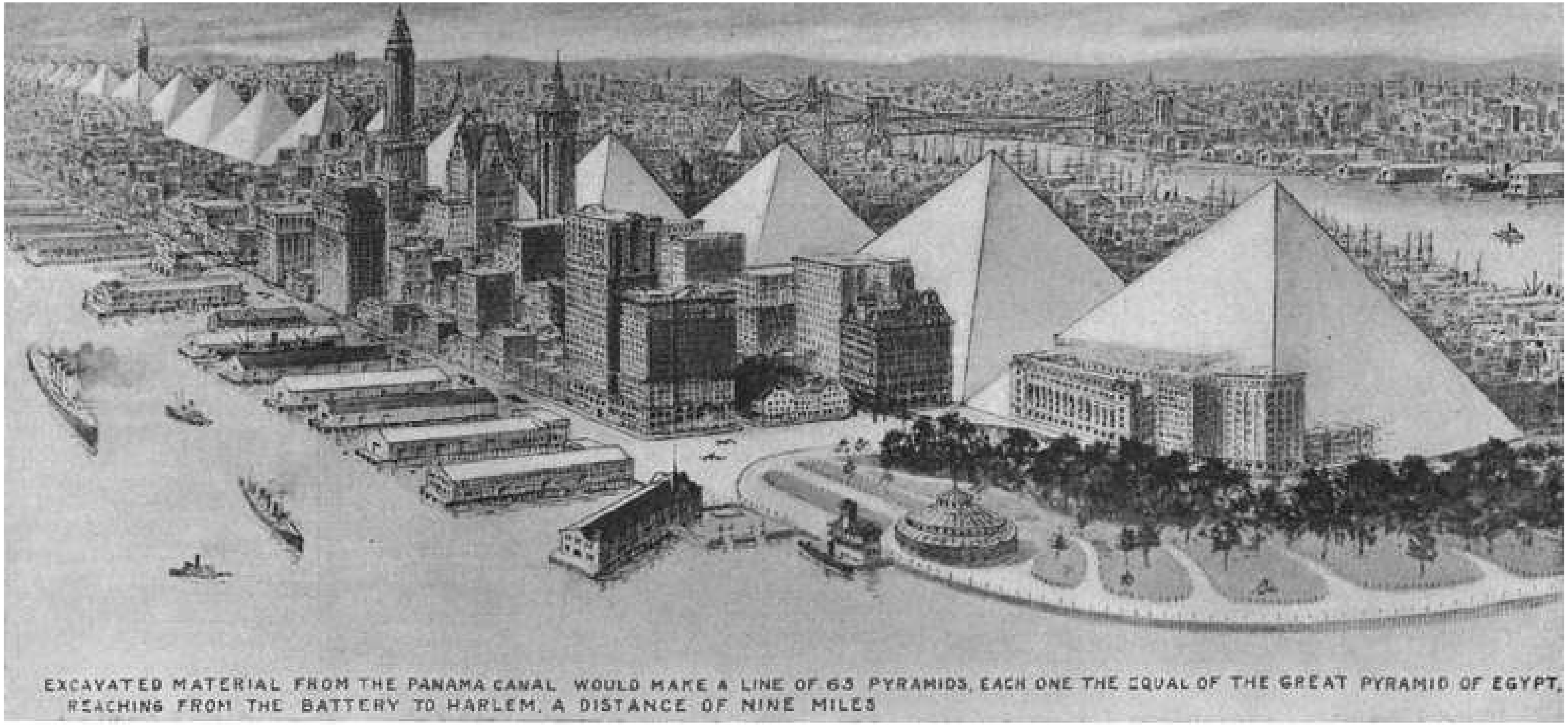
The Panama Pyramid

May, 1904, to June 30, 1914

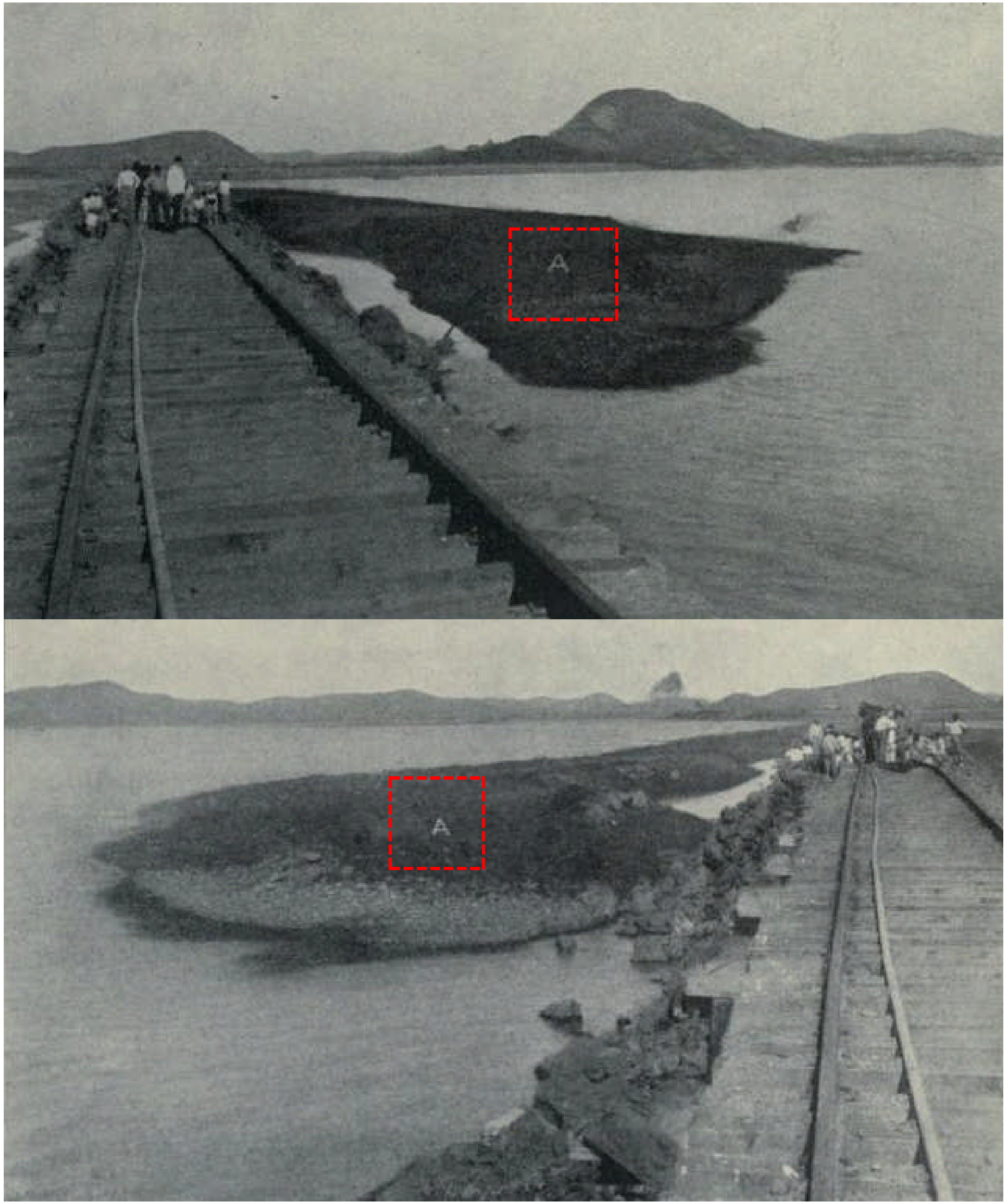
	Cu. Yds.
Dry Excavation	
Gatun to sea	2,181,998
Gatun to Pedro Miguel	110,261,883
Pedro Miguel to sea	4,819,969
Gatun Spillway	1,544,202
Gatun Locks	4,660,055
Pedro Miguel Locks	1,133,280
Miraflores Locks	2,222,582
Hydraulic Excavation	
Gatun to sea	29,605
Gatun to Pedro Miguel	1,441,729
Pedro Miguel to sea	1,549,904
Miraflores Locks	332,703
Dredging Excavation	
Atlantic entrance	39,032,400
Pacific entrance	39,962,470
Preparing Foundations	
Gatun Spillway	44,715
Gatun Locks	228,376
Pedro Miguel Locks	175,987
Miraflores Locks	415,981
Dry Fill	
Gatun Dam	12,229,104
Pedro Miguel Dam	699,518
Miraflores Dam	1,758,423
Back Fill	
Gatun Spillway	50,183
Gatun Locks	2,119,406
Pedro Miguel Locks	834,288
Miraflores Locks	2,366,252
Filling Center Wall	
Gatun Locks	113,163
Pedro Miguel Locks	220,768
Miraflores Locks	249,457

"The total amount of earth excavated and yet to be taken out in building the Panama Canal under the projected plans, amounts to 214,666,594 cu. yd…if the rock and earth dug out in making the Panama Canal were to be built up into a solid pyramid, the proportions of the Great Pyramid, or Pyramid of Cheops, would seem insignificant in comparison. The 'Panama Pyramid,' as it may be called, would tower nearly 2.5 times as high as Cheops, and would contain about 14 times as much material, by volume. In height, it would extend up into the sky nearly 1,150 ft. The area covered by Cheops is slightly more than 13 acres. The 'Panama Pyramid' would extend over nearly 75 acres. Taking the average length of a city block as 600 ft. and its width as the same figure, the 'Panama Pyramid' would cover an area of about 9 times that of a city block. Assuming its base to be perfectly square, the 'Panama Pyramid' would be three city blocks long, three blocks wide, and its height nearly twice that of the tower of the Singer Building in New York City…"

Popular Mechanics, **April 1911**

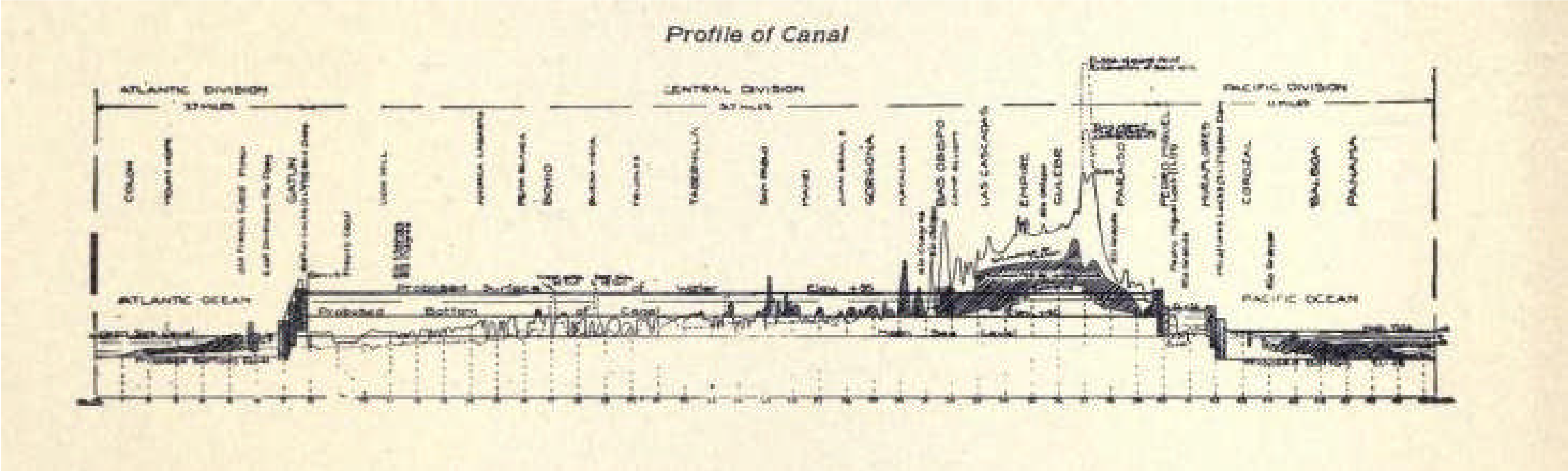


Above: by the time the *Panama Canal* was finished, 268 million cubic yards of dirt and rock had been taken out of the ground or dredged from lakes. This amount of material was so huge that it could have made sixty-three pyramids the size of the *Great Pyramid of Cheops* in *Egypt*. It was so difficult to imagine this amount of material that in November 1912, *Scientific American* illustrated what it would look like if all of these pyramids were lined up along the length of Manhattan Island.



Left T&B: caption: "South End of Naos Island Dump, 4,000 feet from island. Center of "A" is 75 feet from track and 25 feet above the original bottom. Elevation of trestle +14. Dec., 1911"

The Debate



"President Roosevelt will direct the Isthmian Canal Commission to proceed with the construction of a lock type of canal unless congress decides in favor of a sea-level waterway and instructs him accordingly. The foreign consulting engineers favor a sea-level canal; a majority of the American engineers recommend the lock system. The foreigners have been guided by Suez canal history; the Americans by the Sault Ste. Marie canal…"

Popular Mechanics, **April 1906**

"Completed in 1895, this canal formed the last link in an all-Canadian navigation system stretching from the St. Lawrence River to Lake Superior. Designed and built by Canadians, the canal incorporated several engineering innovations. It was the world's longest lock and the first to operate with electrical power. It was also novel in using an emergency swing dam to protect the lock in case of accident. Electricity was generated on site in the powerhouse. Closed in 1987 owing to a lock wall failure, the canal was equipped with a modern lock and opened for recreational use in 1998."

***Historic Sites and Monuments Board of Canada,* 1998**

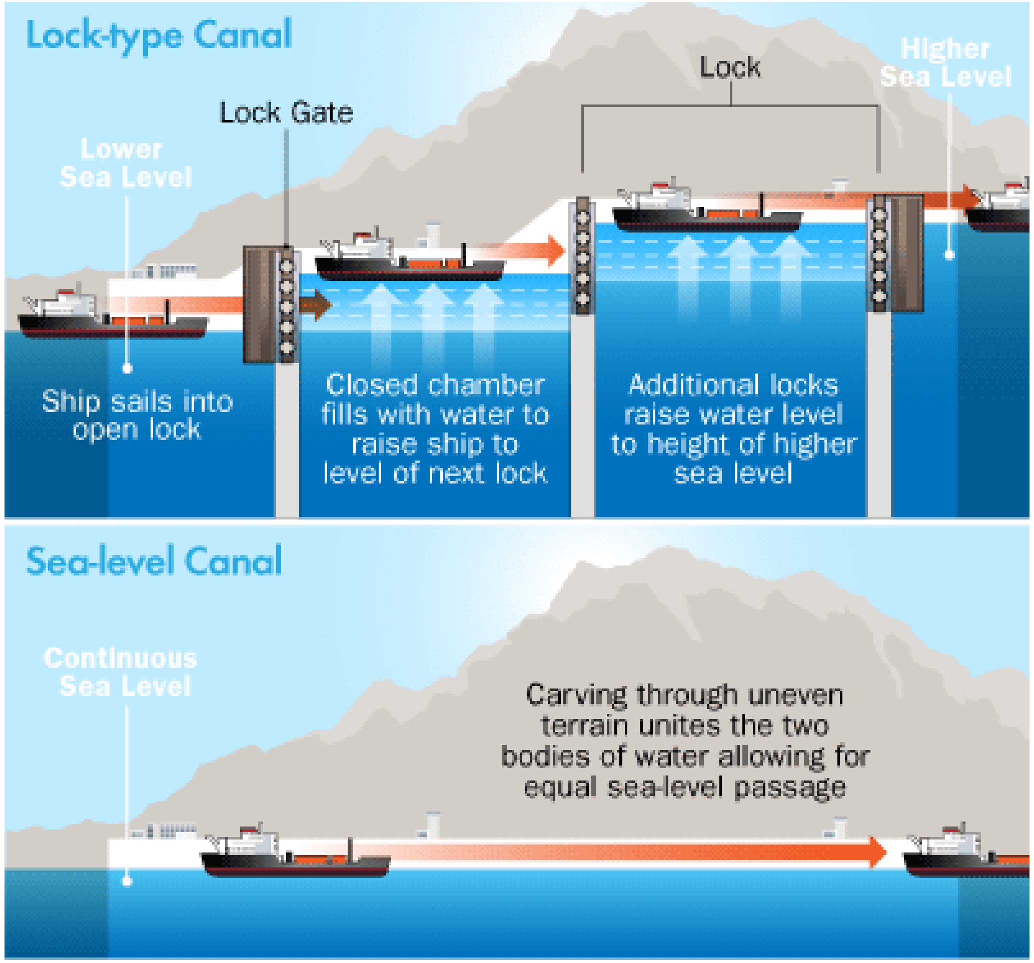
RE: ***Sault Ste. Marie Canal***

"…in February 1904, a commission for the construction of a canal was appointed. In May of that year, work was begun where the French company had abandoned it. In June, 1905, a board of consulting engineers was appointed to consider whether the canal should be at sea-level or with elevating locks. By a vote of eight to five the board reported, in January, 1906, in favor of a sea-level canal. The minority, together with the chief engineer, favored the high level plan, on the grounds that it would provide a quicker passage for ships and an equally safe one; that it furnished the best solution of the vital problem of how to care for the flood waters of the Chagres River; that it would cost less and could be built quicker, and would be less expensive to operate and maintain. When these conflicting reports were submitted to the Isthmian Canal Commission, it voted almost unanimously in favor of a canal with locks, and this plan was adopted by Congress in June, 1906…"

***Popular Mechanics,* December 1913**

“It will be noticed that the American engineers on the consulting board and on the commission by a more than 2 to 1 majority favor the lock canal, whereas the foreign engineers are a unit against it. I think this is partly to be explained by the fact that the great traffic canal of the old world is the Suez canal, a sea-level canal, whereas the great traffic canal of the new world is the Sault Ste. Marie canal, a lock canal. Although the latter, the Soo, is closed to navigation during the winter months, it carries annually three times the traffic of the Suez canal. A careful study of the reports seems to establish a strong possibility that the following are the facts: the sea-level canal would be slightly less exposed to damage in the event of war; the running expenses, apart from the heavy cost of interest on the amount employed to build it would be less; and for small ships the time of transit would probably be less. On the other hand, the lock canal at a level of eighty feet or thereabouts would not cost much more than half as much to build, and could be built in about half the time, while there would be much less risk connected with building it, and for large ships the transit would be quicker; while, taking into account the interest on the amount saved in building, the actual cost of maintenance would be less. After being built, it would be easier to enlarge the lock canal than the sea-level canal.”

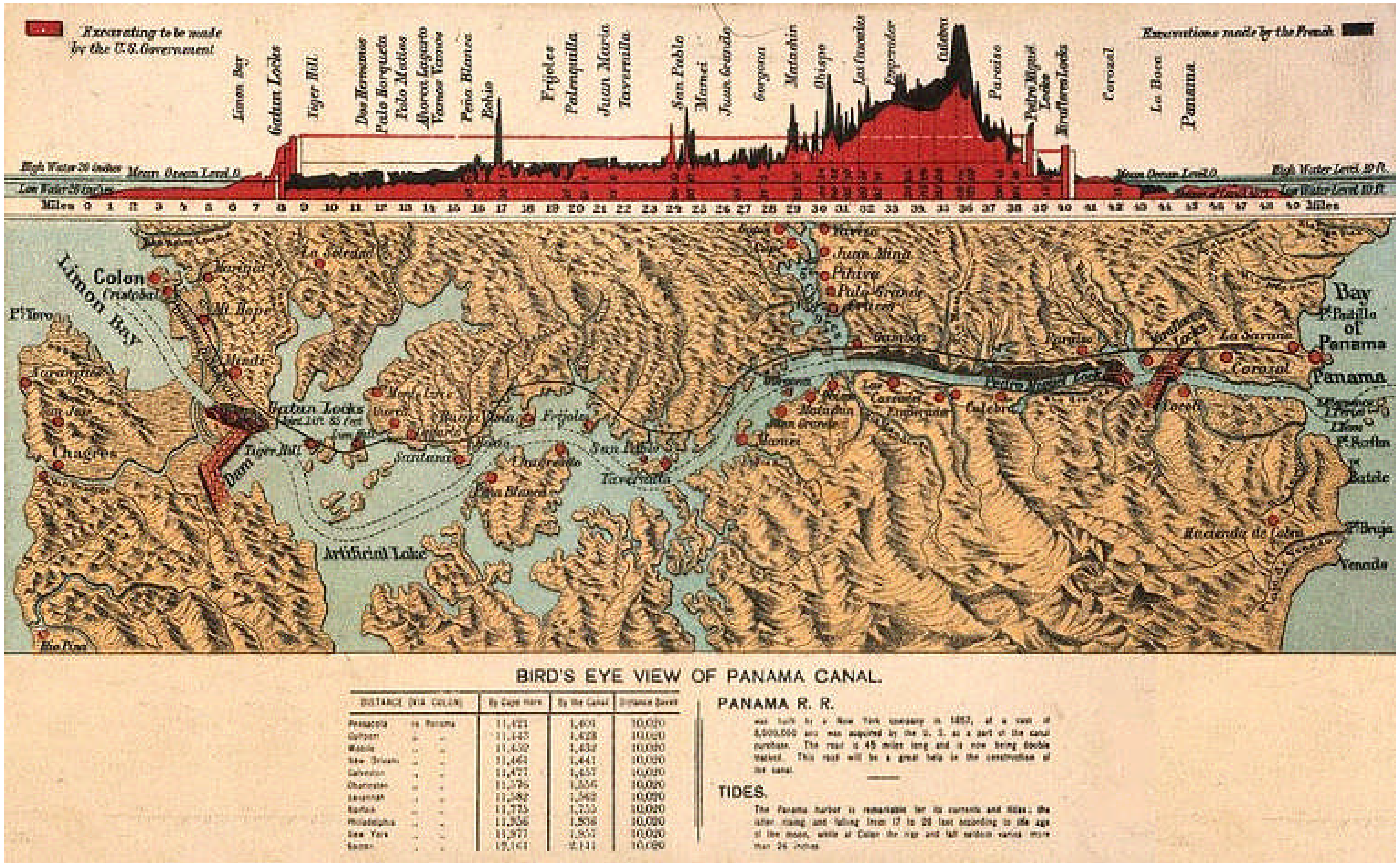
Theodore Roosevelt


Lock-type Canal
Lock Gate
Lock
Higher Sea Level
Lower Sea Level
Ship sails into open lock
Closed chamber fills with water to raise ship to level of next lock
Additional locks raise water level to height of higher sea level
Sea-level Canal
Continuous Sea Level
Carving through uneven terrain unites the two bodies of water allowing for equal sea-level passage

“It will provide a safer and quicker passage for ships...It will provide, beyond question, the best solution to the vital problem of how safely to care for the floodwater of the Chagres…Its cost of operation, maintenance and fixed charges will be much less than any sea-level canal.”

John F. Stevens

RE: it was John F. Stevens who convinced President Roosevelt of the wisdom and necessity of building a lock rather than a sea-level canal, and it was Stevens who lobbied the U.S. Congress and others on *Capital Hill*, just as Frenchman *Godin de Lepinay* lobbied before the Congres International in *Paris* in 1879. The difference was that Stevens succeeded where *de Lepinay* failed. Stevens, with firsthand knowledge from witnessing the *Chagres River* during flood explained, during intense questioning before the *House Committee on Interstate and Foreign Commerce*, the situation using statistics and maps stating repeatedly that: *“the one great problem in the construction of any canal down there is the control of the Chagres River.”* He also helped draft the Senate address by *Philander Knox* on June 19th 1906 on the subject of the canal, the lock plan and *Gatun Dam* in particular. Two days after the Knox speech, the Senate voted for a lock canal 36 to 31; on June 27th 1906, the House followed suit. Just a narrow margin of votes stood between *United States*’ lock canal success and a sea-level canal attempt that, in all likelihood, would have failed. Stevens would call the sea-level plan: *“an entirely untenable proposition, an impracticable futility.”* Proposed as only 150-feet wide for nearly half its length, it was seen by Stevens as: *“a narrow, tortuous ditch”* fraught with the possibility of endless landslides. Goethals reportedly once remarked that there was not enough money in the world to construct a sea-level canal across *Panama*. Stevens estimated completion time for a lock canal to be eight years; by January 1914. He estimated that a sea-level canal couldn’t be completed in less than eighteen years; sometime around 1924.



Excavating to be made by the U. S. Government
Excavations made by the French
Limon Bay
Gatun Locks
Tiger Hill
Frijoles
San Pablo
Gorgona
Matachin
Obispo
Culebra
Paraiso
Pedro Miguel Locks
Corozal
La Boca
Panama
Mean Ocean Level 0
Miles
Colon
Cristobal
Limon Bay
Mt. Hope
Gatun Locks
Dam
Tiger Hill
Chagres
Artificial Lake
Frijoles
San Pablo
Tavernilla
Peña Blanca
Matachin
Mamei
Gorgona
Empirador
Las Cascadas
Culebra
Paraiso
Pedro Miguel Lock
La Sabana
Corozal
Panama
Bay of Panama
Hacienda de Cabra
BIRD'S EYE VIEW OF PANAMA CANAL.
PANAMA R. R.
TIDES.

The Question Asked

"…The question is sometimes asked: What would happen if some radical change should occur in the course of the Gulf Stream, so that in no longer supplied its warm waters to the northern part of the Atlantic?...The permanent dislocation of the Gulf Stream, though not likely to be witnessed in our time, is not absolutely impossible. When the building of the Panama canal was first talked of, fears were often expressed that, by opening a passage to the equatorial current, it might cause that current to flow into the Pacific and thus cut off the supply of the Gulf Stream. Of course, these fears were groundless, because any ordinary canal, even if built without locks, would be far too small to have such an effect. On the other hand, a broad sea-level channel cut through Central America – say at the Gulf of Honduras, which lies closer to the present course of the Equatorial current than does the Isthmus of Panama – would certainly deplete the Gulf Stream, and, if it were big enough, would obliterate it altogether. There is, to be sure, no likelihood that engineers will ever construct such a channel – but nature may. A tremendous earthquake, in that notoriously seismic region, might cause a subsidence of the land and open just such a passage…Professor Alphonse Berget, of the Oceanographic Institute in Paris, has lately suggested that this may happen some day…'Should the Gulf Stream be thus diverted from its course, the British Isles, France and Portugal would have rigorous winters, with temperatures down to thirty or forty below zero'…"

Popular Mechanics, **September 1929**

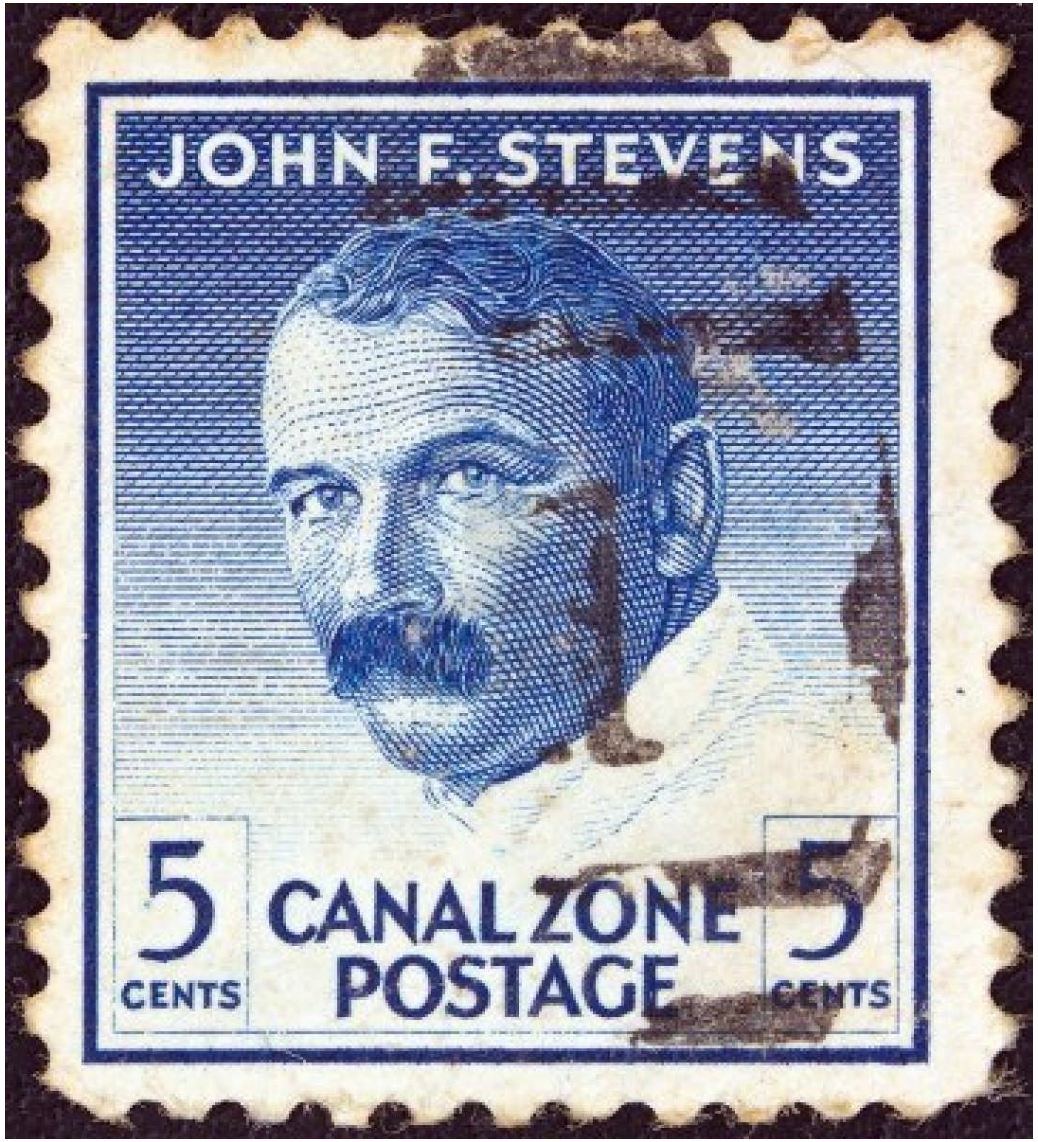

ESKIMAUX'S
ATLANTIC OCEAN
A CHART of The

The Genius of the Panama Canal

“Stevens devised, designed, and made provision for practically every contingency connected with the construction and subsequent operation of the stupendous project...It is therefore to him, much more than to me, that justly belongs the honor of being the actual ‘Genius of the Panama Canal...’”

George Washington Goethals

RE: with all immediate problems solved and the work going well, Stevens suddenly and inexplicably resigned, effective April 1st 1907. Colonel *George Washington Goethals* succeeded Stevens as chief engineer. Amid much speculation about the reason, Stevens said nothing publicly except to say that it was “personal.” As a professional experienced in railroad engineering the canal work, for Stevens, was a straightforward administrative and design problem. He once stated: *“…the problem is one of magnitude and not miracles.”*

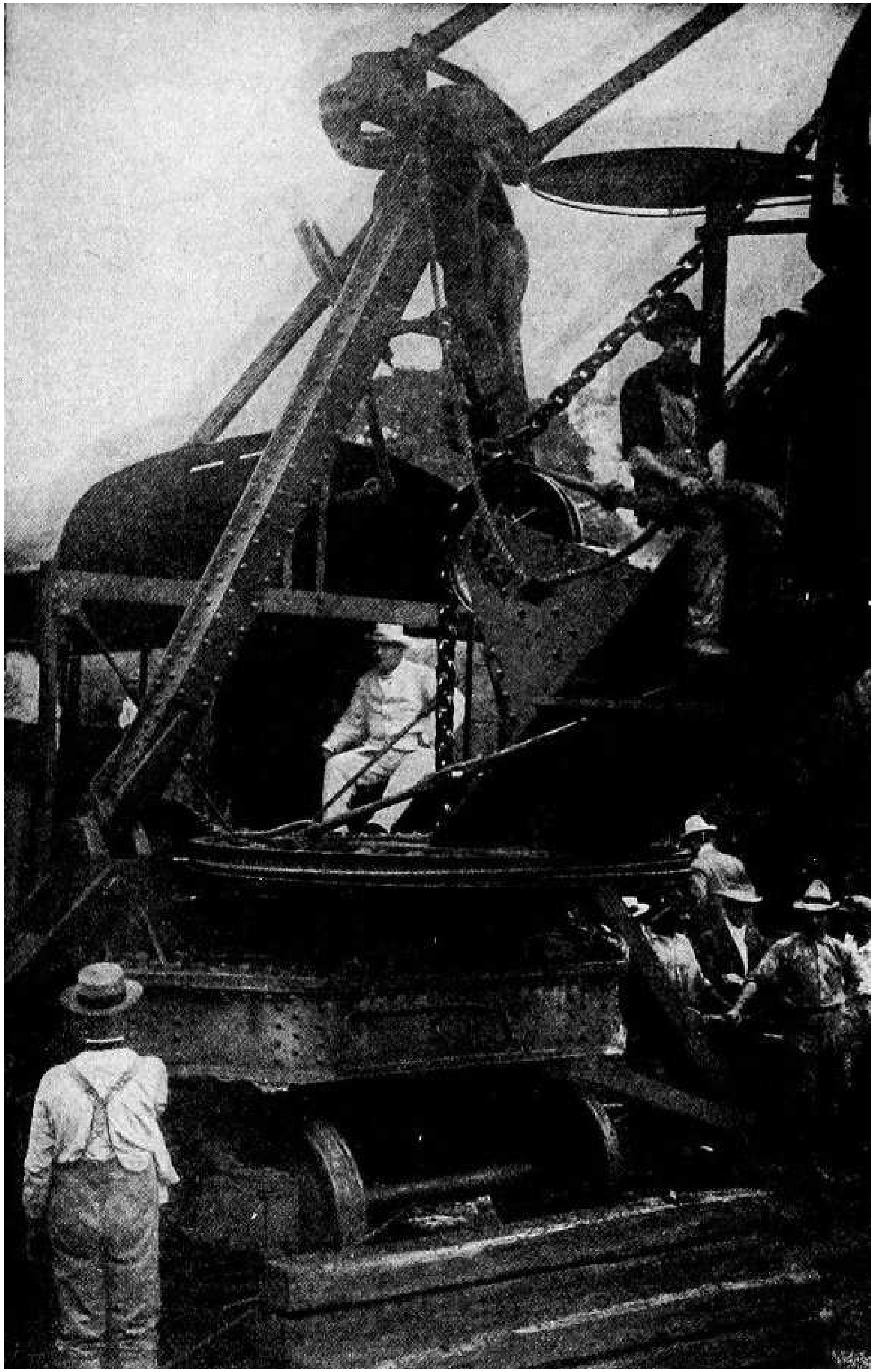

JOHN F. STEVENS
5
CENTS
CANAL ZONE
POSTAGE
5
CENTS

The Grand Army of Panama

"…whoever you are, if you are doing your duty, the balance of the country is placed under obligation to you, just as it is to a soldier in a great war. The man who does his duty, no matter in what position he may be placed, is the man for the job. But to do your duty you must do a little more than just earn your salary. As I have looked at you and seen you work, seen what you have done and are doing, I have felt just exactly as I would feel to see the big men of our country carrying on a great war…you here who are doing your work well in bringing to completion this great enterprise, are standing exactly as a soldier of the few great wars of the world's history. This is one of the great works of the world. It is a greater work than you yourselves at the moment realize…In the Grand Army the spirit what appeals to me is the spirit of fellowship, of comradeship. If a man was a lieutenant general of the army or if he was the last recruit, the youngest recruit whose age would permit him to serve in the ranks, it makes no difference. If he did his duty well, he is a comrade, and recognized in every Grand Army post. And so it should be with you, whether you be chief engineer, superintendent, foreman, steam shovel man, machinist, clerk – this spirit of comradeship should prevail."

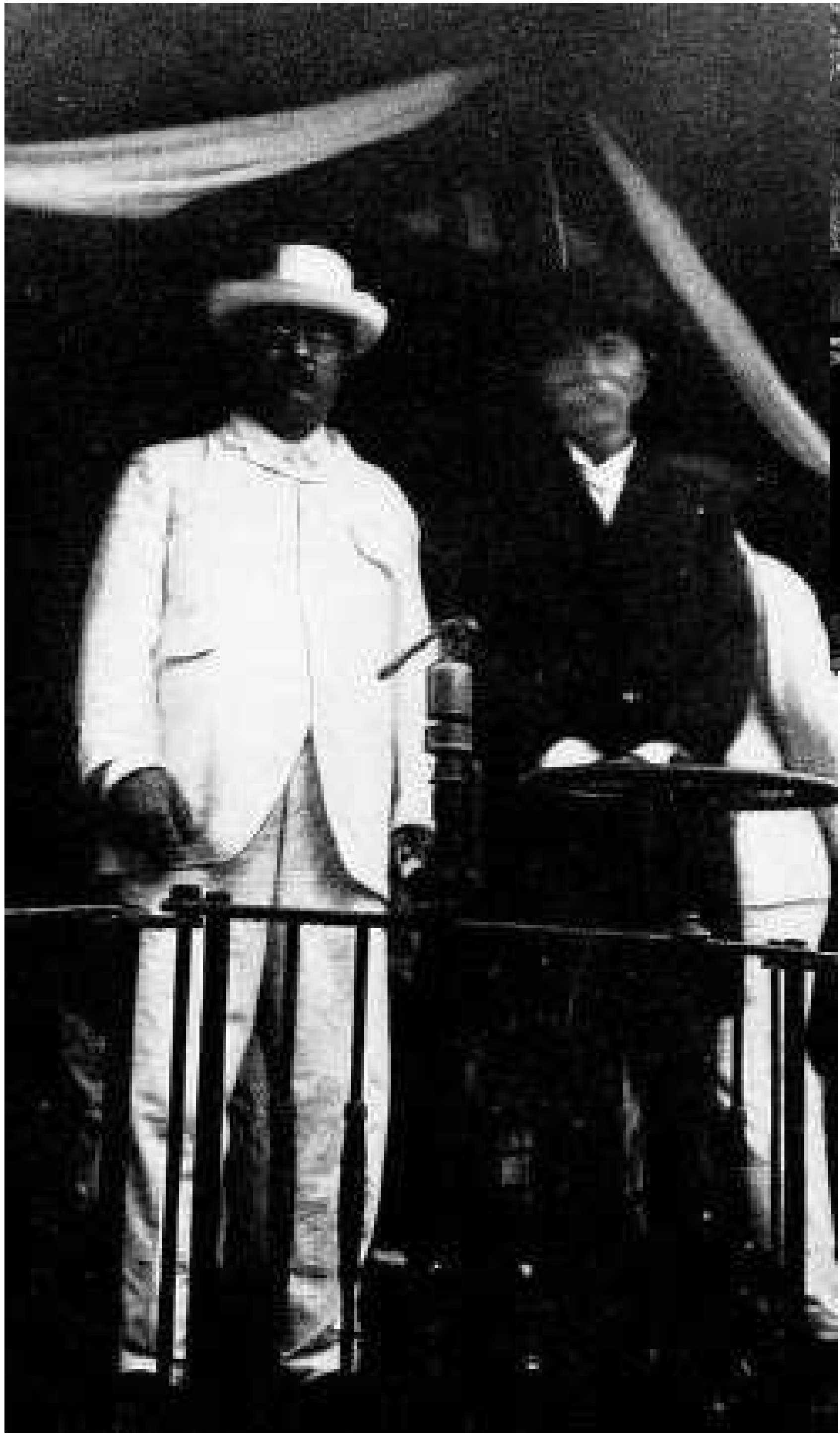
Theodore Roosevelt

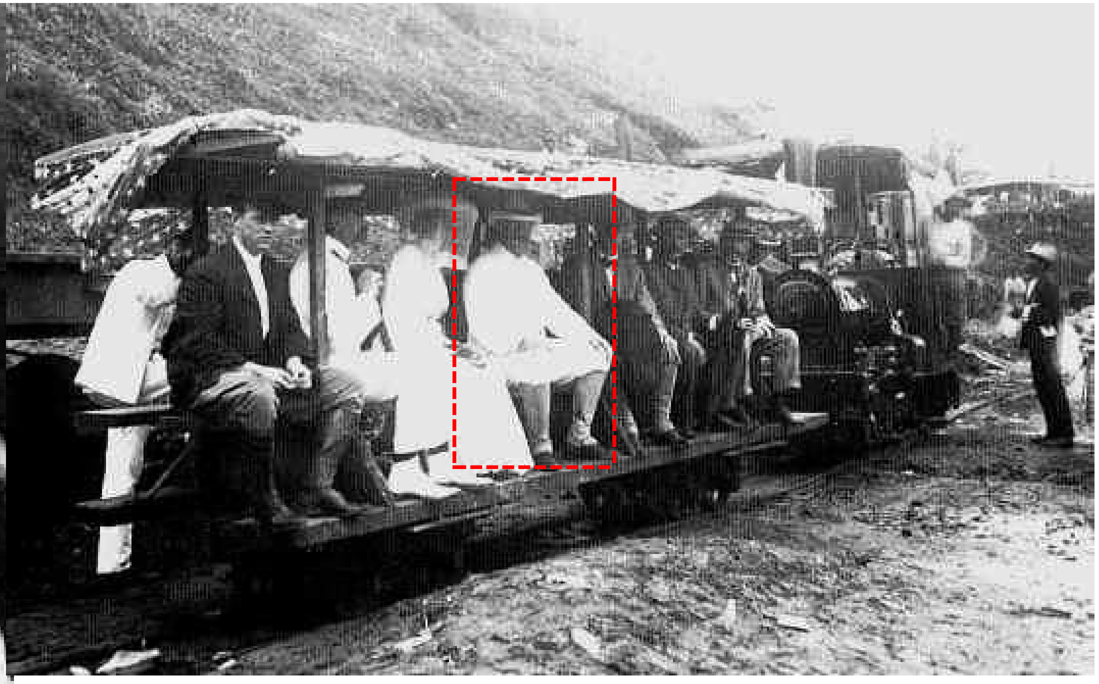
RE: the first POTUS to leave the continental *United States* while in office, TR made a trip to *Panama* in November 1906 to see for himself how things were going. At the end of his last day there, he made an impromptu speech (excerpts above).



With the canal project begun and going well, President Roosevelt's feelings about the *Panama Canal* underwent a catharsis. At first, he viewed it as a political, commercial and military necessity, but now he could afford to allow himself to be inspired by the "romance" of the monumental project engendered by its dramatic challenges of engineering design and geography. Roosevelt now spoke of building the canal as a mighty battle involving the national honor.

<u>Left</u>: caption: "President Roosevelt on a Giant Steam Shovel. During his visit to the Isthmus, while President, Mr. Roosevelt dispensed with ceremony, went among the men, talking and eating with them. In this way he obtained a very intimate knowledge of the great enterprise. His visit marked the first occasion upon which a President of the United States left the country during his term of office."





Roosevelt felt that Stevens, by his resignation, had betrayed the fundamental precepts of such a great and noble enterprise by viewing it as just a job and not putting into it the commitment of heart and spirit that Roosevelt felt it deserved (he failed to mention Stevens in the canal section of his autobiography). He also determined that he wouldn't make the same mistake twice, and appointed as Stevens' replacement an Army man; a member of the *U.S. Army Corps of Engineers*, who would be required to stay on the job as long as his president and Commander-in-Chief wanted him there. The next chief engineer was Lieutenant Colonel *George Washington Goethals* (later promoted to full Colonel in December 1909 and to Major General on March 4th 1914).

Above: TR on tour in Panama

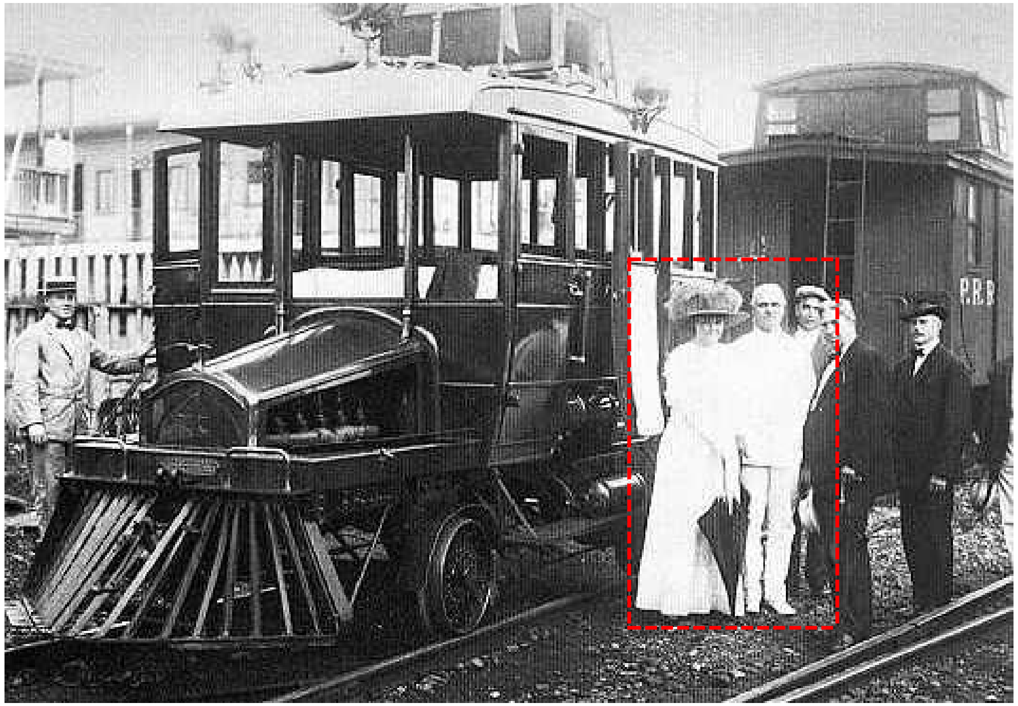
Left: caption: "The Two Presidents; Roosevelt and Amador"

Let Us Try, Let Us Dare, Let Us Do

"I am no longer a commander in the United States Army. I now consider that I am commanding the Army of Panama, and that the enemy we are going to combat is the Culebra Cut and the locks and dams at both ends of the Canal, and any man here on the work who does his duty will never have any cause to complain of militarism."

George Washington Goethals

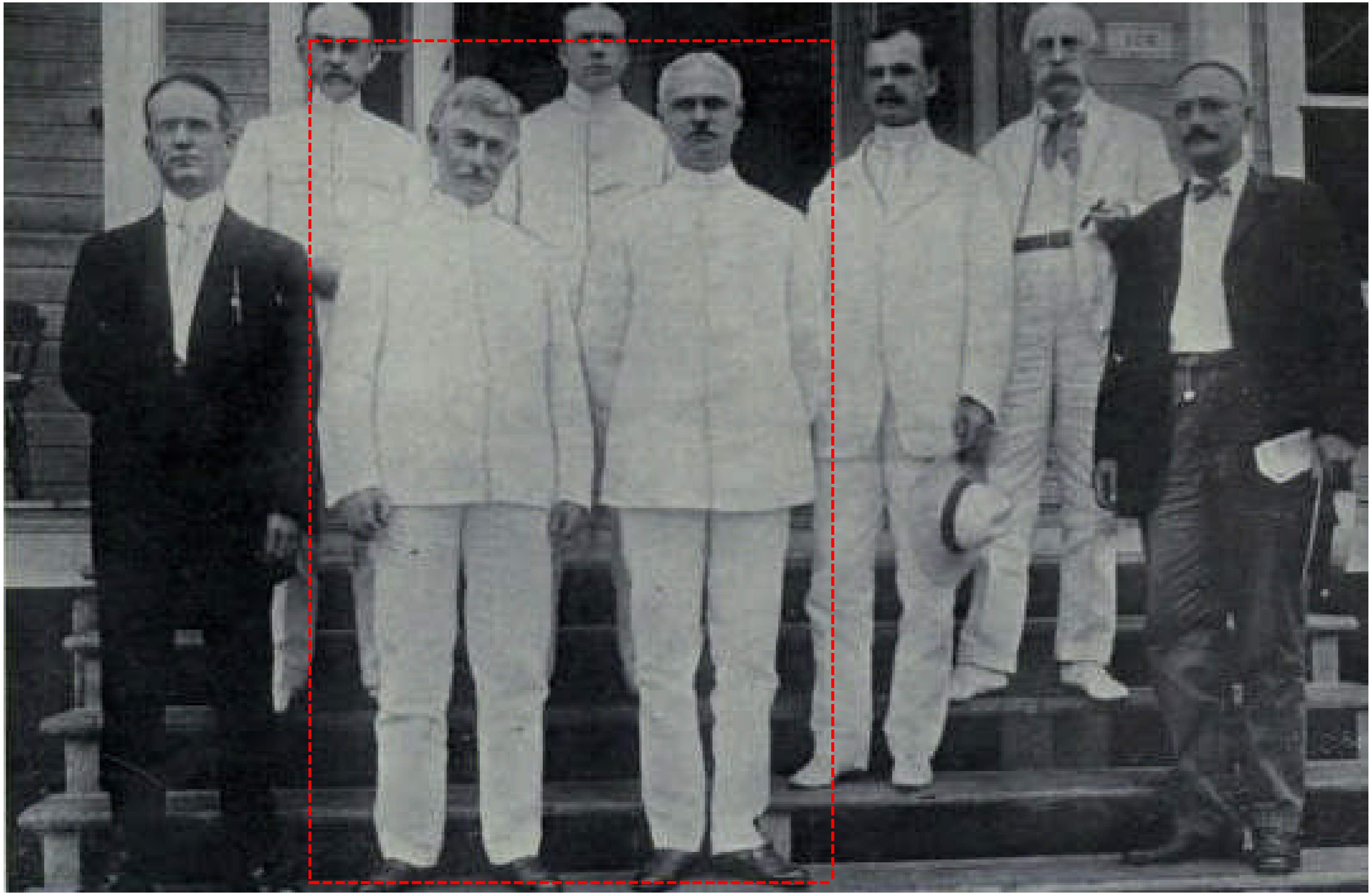
RE: aloof and straight-laced in manner and appearance, Goethals was highly respected for his honesty and fairness and was considered an excellent administrator by his admirers. He quickly put to rest the fears of those who thought they would be working under a military regime.



In addition to serving as chief engineer, Goethals also was named chairman of the *Isthmian Canal Commission* and president of the *Panama Railroad Company* and its subsidiary steamship line, giving him much more power and responsibility than wielded by previous chief engineers. He was responsible only to the *Secretary of War* and the President. Such power couldn't have been entrusted to anyone who could have handled it better than did Goethals, who seemed never to let it go to his head.

<u>Above</u>: Goethals and his wife

<u>Left</u>: "The Two Shovels" - cover of *Scientific American* magazine, Nov. 9th 1912

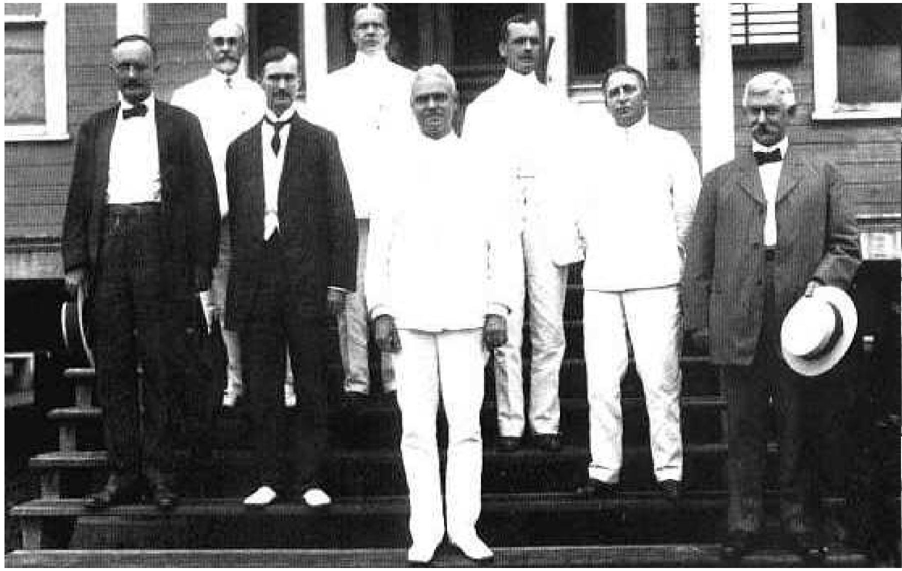
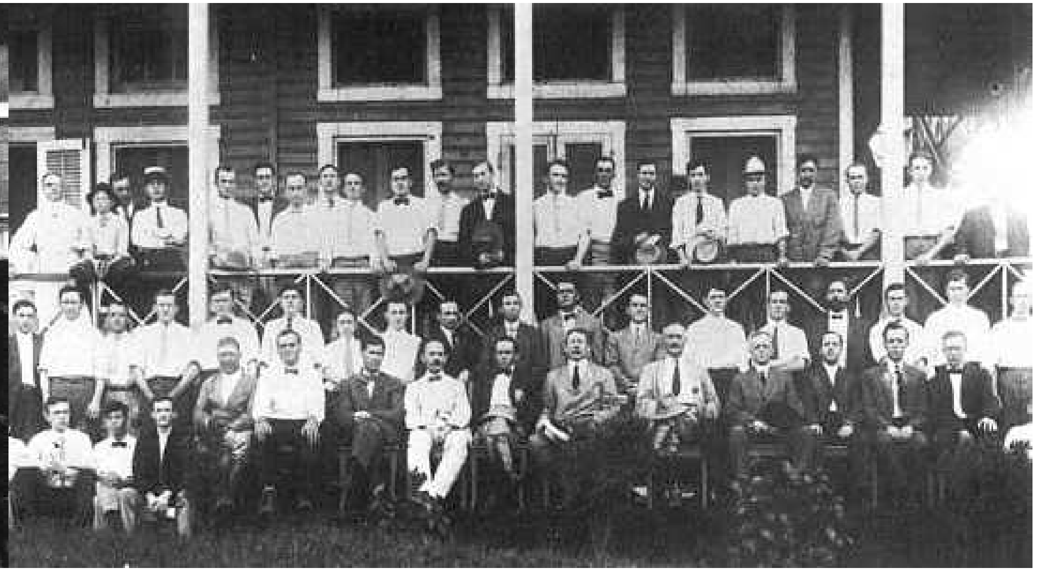


<u>Above</u>: caption: "These are members of the Canal Commission. Colonel Goethals and Colonel Gorgas, the Chairman and the Commissioner of Sanitation, stand on the lowest step, dressed in white.

"Of all questions of contemporary interest, the canal enterprise is the one which offers to the press of the United States the most legitimate opportunity for national glorification. Yet for years its management has been a conspicuous object 'on the other side' of violent abuse or systematic silence…No undertaking of such magnitude as the Panama Canal can be conducted without the commission of errors; and that these, when discovered, should be frankly admitted has long been an accepted principle of the officials responsible for the work. For their sake, and in justice to the Washington administration, it should be recognized abroad, if not at home – owing to the exigencies of political partisanship – that few American enterprises have been more conspicuous for freedom from 'graft'…much of the success which has attended recent work in Panama may be attributed directly to the operations of the pioneer canal builders…"

***The Engineer*, 1911**

RE: editorial comments from a leading British engineering journal

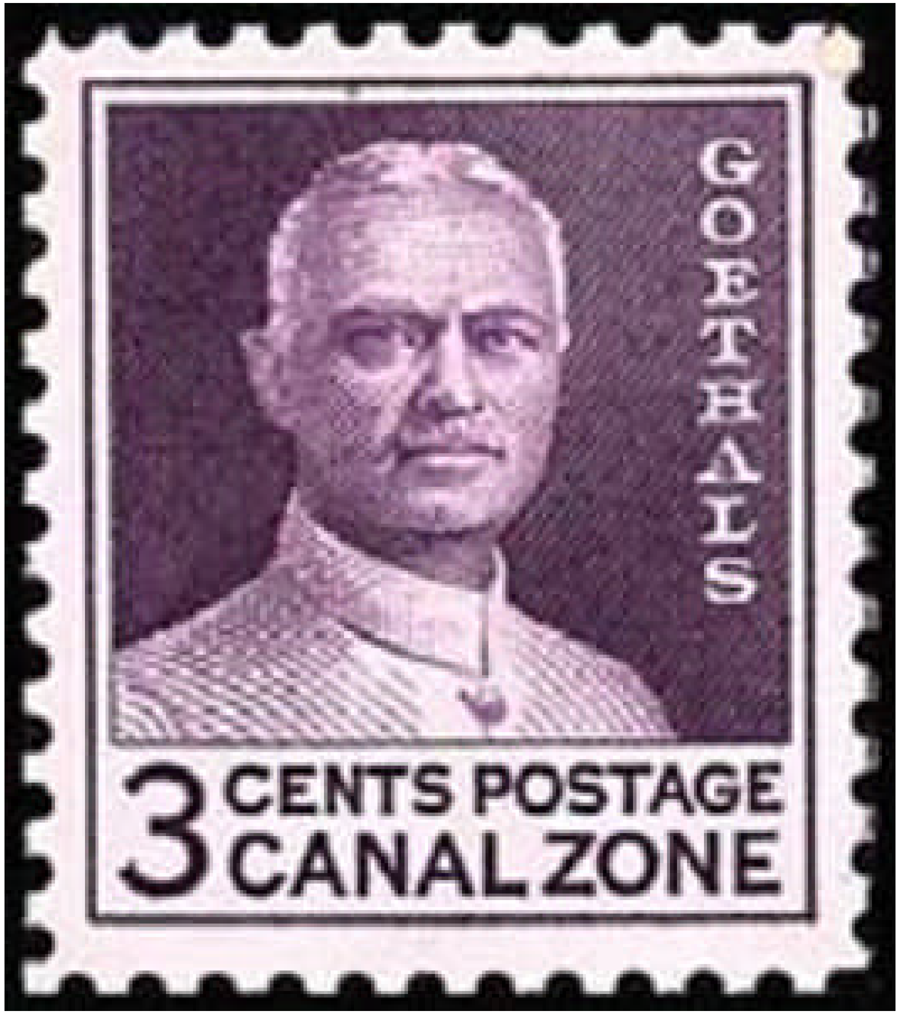
Goethals was well qualified for his post, having graduated second in his class at *West Point* and having had previous experience with locks and dams. Most of his immediate professional subordinates were also military men, including Lieutenant Colonel *Harry F. Hodges*, Major *William L. Sibert*, Major *David DuBose Gaillard* and Rear Admiral *Harry Harwood Rousseau*. Hodges was in charge of the design and erection of the lock gates. Sibert was head of the *Atlantic Division*, which comprised *Gatun Dam* and *Locks*. Gaillard was in charge of the *Central Division*, which included all of *Gatun Lake* and the *Culebra Cut*. *Sydney B. Williamson*, in charge of the *Pacific Division* (from the southern end of Culebra Cut to deep water in the *Pacific*), was the only civilian engineer on this high level team. He was responsible for the construction of *Pedro Miguel* and *Miraflores Locks* with their auxiliary dams. The only naval member of the commission, Rousseau was in charge of the design and construction of all terminals, wharves, coaling stations, dry docks, machine shops, warehouses and other auxiliary structures.

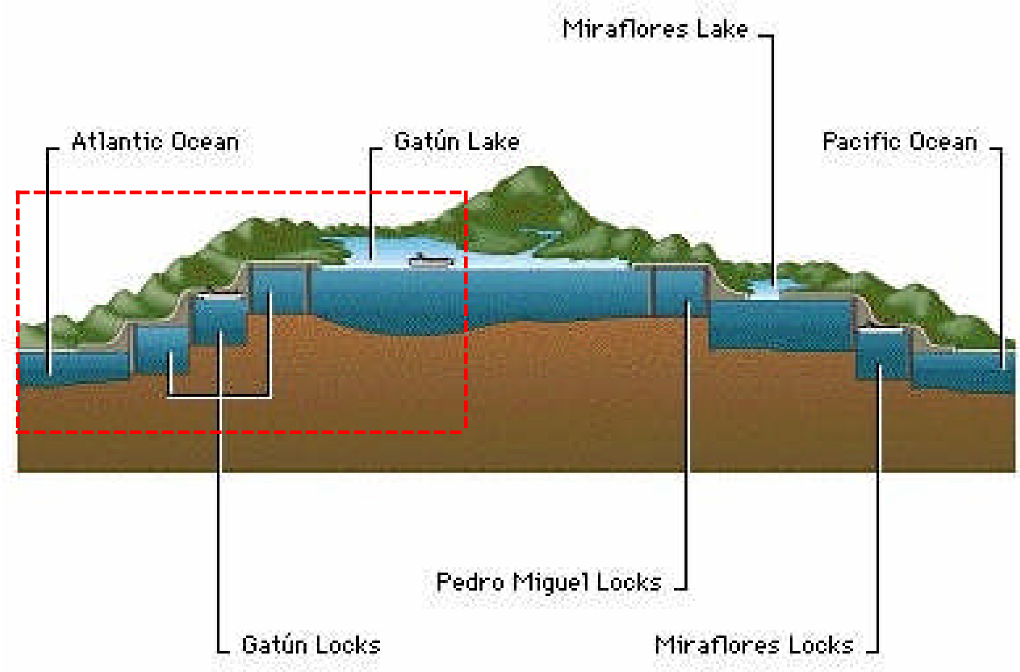
<u>Above</u>: Gothals and his staff (left) / American engineering staff of the *Panama Canal* (right)

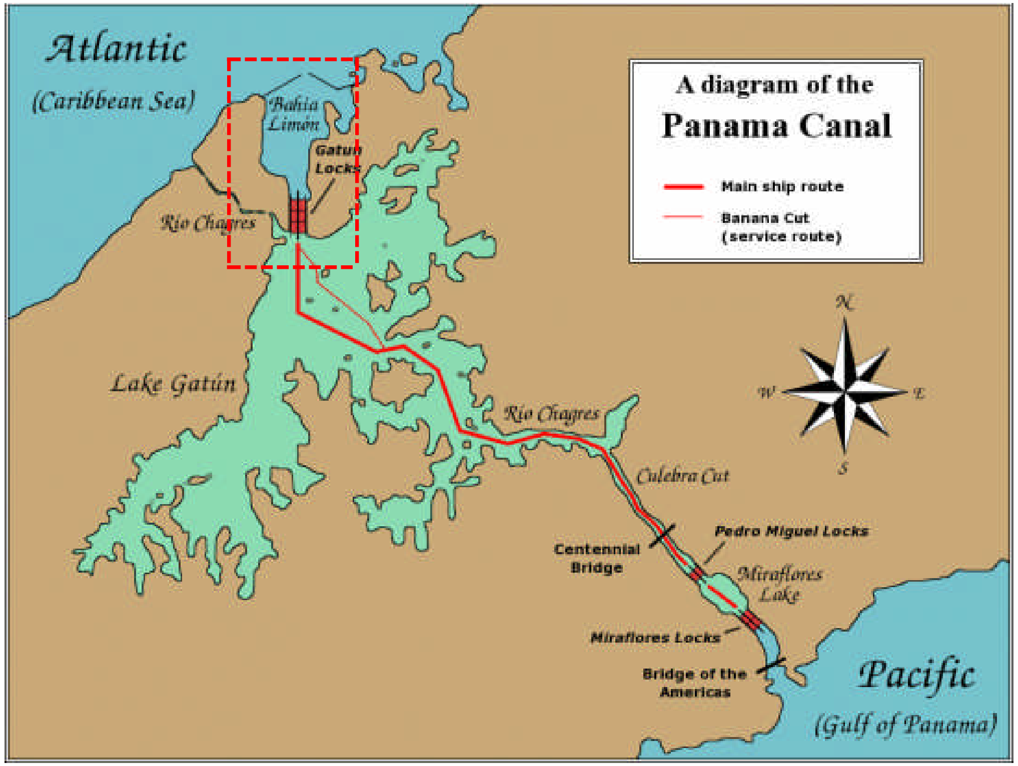
Not Even a Whisper

"…The problems involved have called into play all the resources of modern science, and the result has justified the confidence of the American people in the engineering and administrative skill of the Army Engineer Corps. The operations of the French company were attended by extravagance and corruption to an extent probably un-paralled in the world's history. Efficiency and economy have marked the work under American control, and there has not been even a whisper of improper influences or corruption of any sort…"

***Popular Mechanics,* December 1913**

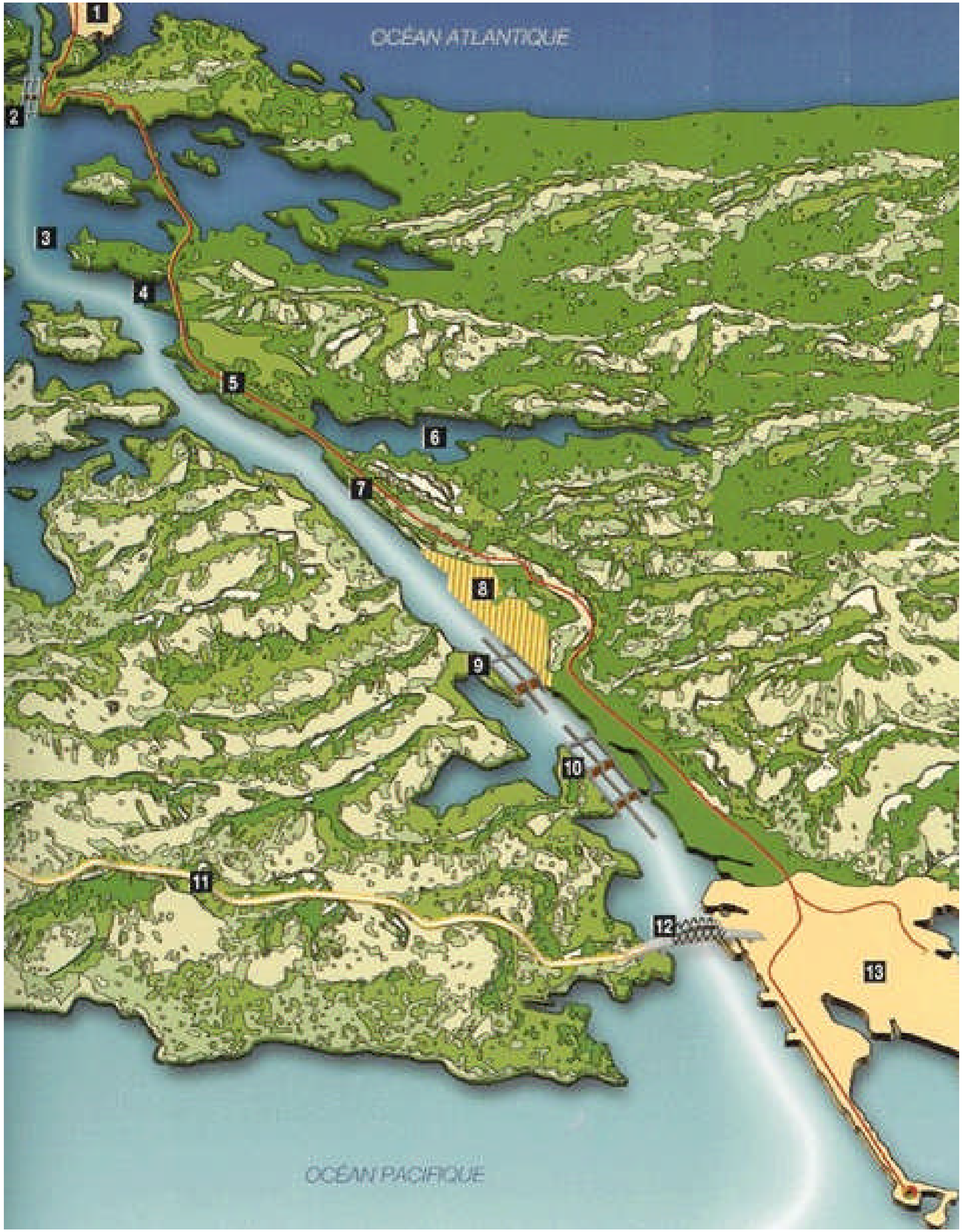

GOETHALS
3 CENTS POSTAGE
CANAL ZONE





"…The canal itself, from deep water to deep water, is 50 miles long. Its general direction from the Atlantic entrance to the Pacific end is from northwest to southeast, the northern terminal being about 22.5 miles farther west than the southern entrance from the Pacific. The first seven miles of the canal, beginning at the Atlantic end, are at sea-level. Five miles of channel, 500 ft. wide, have been dredged to a depth of 41 ft. directly south through Limon Bay, and two miles of this sea-level section has been cut through low-lying land to the entrance to the Gatun Locks, where the ships are raised, in three steps, to a height of 85 ft. above sea level, into the great body of fresh water called Gatun Lake. This lake was formerly the valley through which the Chagres River flowed into the sea…"

***Popular Mechanics*, December 1913**



Colon **(1) is a seaport on the *Caribbean Sea* coast of *Panama*. Colon overlooks the *Bay of Limon* which serves as the *Atlantic* entrance to the *Panama Canal*. At the back of the bay lies the *Gatun Locks* (2) which link the Bay of Limon to *Lake Gatun* (3). Once a ship reaches Lake Gatun, it travels for 15-miles down a channel that was once the *Rio Chagres* (before the lake was created). Bohio (4) is considered the end of Lake Gatun and the start of Rio Chagres. The upper part of the *Chagres River* (5) merges with the canal at a town known as *Gamboa* (6). The *Obispo River*(7) was once a short river that served as a tributary of the Rio Chagres. The Obispo was dredged out and used to connect Gamboa to the *Culebra Cut* (8). The ship reaches the end of its journey 85-feet above sea-level at a place known as the *Pedro Miguel Locks* (9). These locks connect the Culebra Cut to *Miraflores Lake.* The Pedro Miguel Locks lower the ship 31-feet down to Miraflores Lake. One mile later, they reach the *Miraflores Locks* (10). At this point, the ship is lowered again through the Miraflores Locks to sea-level. The ship passes under the *Bridge of the Americas* (12) at *Panama City* (13).**

Distance Chart

The following description assumes entrance from the *Atlantic* side of the canal (reverse if entering from the *Pacific* side).

- ***Limón Bay* (*Bahía Limón*), a huge natural harbor on the Atlantic side, provides anchorage for ships awaiting passage. It runs 5.4 miles from the outer breakwater to the Gatún Locks. An extra 2 mile channel forms the approach to the locks from the Atlantic side.**

Total: 7.4 miles

- **The *Gatún Locks*, a 3-stage flight of locks 1.2 miles long, serve to raise ships from sea level up to the level of *Lake Gatún* or lower ships coming from the Pacific direction.**

Total: 8.6 miles

- **Lake Gatún, an artificial lake formed by the building of the nearby *Gatun Dam*, carries vessels 15 miles across the isthmus using much the same channel originally created by the *Rio Chagres*.**

Total: 23.6 miles

- **The *Chagres River* (Río Chagres), a natural waterway enhanced by the damming of Lake Gatún, runs east-west 5.3 miles between the *Culebra Cut* and Lake Gatun.**

Total: 28.9 miles

- **The Culebra Cut (aka *Gaillard Cut*) slices 7.8 miles through the *Continental Divide* at an altitude of 85-feet and passes under the *Centennial Bridge* just before reaching the *Pedro Miguel Lock*.**

Total: 36.7 miles

- **The single-stage Pedro Miguel Lock is 0.9 miles long. It is the first part of the descent (or ascent) to the level of the Pacific Ocean. This lock has a drop of 31- feet. It takes a ship from 85-feet level down to the level of *Miraflores Lake*.**

Total: 45.6 miles

- **The artificial Miraflores Lake is the next stage. Resting at an elevation of 54-feet above sea level, it is 1.1 miles long.**

Total: 46.7 miles

- **The two-stage *Miraflores Lock* system, including the approach wall, is 1.1 miles long. Each stage raises or lowers a ship 27-feet. So the combination adds up to a total lift or drop of 54-feet at mid-tide.**

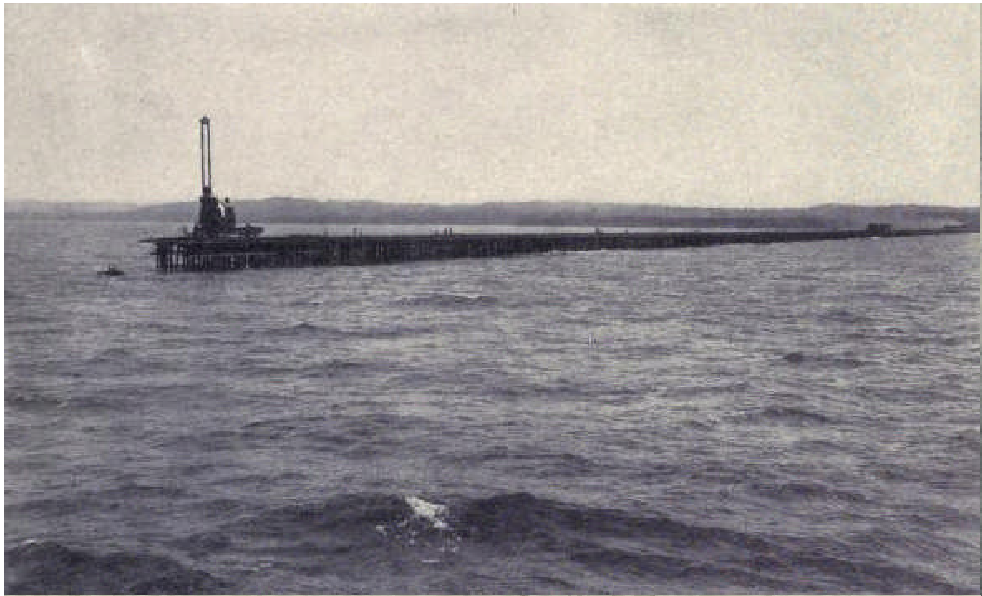
Total: 47.8 miles

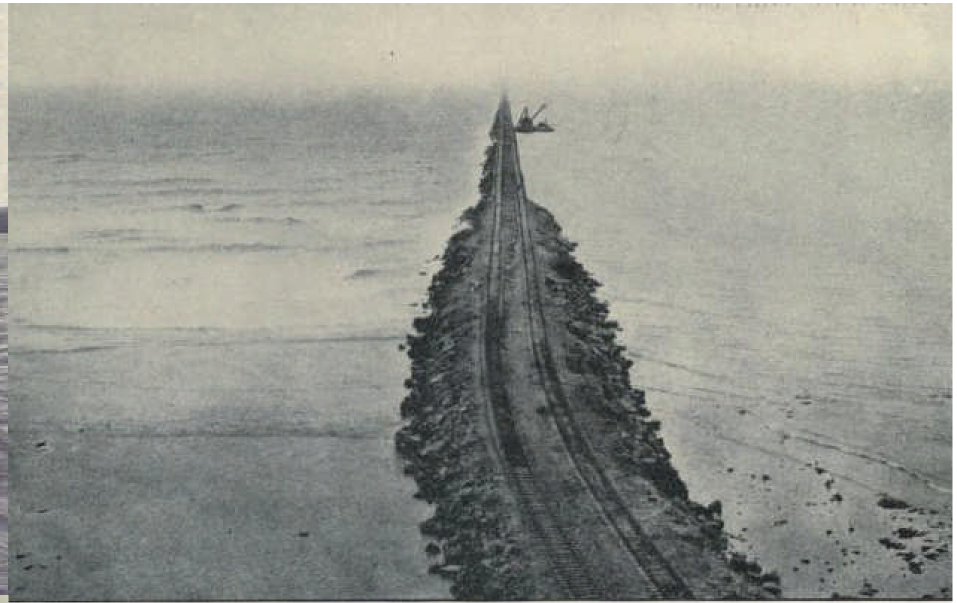
- **From the Miraflores locks, ships travel at sea level 8.2 miles down a channel to the *Gulf of Panama* on the Pacific side, passing under the *Bridge of the Americas* in the process.**

Total: 56 miles

"…The first evidence of American work at Panama will present itself, as we enter Colon Harbor, in the form of a massive breakwater, over two miles in length, which extends from Toro Point at the Westerly side of Limon Bay. Rounding the breakwater, which by the way, has been built to protect shipping in the bay against the heavy northeasters, we shall enter a channel, 500 feet in width and 41 feet deep, which has been dredged from deep water to the shore line, a distance of about four and one half miles…"

Scientific American Supplement, **November 23rd 1912**

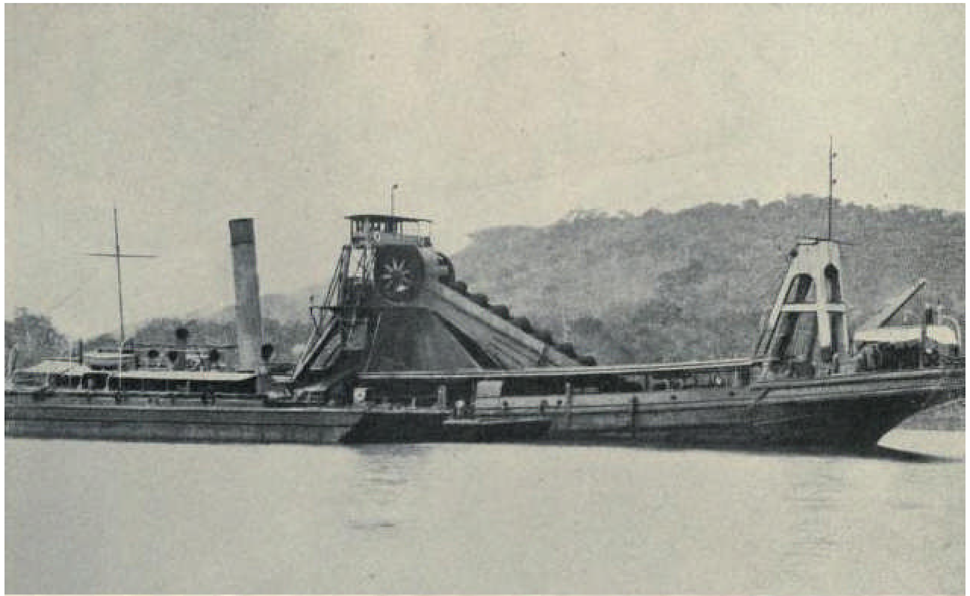




<u>Top Left</u>: caption: "Toro Point Breakwater, from the sea. One mile of trestle completed"

<u>Top Right</u>: caption: "West Breakwater, looking seaward from Toro Point. Showing dredge at work on face of breakwater, June 1912"

<u>Left</u>: caption: "Toro Point Breakwater. Looking toward water end, July 1912"

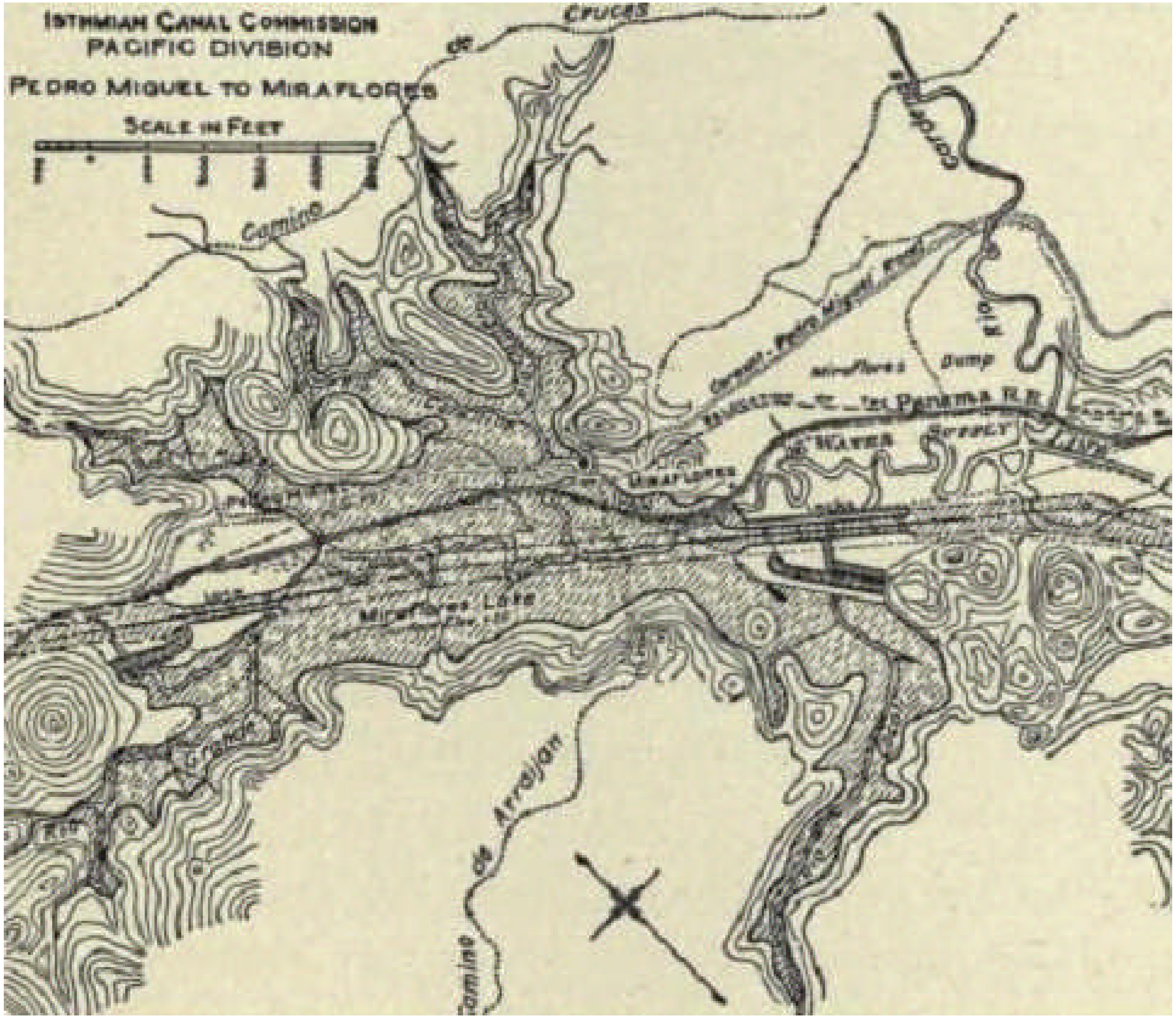


"…Leaving Colon on the left, our ship will steam a straight course through a comparatively low-lying land from the shore to the entrance of the Canal Locks at Gatun. This section of the canal will be also 500 feet in width and 41 feet deep, and here we pass through the slight divide, known as the Mindi Hills, on the farther side of which is the valley of the Chagres River…"

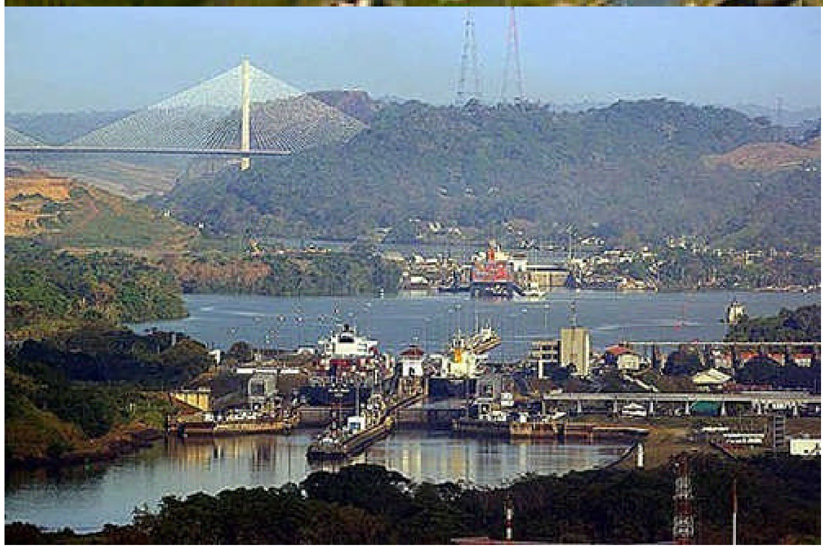
Scientific American Supplement, November 23rd 1912

<u>Top</u>: caption: "Dredge 'Corozal' in channel near station 2210 of the canal operations, June 1912"

<u>Bottom</u>: caption: "Atlantic entrance to the Panama Canal, looking south toward Gatun, showing completed section of Main Channel 500 feet wide"



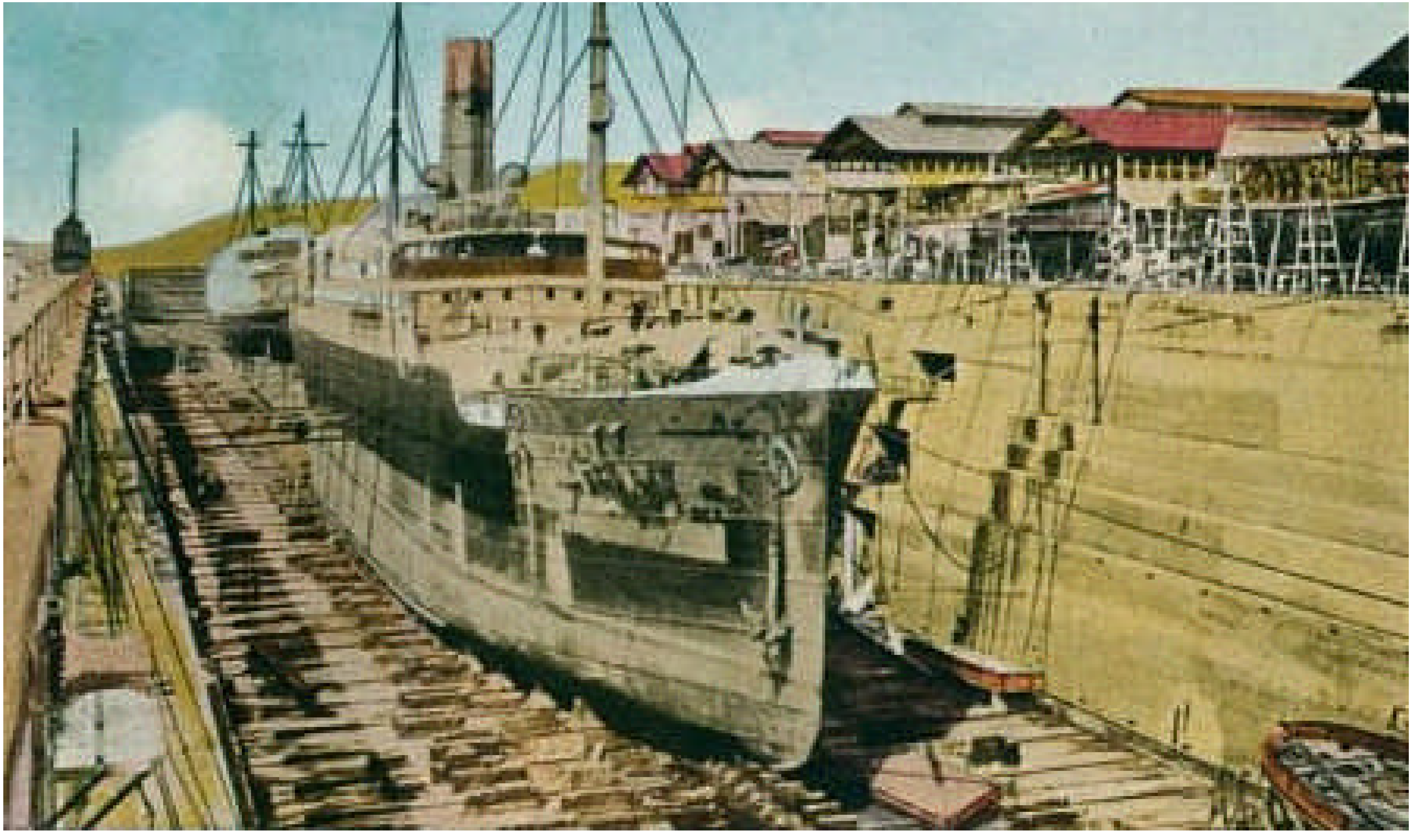
<u>Above</u>: map of the *Pacific Division* of the *Panama Canal* - *Pedro Miguel* to *Miraflores*



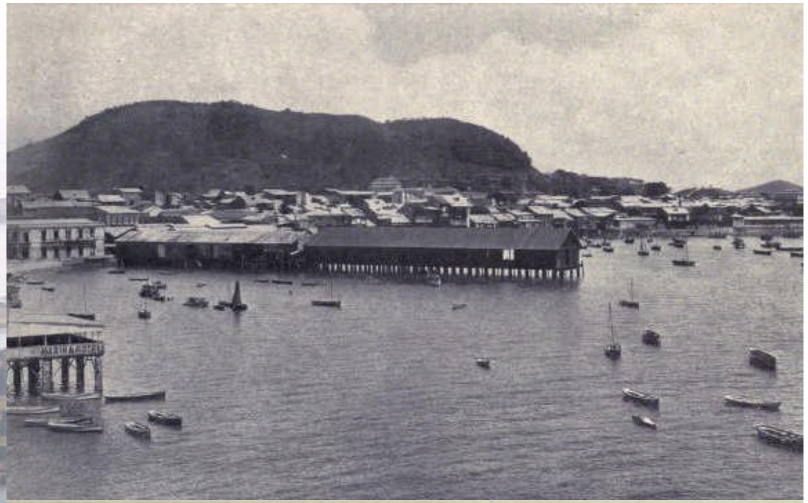
<u>**Above & Left**</u>**:** ***Pedro Miguel Locks*** **(foreground) and** ***Centennial Bridge*** **(beyond)**

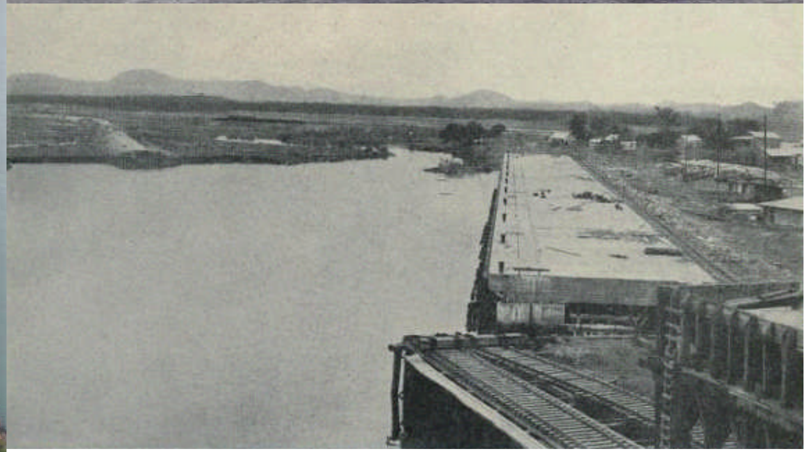
“In contemplating the great engineering problem being solved in the construction of the Panama Canal, the people of the United States have almost forgotten that the plans for the big ‘ditch’ also provide for the largest and most completely equipped harbor and dock system in the world, to be located at the Pacific end of the canal. A strip of land along the water front two miles in length has been reserved for the docks, and while but two-thirds of this will be immediately approved, the improvements thus provided for embrace construction work that will give the turning basin alone an area of 271 acres. There will be a series of piers on either side of the canal entrance, each of which will be 1,000 ft. long. The width of the canal between the pier ends will be 3,000 ft…It now requires 21 days to carry a car load of freight across the continent by rail from the shipper in California to his agent in New York. With the use of 16-knot steamers from San Francisco to Panama and trans-shipping at Panama for New York, the freight schedule between the two cities can be reduced to 14 days…”

***Popular Mechanics,* October 1911**

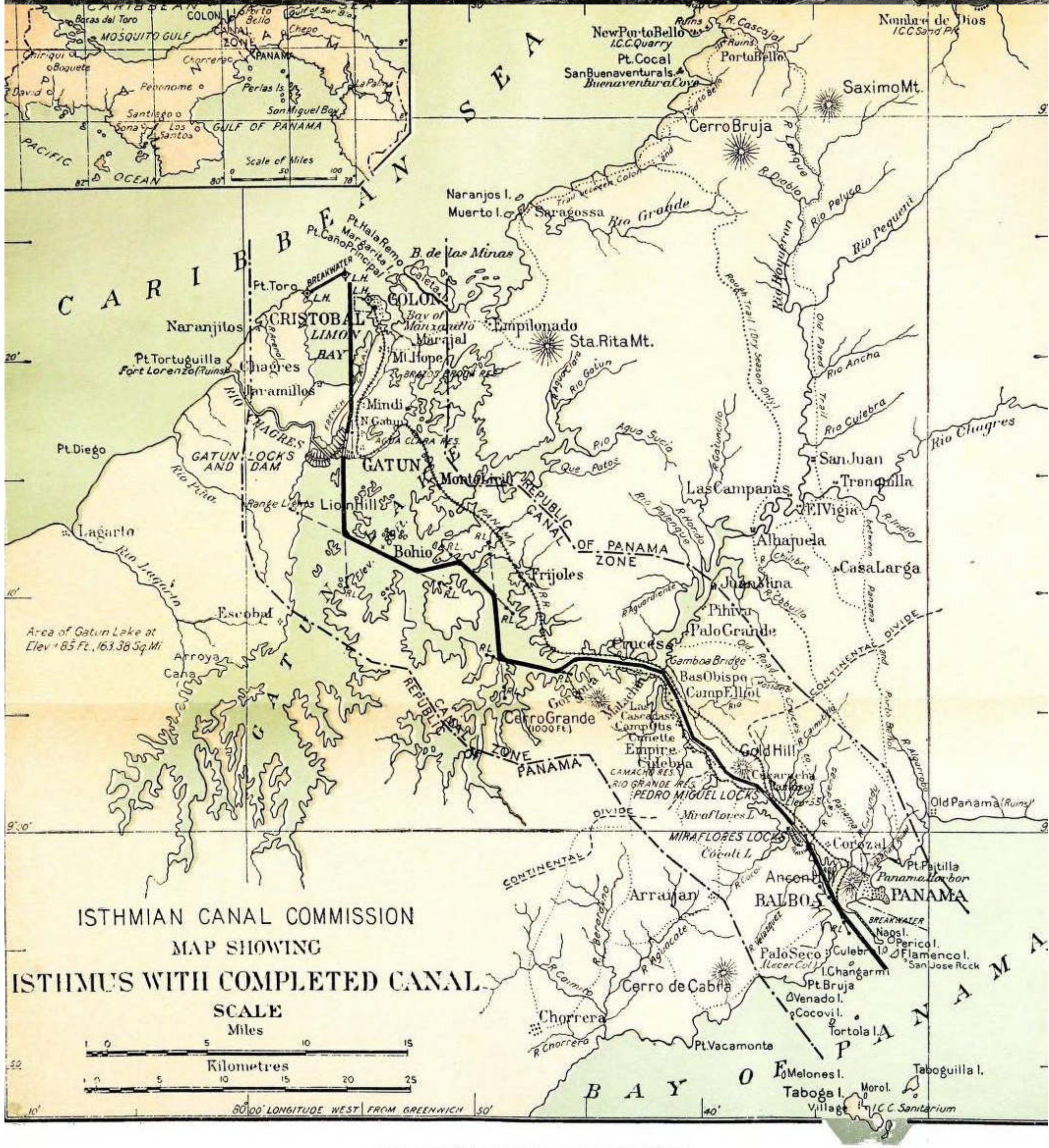


<u>Above</u>: (postcard) caption: "Pacific Terminal Dry Docks, showing two large steamers being repaired"





<u>Above Top</u>: caption: "General view of Panama Bay and Ancon Hill"
<u>Above Bottom</u>: caption: "Balboa – Lumber Dock of reinforced concrete, looking northeast. June 1912. This Pacific Port at the southwestern end of the Canal will benefit largely from its construction."
<u>Left</u>: *Bridge of the Americas* over the canal at *Panama City*

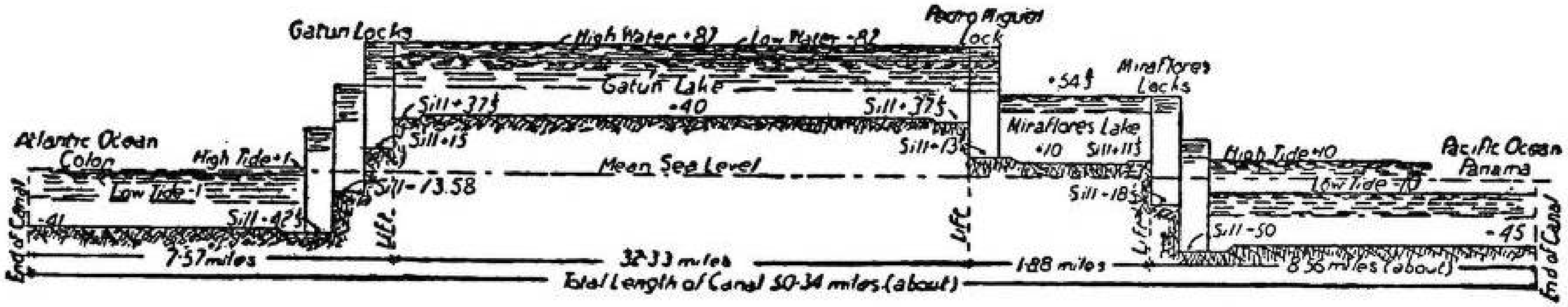


THE ISTHMUS WITH COMPLETED CANAL.

Above: caption: "Bird's-eye view of Panama City from Ancon Hill, 1913"

Left: caption: "The Isthmus with Completed Canal. The dotted lines show the boundary known as the Canal Zone, a strip ten miles wide, from deep water in the Atlantic to deep water in the Pacific, and extending five miles on each side of the center line of the Canal, which was purchased by the United States from the Republic of Panama. The heavy line shows the Canal, and the crossed line just above it the relocated Panama Railroad. The cities of Colon and Panama, though included in the limits of the Zone, are reserved to the Republic of Panama. The sanitation of these cities is however, under the control of the United States."

<u>Above</u>: modern-day *Panama City* with its skyscraper skyline



Major design changes were made as work progressed. For example, the bottom width of the canal channel in *Culebra Cut* was widened from 200 to 300-feet. At the request of the *U.S. Navy*, locks chambers were enlarged from 95 to 110-feet to accommodate vessels then on the drawing board. A chain of small *Pacific*-side islands (*Flamenco, Perico, Naos* and *Culebra*) were joined to create a three-mile-long breakwater across tidal flats to prevent silt from clogging the channel entrance. The discovery of poor foundation materials at the *Sosa Hill* site caused the two-step set of Pacific-side locks to be relocated farther north to *Miraflores*; the locations of other locks remained unchanged.

<u>Above</u>: caption: "Diagram Showing Lake Elevation"

Above: caption: “The Culebra Cut. Dazzling colors combined with its colossal proportions make this man-made gash in nature’s eternal hills a magnificent spectacle. Its fullest glory will soon be dimmed, for the tropic jungle will cover its brilliant hues with a robe of green”

Part 4

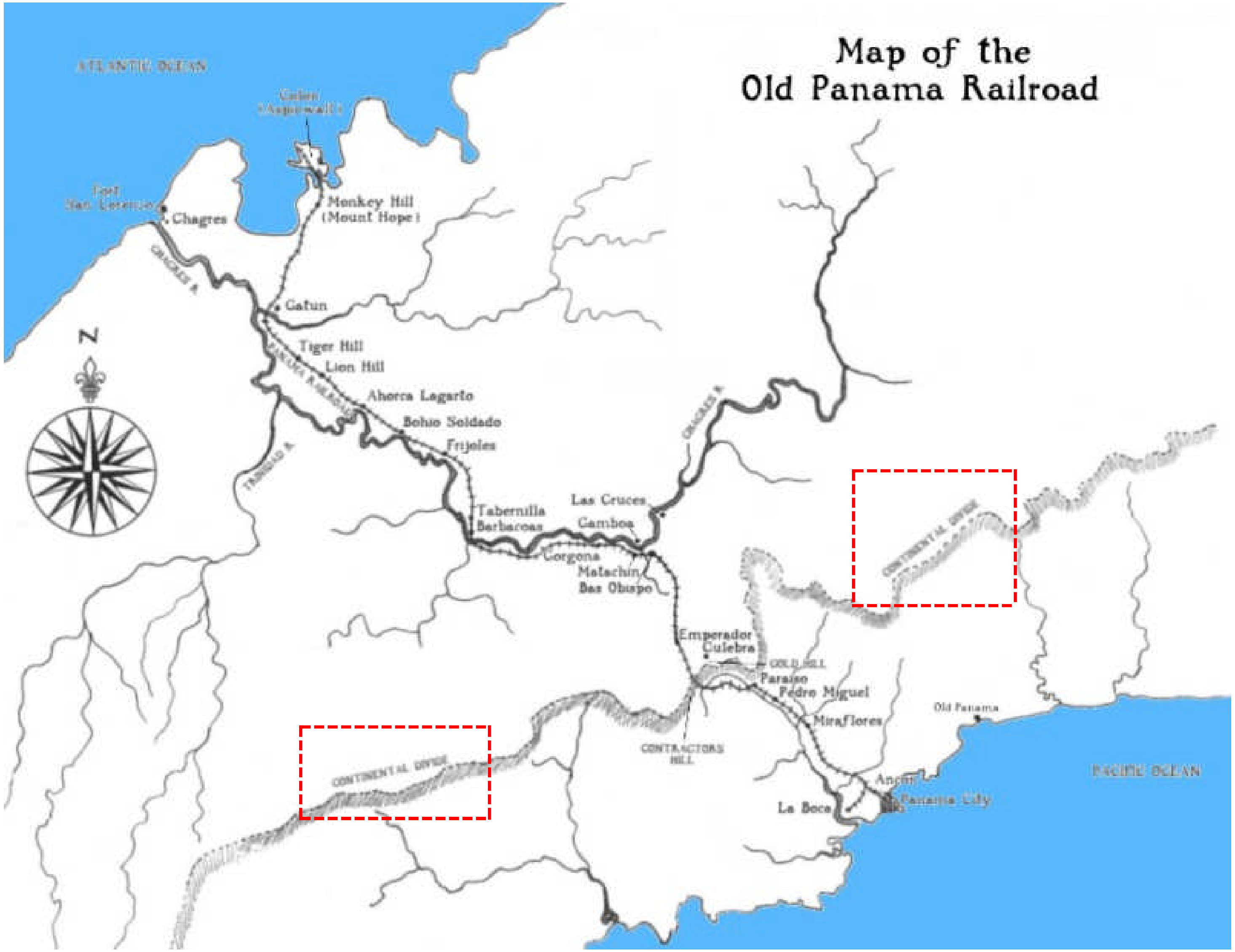
Gatun

Cordillera of the Americas

There is an enormous, unbroken mountain chain in the Americas that starts in *Alaska*, continues through *Canada* and the *United States* as the *Rocky Mountains*, on through *Central America* and then down through *South America* as the *Andes Mountains*. It is sometimes called the "Cordillera of the Americas," "cordillera" being the Spanish term for "Chain of Mountains."

The Rio Chagres

The *Chagres River* is the *Mississippi* of *Panama*. It's 120-miles long and serves as the main drainage route to the ocean for much of Panama's rainwater. The "Continental Divide" describes the mountainous highpoint that separates the water systems that drain into the *Pacific Ocean* from those river systems and/or into the *Atlantic Ocean* (including those that drain into the *Gulf of Mexico* and the *Caribbean Sea*). For example, In the continental *United States*, the majority of rivers head east due to the location of the *Rocky Mountains* in the west. The major exception is the *Colorado River*. Located on the western side of the Continental Divide, the Colorado River heads southwest towards the *Pacific Ocean* carving out the *Grand Canyon* along the way. Unlike the gigantic peaks of the Rockies and the Andes that deposit much of each year's rainfall into lakes and ponds, when it rains in Panama, very little rainwater is contained. Instead, the water is delivered almost instantly to the Chagres. Since practically every other major Panamanian river connects to the Chagres, the river would instantly turn into a raging torrent any time there was a storm. In the mountains of central Panama, the *Rio Chagres* and its tributaries receive from 100 to 200-inches of rainfall each year, a significant amount of precipitation. However, towards the end of its journey to the Caribbean, the Chagres slowed down as it flowed into a giant valley. This valley was a vast swampland that would periodically flood whenever there was a significant rain; the valley acting like a gigantic retention pond.

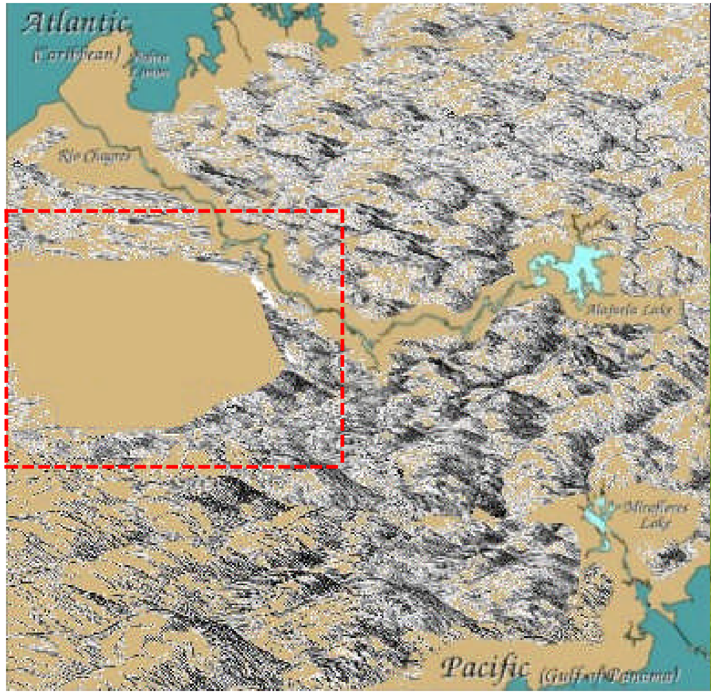

Map of the
Old Panama Railroad
ATLANTIC OCEAN
Colon
(Aspinwall)
Fort
San Lorenzo
Chagres
Monkey Hill
(Mount Hope)
Gatun
Tiger Hill
Lion Hill
Ahorca Lagarto
Bohio Soldado
Frijoles
Tabernilla
Barbacoas
Las Cruces
Gamboa
Gorgona
Matachin
Bas Obispo
Emperador
Culebra
GOLD HILL
Paraiso
Pedro Miguel
Miraflores
CONTRACTORS
HILL
CONTINENTAL DIVIDE
CONTINENTAL DIVIDE
Old Panama
La Boca
Ancon
Panama City
PACIFIC OCEAN
N

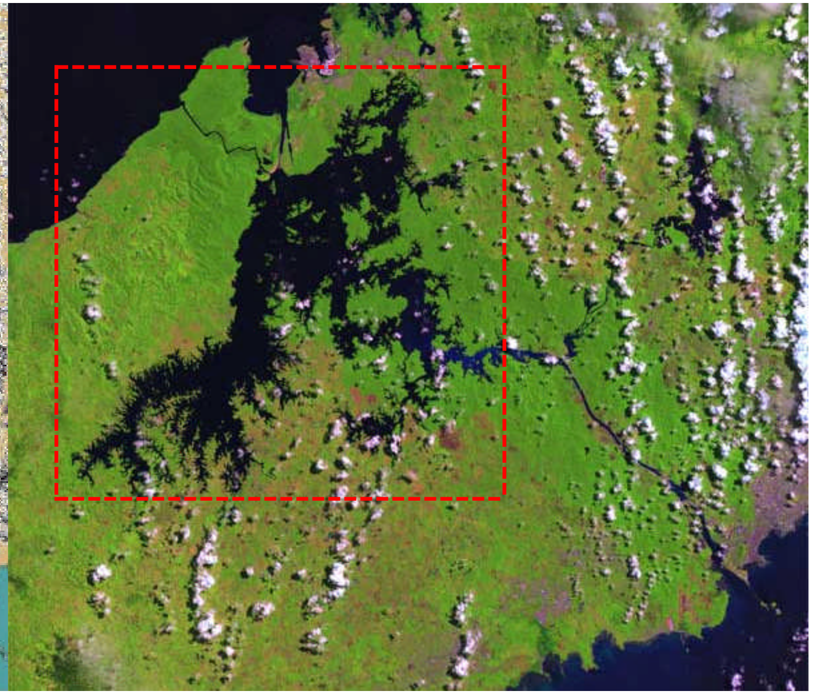

THE ISTHMUS OF PANAMÁ.
Route of Canal shown thus,
ATLANTIC OCEAN
PACIFIC OCEAN
Colon (Aspinwall)
Minas Bay
Saragossa
R. Grande
L. Manzanilla
Limon B.
Monkey Hill
Chágres
R. Chagres
R. Gatun
Altos de Algarroba
San Juan
Agua Sucia
Gatun
Tiger Hill
Lion Hill
Ahorca Lagarto
Bohio Soldado
Buena Vista
Bruja
Fryoles
La Campana
Altos de Maria Enrique
Rio Trinidad
PROPOSED PANAMA CANAL
San Pablo
Gorgona
Matachin
Obispo
Emperador
Culebra
Paraiso
Pedro Miguel
Rio Grande
Ruins of Old Panama
Tabernilla
Co. Gigante
R. Los Sales
Caña Quebrada
Corozal
Panamá
Bernardino
Chorrera
Pta. Bruja
Pta. Vaca de Monte
Taboga
Taboguilla
English Miles.
Kilometers.

"…The most difficult engineering problem that confronted the canal builders was the control of the flood waters of the Chagres River. The heavy tropical rains flow down the mountain sides and through the narrow valley with tremendous force and, in the space of 24 hours, the river has been known to rise more than 25 ft. To control the flood water the Gatun Dam was built. This is an artificial embankment of rock and earth, which holds the waters back to form Gatun Lake. The islands which appear on the lake were formerly the tops of hills that rose from the bottom of the Chagres Valley…"

Popular Mechanics, **December 1913**


The major river of *Panama* is the *Rio Chagres* which is much closer (twelve miles) to the *Pacific Ocean* than it is to the *Atlantic Ocean*. However, the Chagres is on the Atlantic-side of the *Continental Divide*. Like the *Amazon River,* it is forced to take the longer route to the Atlantic. The greatest difficulty of the Panama route was how to control the powerful *Chagres River* and its many tributaries. The Chagres' source was in the *San Blas Mountains* (part of a mountain chain that runs through *Central America* connecting the *Rocky Mountains* to the *Andes*) and drained a huge basin of 1,320 square miles; nearly half of Panama. The flooding of the upper Chagres was problematic however, the Chagres slowed considerably when it reached the vast low-lying *Chagres Valley*. The general elevation of the valley was barely above sea-level. That meant the Chagres River wasn't nearly deep enough to allow a ship to cross it. The only solution would be to dredge a deep channel into the *Rio Chagres* - the American engineers had a better idea; turn the entire valley into a deep lake. One of the major factors in Nicaragua's favor had been the presence of its massive *Lake Nicaragua* right in the middle of the proposed canal route. Panama had no lake comparable to *Lake Nicaragua*. However, rather than lower the Rio Chagres by digging and dredging, by damming the Chagres a huge low-lying valley would be transformed into an immense lake effectively raising the river 85-feet above sea-level. Then, the engineers proposed to dig out the ten-mile stretch of the Continental Divide between the bend in the Chagres at *Gamboa* (the river was about 42-feet above sea-level at its Gamboa bend) and connect it to *Miraflores Lake* on the other side of the Continental Divide. Fortunately, Panama has the lowest point on the mountain chain. Even so, the lowest point was still 360-feet above sea-level.





When engineers originally studied the topography of the *Isthmus of Panama*, they spotted an unusual depression in the land near the *Caribbean/Atlantic*-side. What created such an immense low spot in this mountainous country? The features of the valley were such that it didn't look like the *Chagres River* had created it. The area was much too wide and asymmetrical for that; there was none of the usual tapering of hills alongside the river. That led to speculation that the area may have been the remnants of a volcanic crater. However, the depression lacked many of the features commonly associated with volcanic craters. For one, volcanic craters are elevated; this depression was at sea-level. That led to another theory that the vast *Chagres Valley* might be an impact crater. In any event, it was apparent to everyone that the terrain was unusually well-suited for creating a reservoir. A line of hills on all sides of the valley formed a natural bowl making the Chagres Valley a natural drainage basin. Parts of the valley would flood whenever there was a heavy rainfall leading to the marshy conditions that made this area a giant swampland.

<u>Left</u>: caption: "Panama Before the Canal" (depression outlined)
<u>Right</u>: satellite view of *Gatun Lake* (outlined)

Above: ***Chagres River*** **entrance to the** ***Atlantic Ocean*** **(near** ***Fort San Lorenzo*****)**

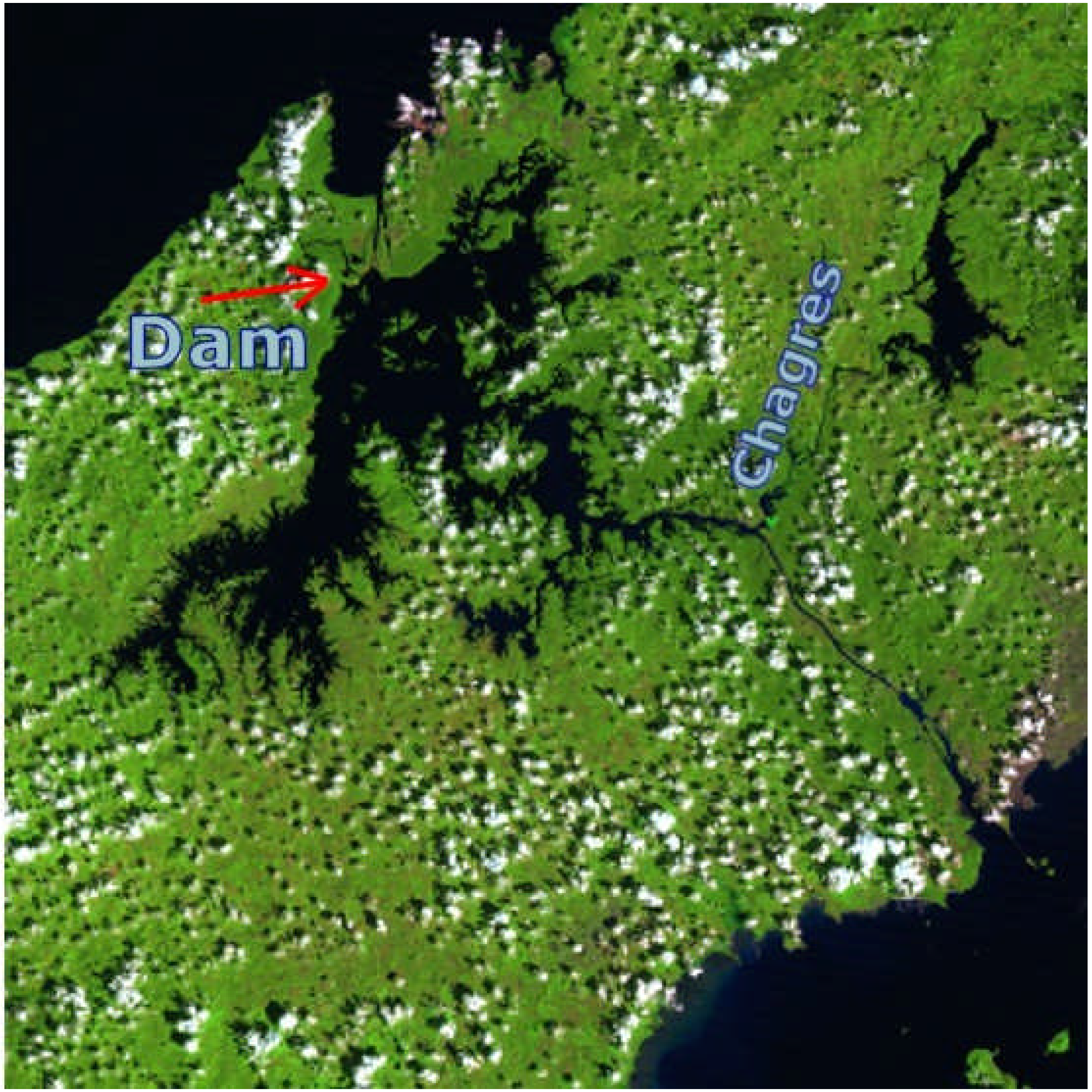
Then, the question the American engineers asked was: *why was there no natural lake?* The answer was that there was one large opening in the ring of hills around the depression. The *Rio Chagres* was nearly a mile-wide at the gap where it left the valley. No matter how hard it rained, the Chagres would drain the waters through that gap. The engineers realized that the tall hills bordering the valley of the Chagres meant there was no possible escape for any water if that gap could be plugged. If they could close that gap with a dam, the geography of the area would be ideal for the creation of a large lake, but a mile-wide gap is an unusually broad span for a dam. If the engineers wanted to make an earthen dam, they would need a huge amount of dirt. The excavation of the *Culebra Cut* would provide all the dirt required.

Left: bird's-eye view of Gatun Lake and the Chagres Valley

Gatun Dam

"…At this point the valley narrows down to a width of about a mile and a half and to our right we note the long straight skyline of the crest of an artificial hill, 115 feet in height, which has been built laboriously from one side of the valley to the other and is known as the Gatun Dam. At the center of this dam we see the Spillway, with the surplus waters of the lake flowing through its gates and passing down through the wide Spillway channel to discharge into the old bed of the Chagres River…"

***Scientific American Supplement,* November 23rd 1912**

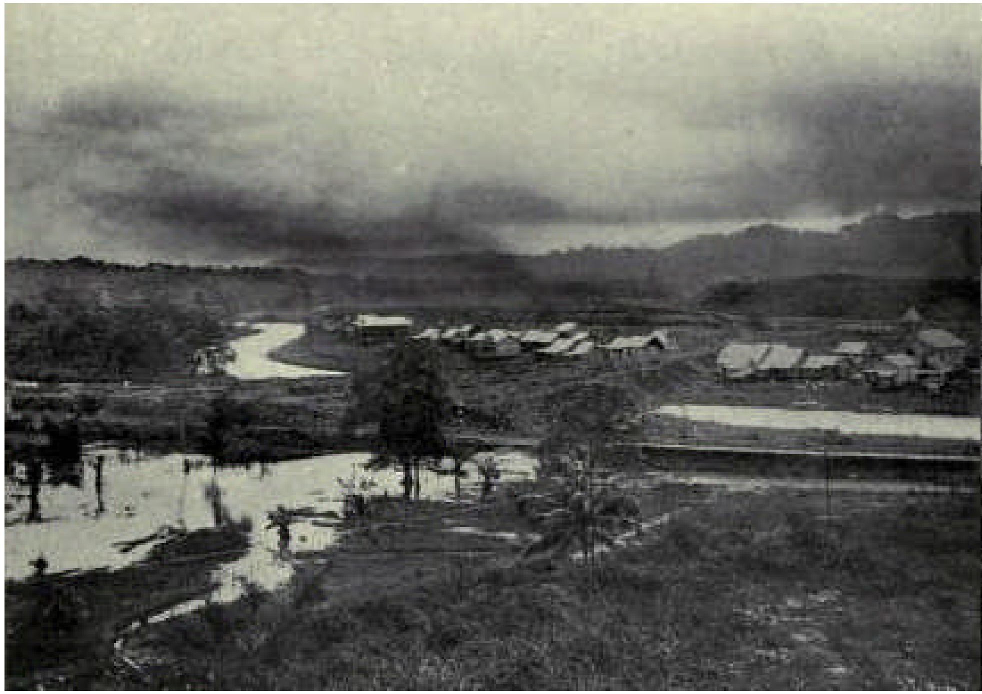
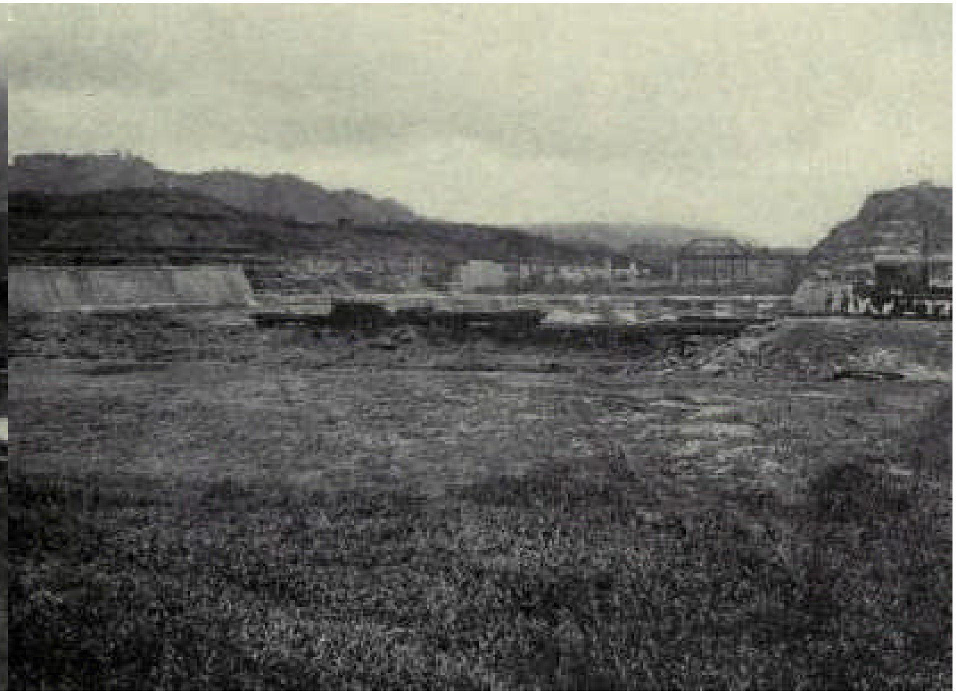

Dam
Chagres

Reckless Gambling With Fate

“…The construction of the great Gatun dam, in particular, has occasioned much trouble and worry. The purpose of this dam is to retain an ample supply of feed water for the canal, and the dam will be required to withstand the pressure of an immense volume of water 95 feet in depth. This requirement, which is exceeded in the case of the Assouan dam in Egypt, would present no great technical difficulties in favorable conditions, but the Gatun dam, though it rests in general on bed of clay, crosses two former channels of the Chagres river which are filled with porous detritus to a depth of 288 feet. No expert knowledge is needed in order to appreciate the insecurity of a dam resting on a foundation which is not watertight. This construction has been much discussed and severely criticized in America. Col. Goethals, the chief engineer of the canal, and his associates, feel assured of the staunchness of the dam, but the opinion of the unquestionably high authorities is naturally optimistic. The worst feature of the case is the impossibility of justifying this confidence until the dam has been completed and the basin filled, when it will be too late to correct errors in construction. The engineers who were formerly in charge of the work were compelled by the pressure of public opinion to promise that they would strengthen the foundation of the dam by driving piles at the weak spots, but this precaution has been neglected as unnecessary. Even with perfect confidence in the accuracy of the calculations and the examination of specimens of the substratum, this appears like reckless gambling with fate…”

***Scientific American Supplement,* September 23rd 1911**

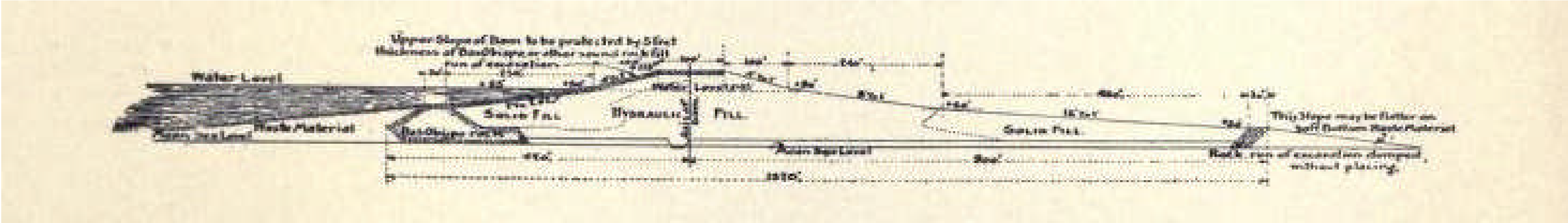
RE: excerpt from an article entitled: “A German View of Our Panama Canal Worries”

The *Gatun Dam* covered with rock and earth (to a depth of 100-feet) the old fishing village of *Gatun* which was located between the *Chagres River* and the old *French Canal*. Reluctant to move, it was not until the Americans began to dump materials at the "toe" of the dam (which rolled into and under their houses) that the townfolk realized the necessity of moving. The *Chagres Valley* was divided into two parts where it crossed by the Gatun Dam. These parts were separated by a hill more than 100-feet high through which the spillway channel was excavated. This hill was thus named "Spillway Hill" by the American engineers.

<u>Left</u>: caption: "Dam Construction through Gatun Village"

<u>Right</u>: caption: "Spillway Channel during construction, Gatun, Canal Zone"



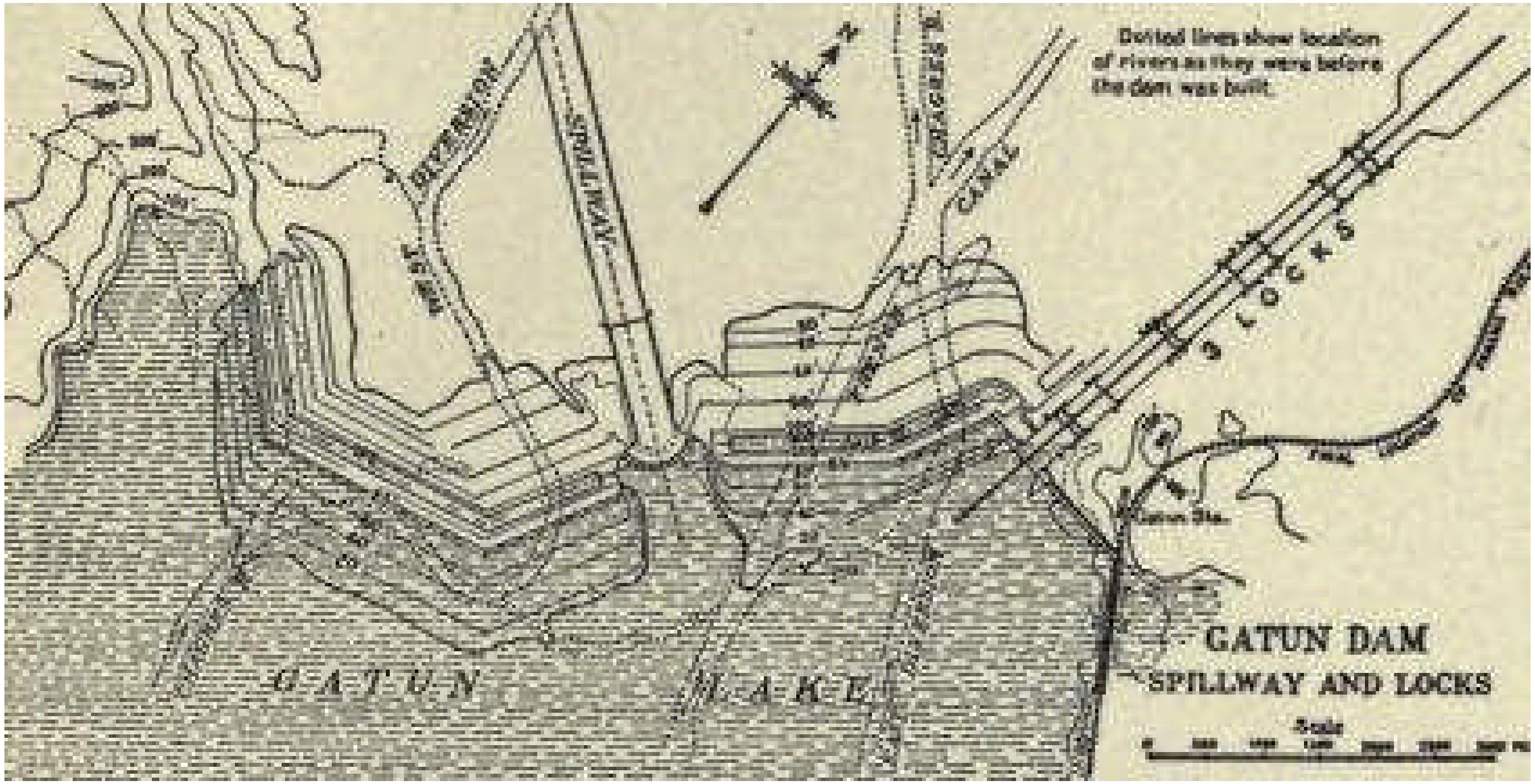
Experiments and investigations were made for the purpose of testing the impermeability of the material available for the construction of the *Gatun Dam* consisted of building a short length of two experimental dams consisting of the same material that was to be used in the dam itself. The fill material would be placed using the "Hydraulic Method" which was the manner proposed for placing the material in the full-scale dam. The first of these experimental dams was built by pumping all of the material into the downstream edge of the dam resulting in the finer, more impermeable material placed in the center. Both experimental dams were subjected to head-of-water pressures corresponding to the actual dam. Seepage tests revealed that a dam built of the experimental material/method would be relatively impermeable.

<u>Above</u>: cross-section of *Gatun Dam*

Both borings and test pits were used to test the materials underlying *Gatun Dam*. Except for *Spillway Hill*, "wash drill borings" were made in all of the dams' foundations. The sample would be obtained by driving an open pipe (hanging free within the surrounding hole) into the material. The pipe would be filled with material to the depth that it was driven and the sample/s labeled and stored. Such holes were located across the entire dam site. A test-pit was sunk in the eastern half of the dam to a depth of 80-feet below sea-level. The amount of pumping necessary to keep this pit dry was a direct measure of the water-tightness of the material. By comparing the material actually encountered at the various depths in this pit with the "drive" (wash drill) samples obtained in the many bore holes at the same depths, an accurate conclusion of relative impermeability was drawn as to the nature of the material below the dam.

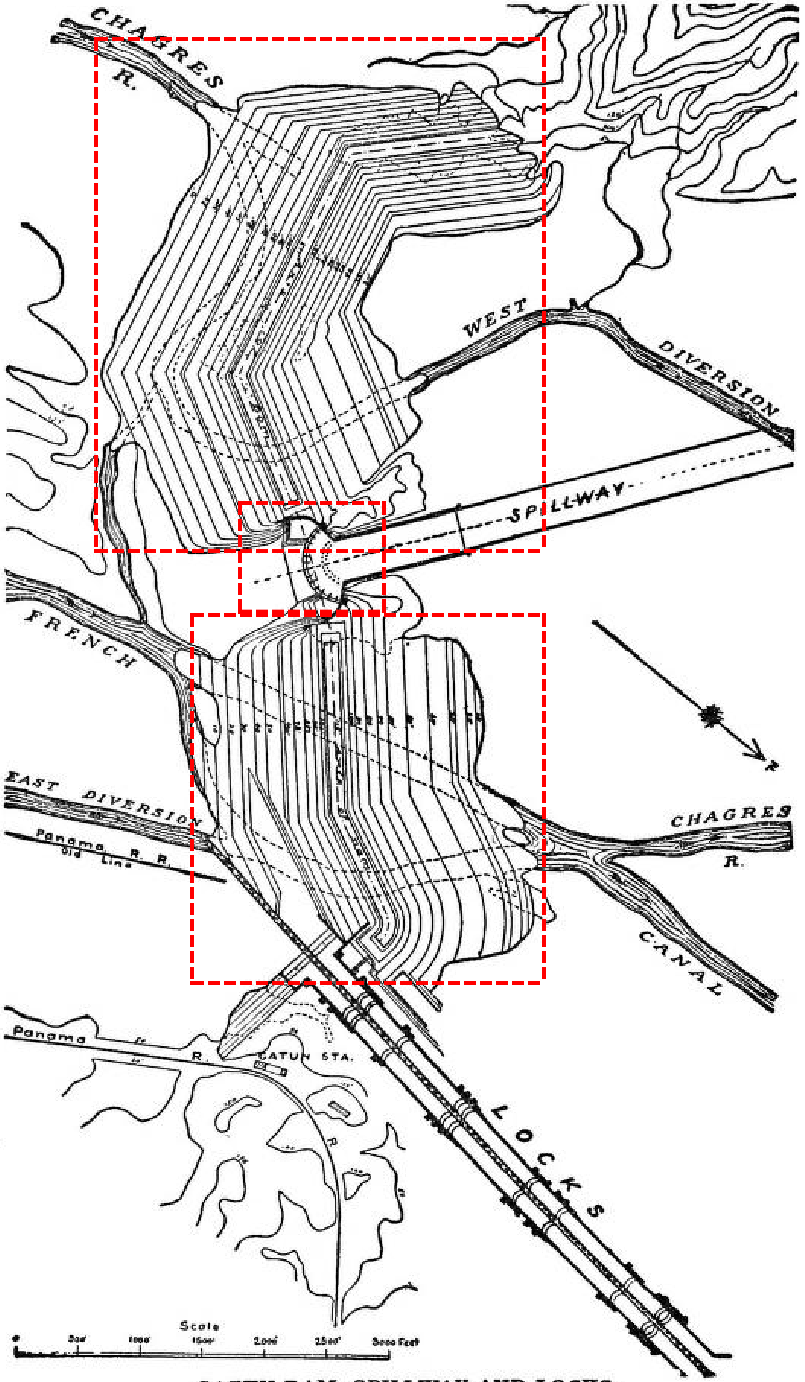
Coincident with the material tests, careful examinations were made of all the “saddles” or low places in the ridges surrounding what would become *Gatun Lake* at heights approximating the lake level. Test borings were drilled in all of these saddles to determine the character of the material; its water-tightness and general suitability to form a portion of the rim of the lake. An accurate contour survey (with contours extending fifteen-feet above the proposed lake level) had been made prior to these tests.

Above: Gatun Lake and its surrounding hills



<u>Above</u>: In April 1907, a solitary steam-shovel began grading a "pilot" track along the axis of the spillway cut and in June work commenced on driving a trestle along the 30-foot contour of the north face of the dam. As depicted in the diagram above, the waters of the *Chagres River* were passing the site of the *Gatun Dam* through three channels (dotted lines);

- **the old bed of the Chagres River**
- **the old *French Canal***
- **the *West Diversion Channel* dug by the French (west of *Spillway Hill*) to divert the Chagres from the then proposed canal**



GATUN DAM, SPILLWAY AND LOCKS.

Gatun Dam **is 8,200-feet long and is composed of three sections;**

- **an earthen dam (connecting the locks with *Spillway Hill* – at bottom)**
- **a concrete dam (with regulation works across the channel in Spillway Hill - middle)**
- **an earthen dam (from Spillway Hill to the high ground bounding the west-side of the *Chagres River Valley* – top)**

The plan of procedure was to first build a dam across the *Chagres River* proper and one across the old *French Canal,* thus diverting all the flow of the Chagres into the channel west of Spillway Hill. This would negate all water difficulties from that half of the dam east of Spillway Hill enabling work to commence. Then, a 300-foot wide channel would be cut through Spillway Hill through which, when completed, the entire flow of the Chagres was to be diverted.

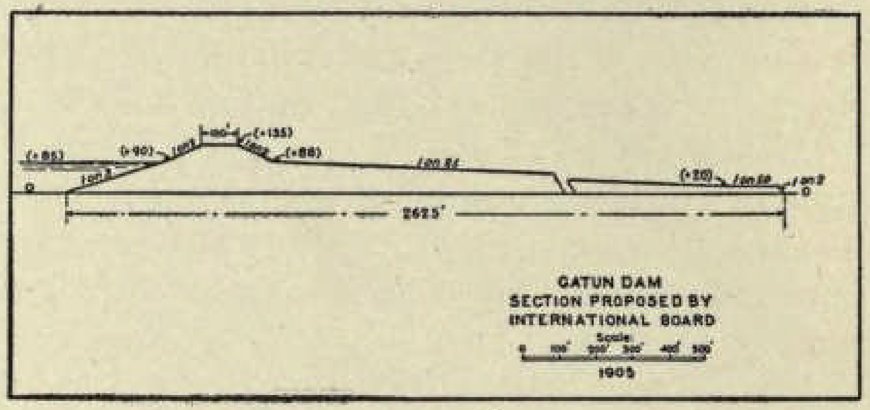


DIAGRAM 2

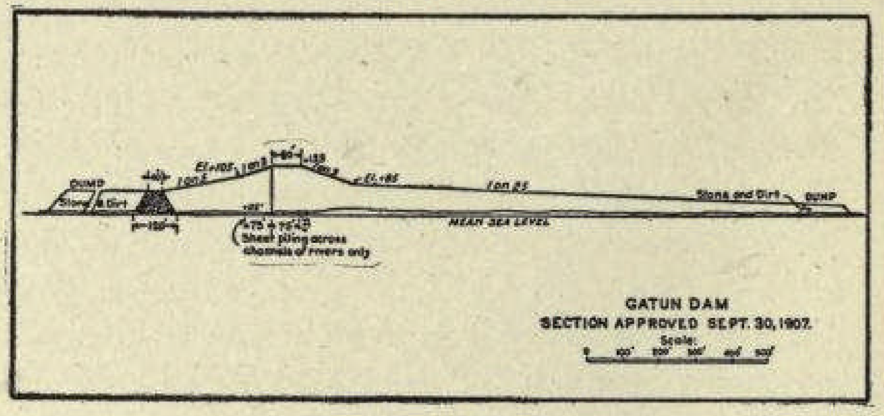


DIAGRAM 3

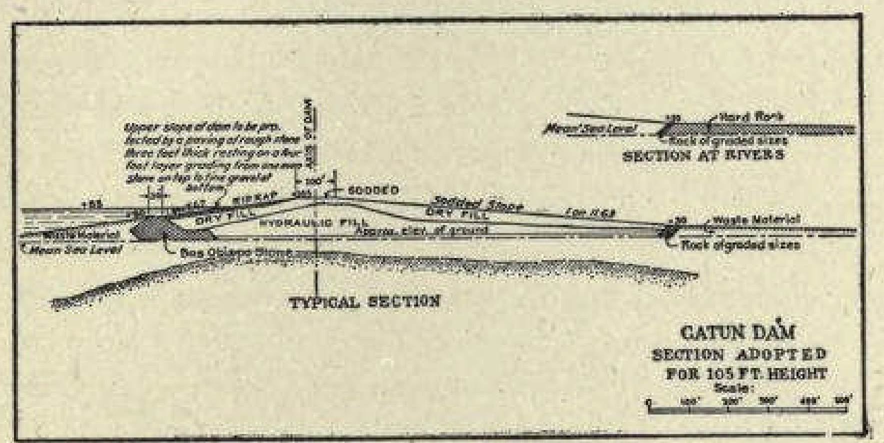
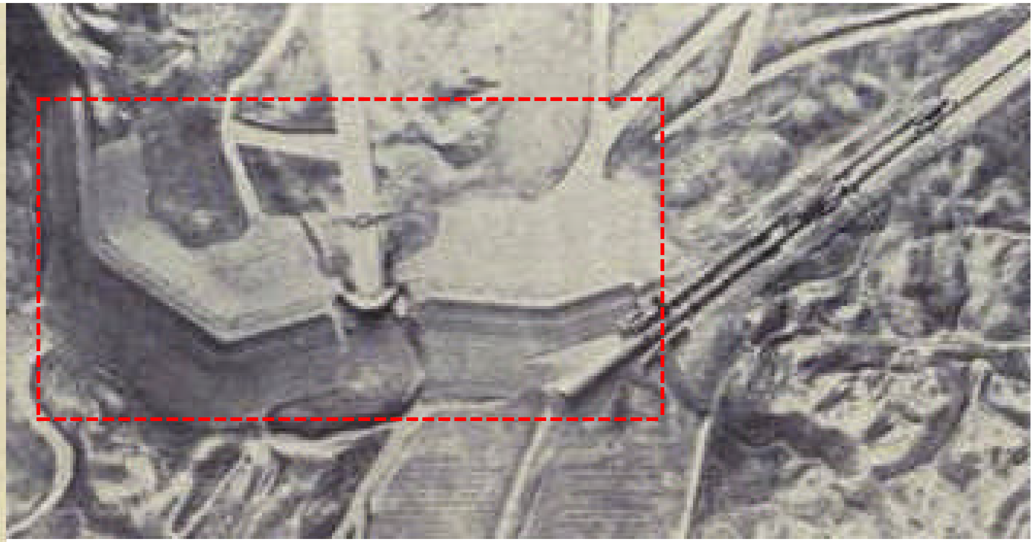


DIAGRAM 4



<u>Above</u>: model of Gatun Dam, Locks and Spillway

<u>Left</u>: the section *<u>proposed</u>* for *Gatun Dam* in the adopted project is shown in *Diagram 2* (top). *Diagram 3* shows the first *<u>approved change</u>* in this plan (center). *Diagram 4* shows the section as actually built (bottom).

Once the *Spillway Channel* was complete, work on the western half of the dam would commence. Upon completion of the earthen sections (east and west), the concrete dam with regulation works (at the south-end of the Spillway Channel) would commence while the *Chagres River* passed through temporary culverts. Though no major difficulties were encountered in building the dams across the Chagres River channel and/or the old *French Canal* (the river's water level was not raised during construction), the opposite was true when the Chagres was forced from the *West Diversion Channel* into the Spillway Channel. The bottom of the Spillway Channel was constructed at an elevation ten-feet above sea-level while the bottom of the West Diversion Channel was twenty-feet below sea-level. For about ten miles above Gatun, the effects of the tides was felt in the Chagres River. In order to force the river through the channel excavated for the Spillway, it was necessary to bar the passage of the river through the West Diversion Channel. The Chagres would have no outlet until it had risen ten-feet, at which point it would commence to flow through the Spillway Channel. However, its entire discharge would not be realized until the river rose fourteen-feet.

In making the diversion from the *West Diversion Channel* to the *Spillway Channel*, two diversion dams using rock and dirt spoil from *Culebra Cut* were built simultaneously across the former. Situated above (upper) and below (lower) the site of the *Gatun Dam* proper, one was across the 30-foot contour of the south face and the other across the 30-foot contour of the north face of the dam. The logic behind these dams was that, during construction, the head-of-water from the rising river would be divided between the two dams (the Spillway/Main dam would encompass both diversion dams when built). Trestles were built across the diversion channel for the purpose of dumping rock and fill. After the flow of the river through the West Diversion Channel was completely stopped, the two diversion dams were raised to the height of the top of the trestle and widened. Twenty-inch pipes were laid through the levees (which formed an extension of the diversion dams forming a continuous barrier) on the north face to drain-off any water that seeped through the dam on the south face. Two days after completing the diversion dams, a settlement in the levee stopped the flow of water through the drain pipes filling the space between the diversion dams with water. The north (upper) diversion dam moved leisurely downstream spreading itself out in the bottom of the West Diversion Channel. With one of the diversion dams gone, the sudden rush of water caused the bank of the south (lower) dam to slide into the diversion channel. Trains were sent out onto the trestle and about 30K cubic yards of rock were dumped into the breach. Once complete, the rock fill slipped into the river destroying the remaining portion of the levee that had remained in-place.


The rising river had formed a lake fourteen-feet above sea-level. Two suction dredges were brought in to raise the lake bed above the weak spot. An island of sand and clay three-quarters of an acre in size was formed above the breach. This allowed time for first the south and then the north diversion dam/s to be rebuilt and new pipes laid below the levees. Thereafter, the water of the Chagres were successfully diverted into the *Spillway Channel* permanently.

Left: caption: "Remains of the North Diversion Dam, Gatun Dam"

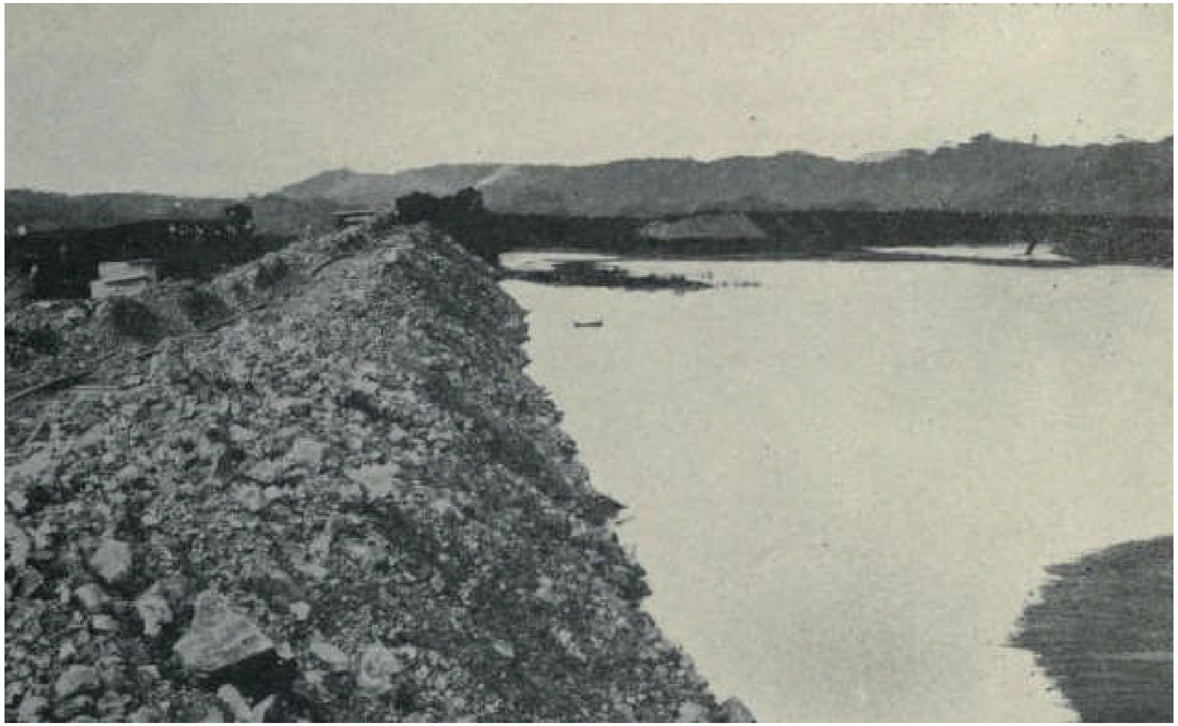
Right: caption: "Slipping of the South Toe of Gatun Dam, Top View, November 21st 1908"

To form the earthen dams, a twenty-foot wide by ten-foot deep cut was made along the axis of the dam by a steam shovel. For 400-feet on either side of the cut was plowed or picked so that a watertight bond between the central part of the dam and the material placed atop was made. This central or "watertight" part of the dam (between the rock toes) was composed of a mixture of sand and clay and was pumped into placed by suction dredges. Rock fill on the east half of the dam was to be carried to an elevation of 60-feet above sea-level before placing any of the hydraulic fill (except in the stream beds).

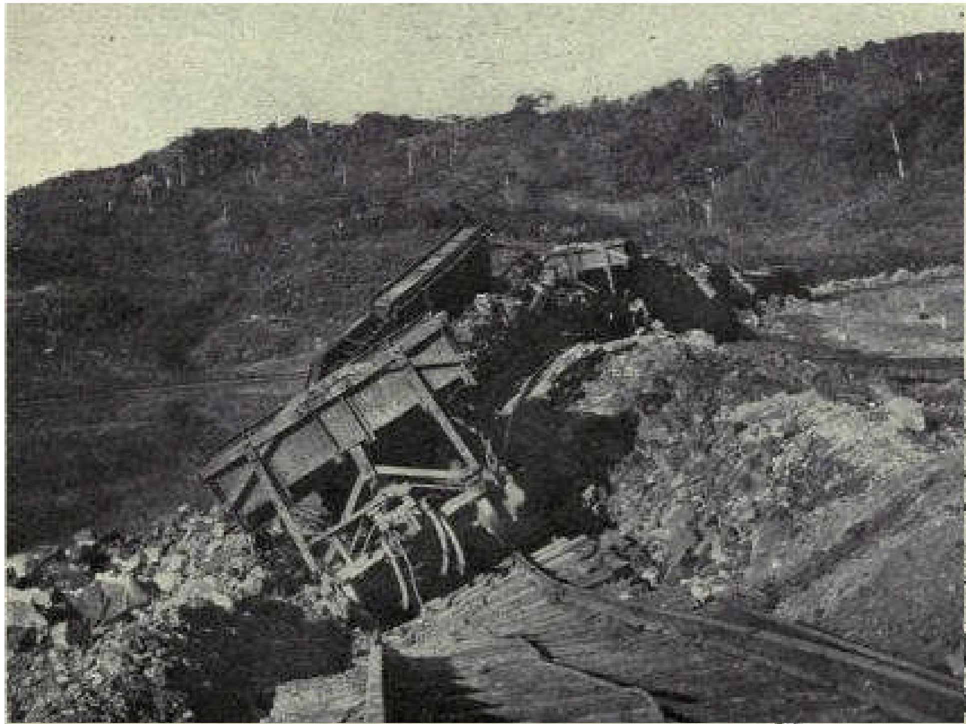
Left: caption: "How the watertight core on the Gatun Dam was made. The mud left after the water drains away dries and hardens. The dam is half-a-mile thick at the base."

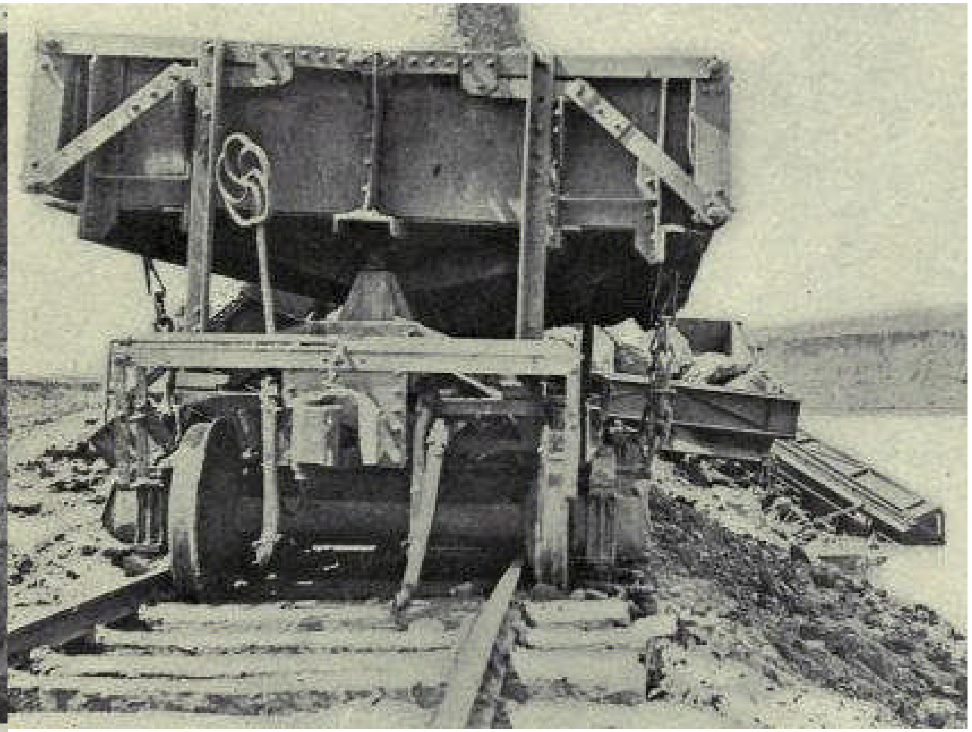
Right: caption: "Gatun Dam, East Section. Showing discharge from suction dredge, with hydraulic fill, looking west"

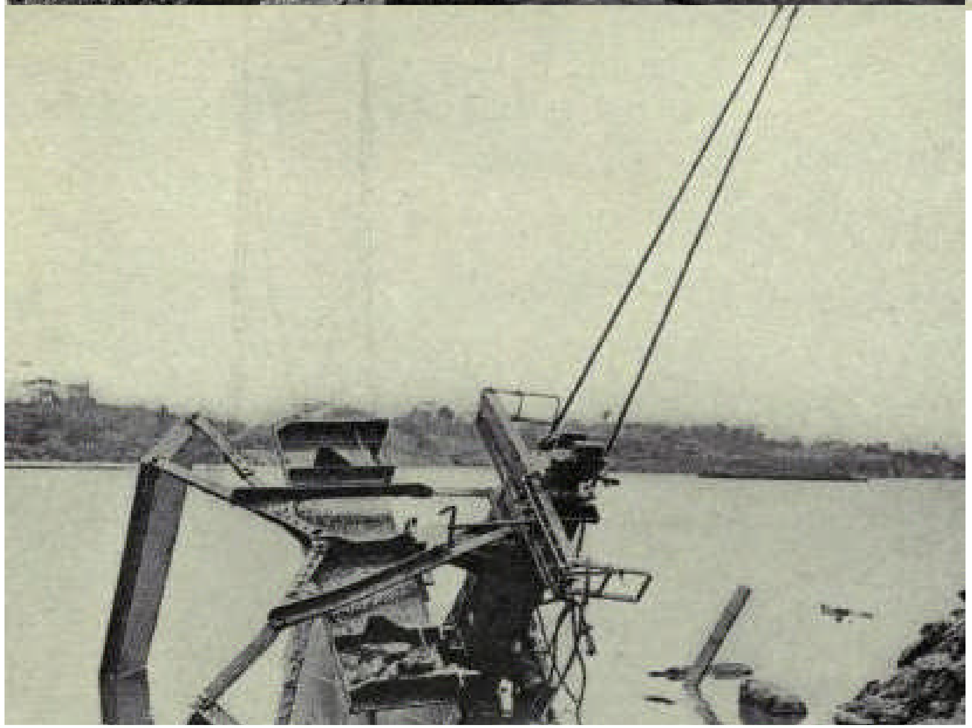


Ridges of dry material were required to hold the hydraulic material in place during construction. The necessity of building up these ridges as the dam grew required that the hydraulic material be delivered to both faces of the dam simultaneously. Typically, ease of construction determines whether the material is delivered to one or both faces

<u>Above</u>: caption: "Gatun Dam, West Section of dam looking west, showing progress of Hydraulic fill. This great dam is nearly 1.5 miles long and one-half mile wide at its base"







Slides occurred during the construction of the earthen dams due to the inability of the hydraulic fill to support the overlapping dry fill. On many occasions, these slides carried loaded train cars into the wet fill and became almost a daily occurrence that was deemed necessary for consolidation of the wet and dry fill.

<u>Top Left</u>: caption: "Slides into wet fill, Gatun Dam"

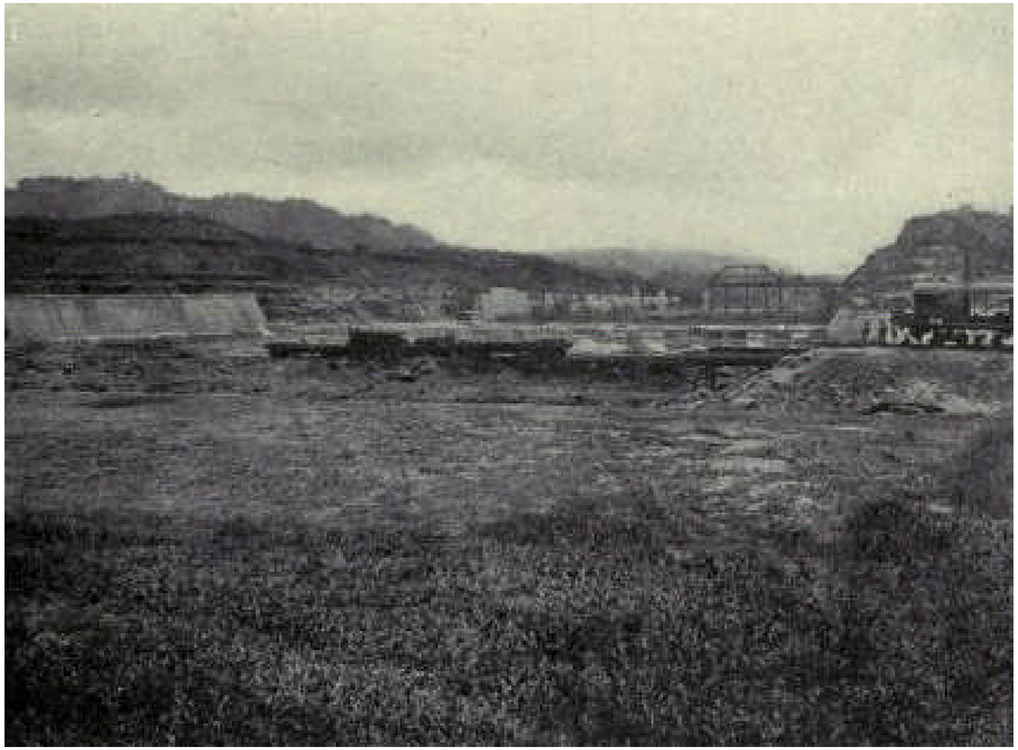
<u>Top Right</u>: caption: "Slides into hydraulic fill, Gatun Dam"

<u>Left</u>: caption: "Removing cars from wet fill, Gatun Dam"

Spillway Dam

“…Among the most valuable assets purchased by the United States from the French canal company were the data of the water flow on the Isthmus. The greatest known discharge from the Chagres River is 137,500 cu. ft. per second. The spillway of the Gatun Dam, constructed of concrete on a rock foundation, will permit the flow of 154,000 cu. ft. per second, and regulating weirs have been provided so that a much greater excess can be carried off safely into the old bed of the Chagres River and out to sea. The highest known flood of the Chagres River would raise the level of Gatun Lake only one foot in 9.5 hours, even though the spillway and weirs were all closed. In the rainy season, the water will be impounded to a depth of 87 ft., providing for a reserve supply for the operation of the locks throughout the dry season…”

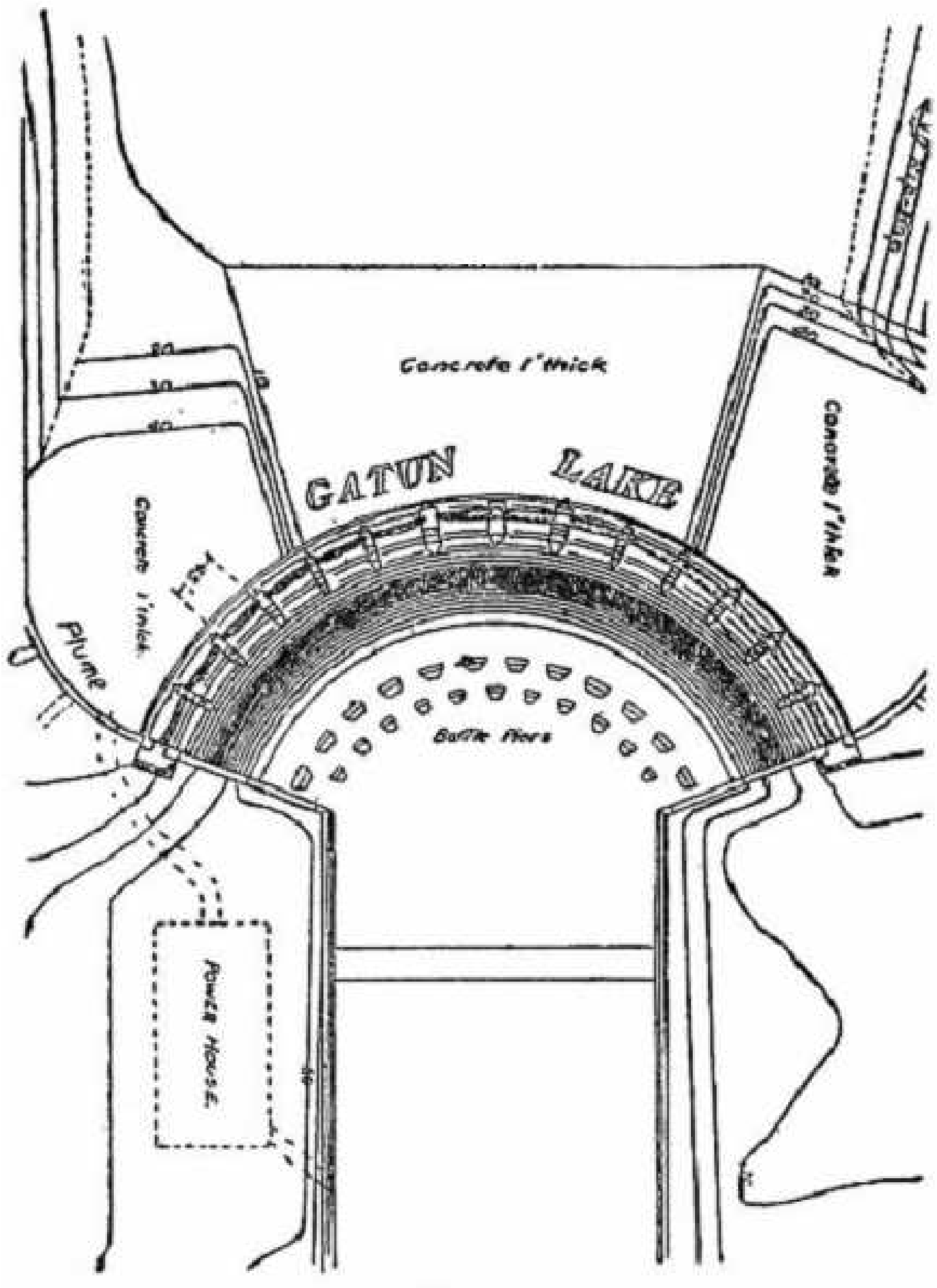
***Popular Mechanics,* December 1913**



In making the cut for the channel through *Spillway Hill*, it was necessary to make it big enough for the floods of the *Chagres River* to pass without the river rising high enough to interfere with construction work on any part of the canal. Therefore, the bottom of the cut was ten-feet above sea-level and made 300-feet wide. Digging the *Spillway Channel* was straightforward, but on one occasion the Chagres flooded the channel sweeping aside everything in its path. The Spillway Channel excavation involved 1,544,202 cubic yards of material. The bottom and sides of the Spillway Channel were *Argillaceous Sandstone*; a soft rock that could be eroded and which would decompose in the air. Therefore, to protect the rock and prevent seepage, all exposed rock surfaces were covered with concrete. The bottom of the Spillway Channel was lined with concrete throughout (twelve-feet thick just below the dam site). Concrete retaining walls were built along the sides of the channel allowing for the placement of the Spillway Dam's foundations.

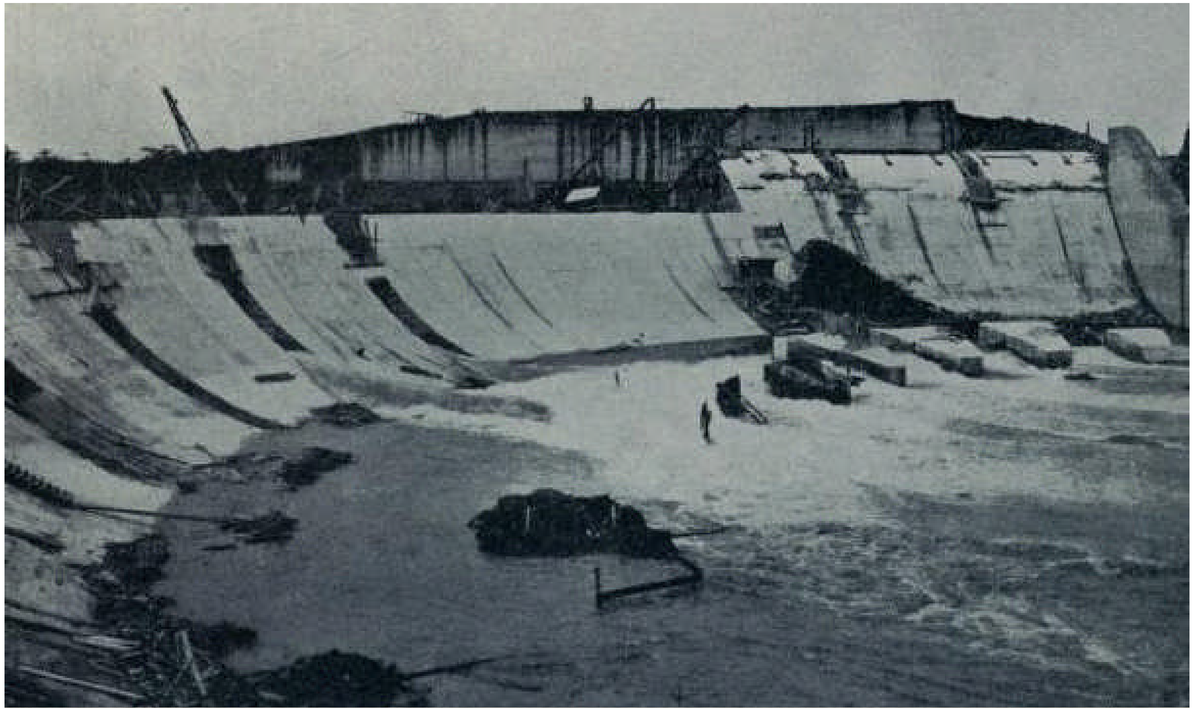
Above: caption: "Spillway Channel during construction"

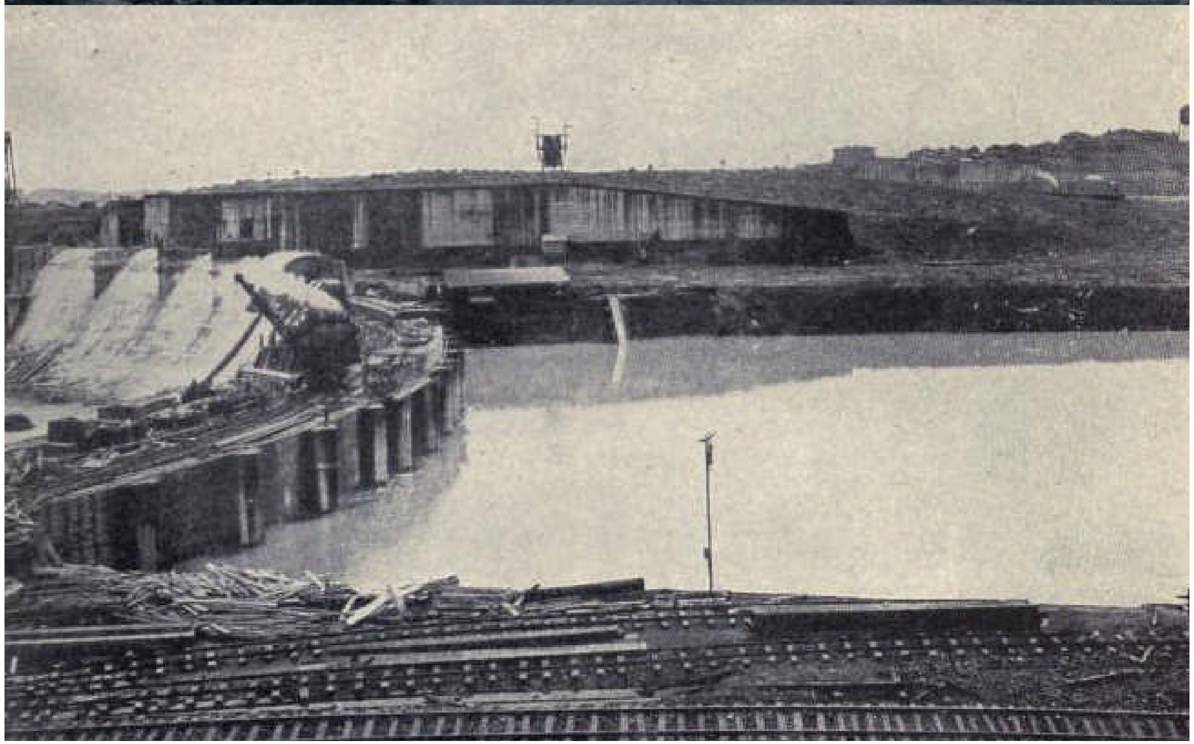
Construction of the *Spillway Dam* was, by necessity, last because its construction would complete the barrier across the *Chagres Valley* and cause the creation of *Gatun Lake*. Before the earthen dams had reached their final heights, it was not safe to allow this lake to exceed a certain height. As well, the lake could not be allowed to rise high enough to overflow the miter-sills of the *Gatun Locks* before the gates and appliances were erected in the south-end of the locks. Also, the lake could not be allowed to fill until the relocated *Panama Railroad* was complete and work in the *Culebra Cut* so advanced that it could be completed with dredges.



<u>Left</u>: Spillway Dam

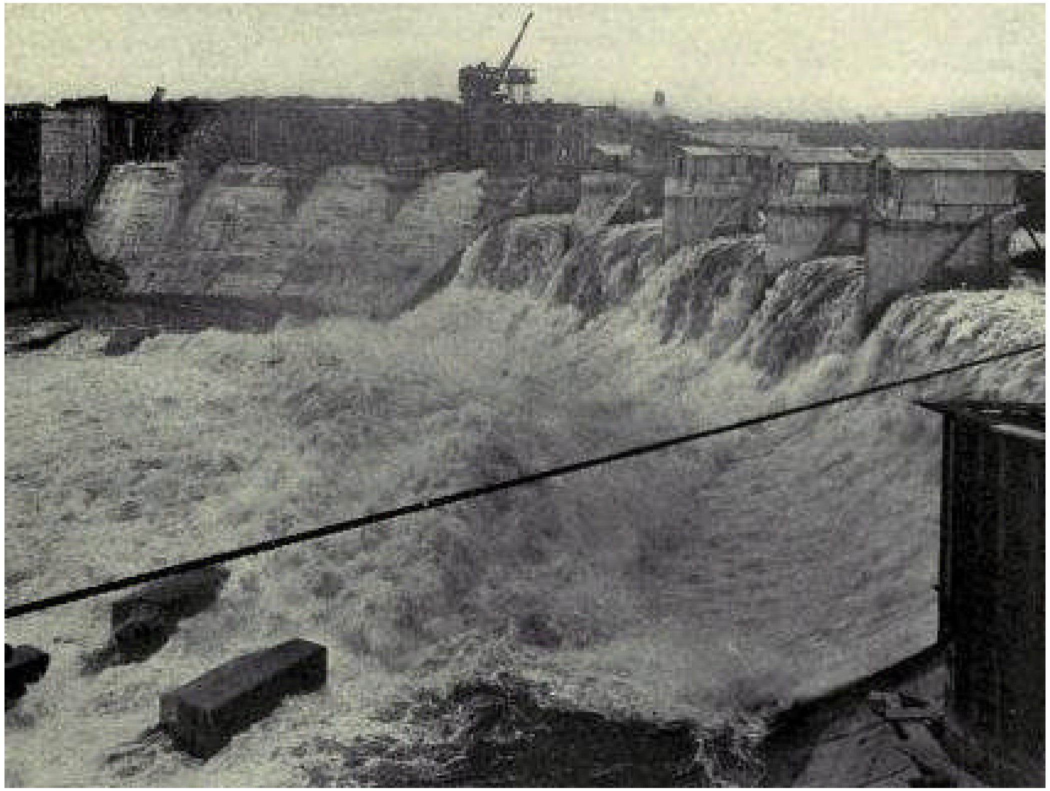
In constructing the *Spillway Dam*, stubs of small piers were built twenty-feet apart along the upper (north) face of the dam. These piers were made to such a height that their upper surface would be out of water during the dry season thus affording a starting point for future work (their faces were grooved to allow water-tight curtains to be dropped into place). Stubs complete, the *Chagres River* was allowed to flow through the *Spillway Channel* until work on the dam resumed (when formation of the lake would not interfere with other work on the canal). When time came for completion of the dam, the first operation was to extend, in the dry season, the pier stubs to a height of 35-feet, continuing the grooves to the top then, atop these piers, erect a railroad bridge. The plan of construction contemplated first completing about two-thirds of the dam to a height of 50-feet above sea-level and to provide in this part three openings each eight by eighteen feet, through which the Chagres River could flow for ten months of the year. Valves with operating machinery were provided for opening and closing the sluices, thus enabling the engineers to regulate, for the greater portion of the year, the elevation of *Gatun Lake*. During the dry season, the dam would be completed. Practically all of the concrete used in building the dam to a height of 50-feet was placed from cars on the railroad bridge atop the piers via dumping it directly into place or by chutes that carried it into place. [409]





Top: caption: "Gatun Spill-way looking South-West, showing downstream face of Ogee Dam, June 6, 1912"

Bottom: caption: "Gatun Spillway looking east towards locks, showing up and down stream faces of Ogee Dam, June 6, 1912"



The water-tight curtains allowed water flow to be blocked from any part of the dam during construction while the central part of the dam was finished to a height of 50-feet above sea-level. Lake level was controlled by valves in the openings through the dam until the rainy season arrived. It was expected, despite the openings in the dam, that the Chagres would rise and overflow the incomplete portion of the dam. As soon as the rains stopped sufficiently to allow the openings through the dam to lower the lake below +50, the work of completing the dam was resumed, all water passing under the dam through the openings

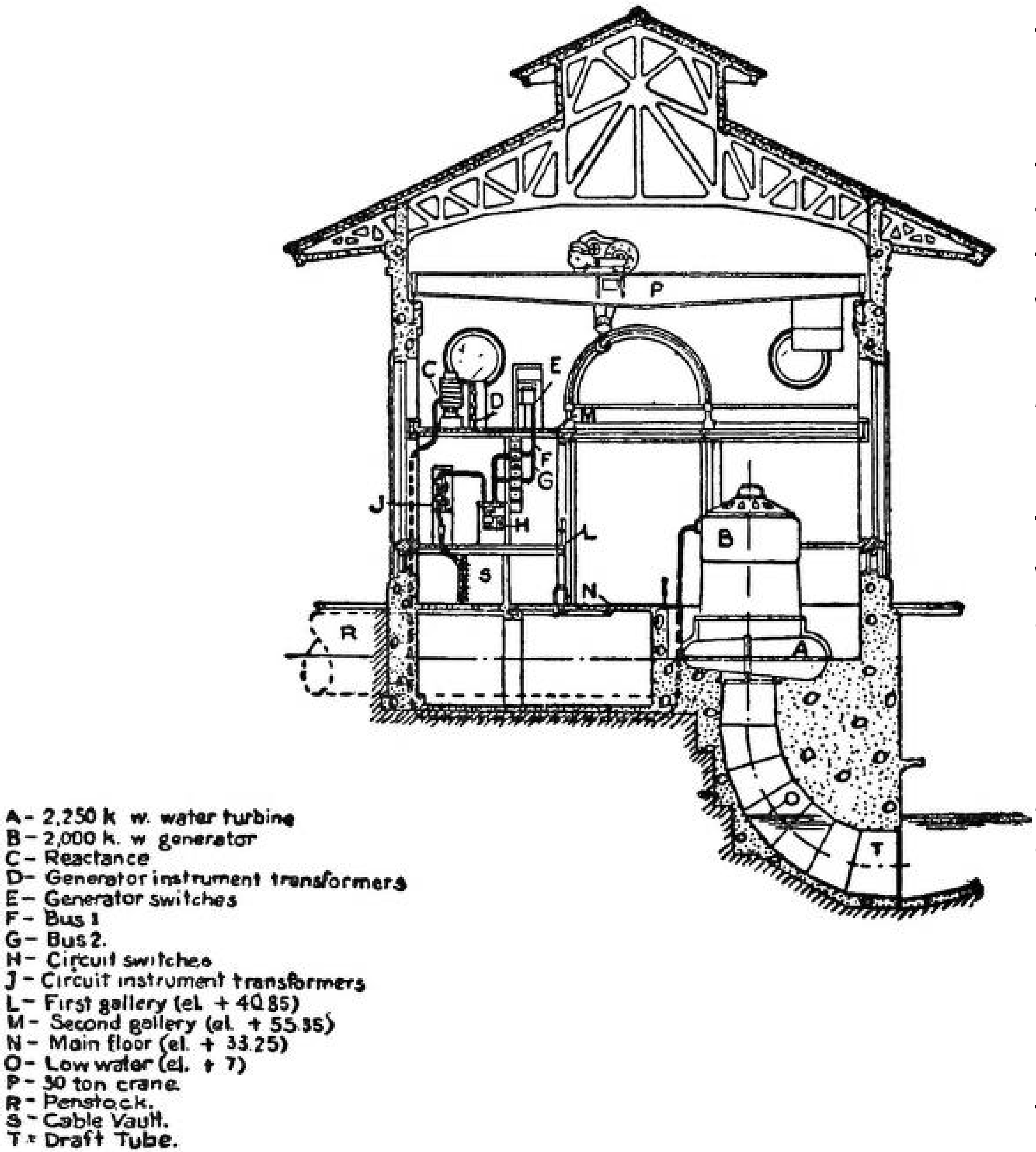
Above: caption: "Flood water passing over incomplete Spillway Dam at Gatun"

In order to build the piers and install the *Stoney Gates* composing the regulating works, a heavy trestle was constructed on the incomplete dam from which the piers were completed and the *Spillway Gates* placed. Weighing 42-tons each, they were loaded onto flat cars, brought out onto the trestle and lowered into place by two wrecking cranes.

<u>Above</u>: caption: "Gatun Spillway Dam under construction"

"…The normal flow of water through the Gatun spillway operates the hydro-electric plant which supplies power and light for the operation of the canal. With a head of 75 ft., with a tailrace 8 ft. above sea-level, there is enough power available for any probable demand for years to come. The equipment now being installed consists of three 2,250-kw water turbines, operating three 2,000-kw generators, while a steam generating plant at Miraflores is coupled to the same transmission line…"

***Popular Mechanics,* December 1913**



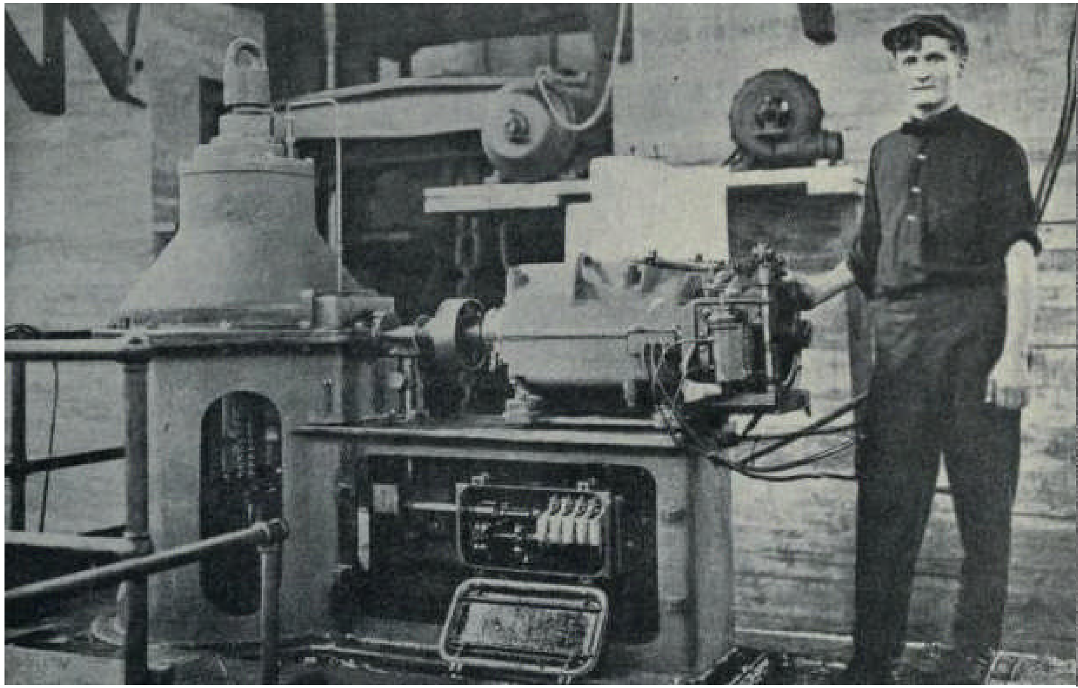
THE HYDROELECTRIC STATION AT GATUN.

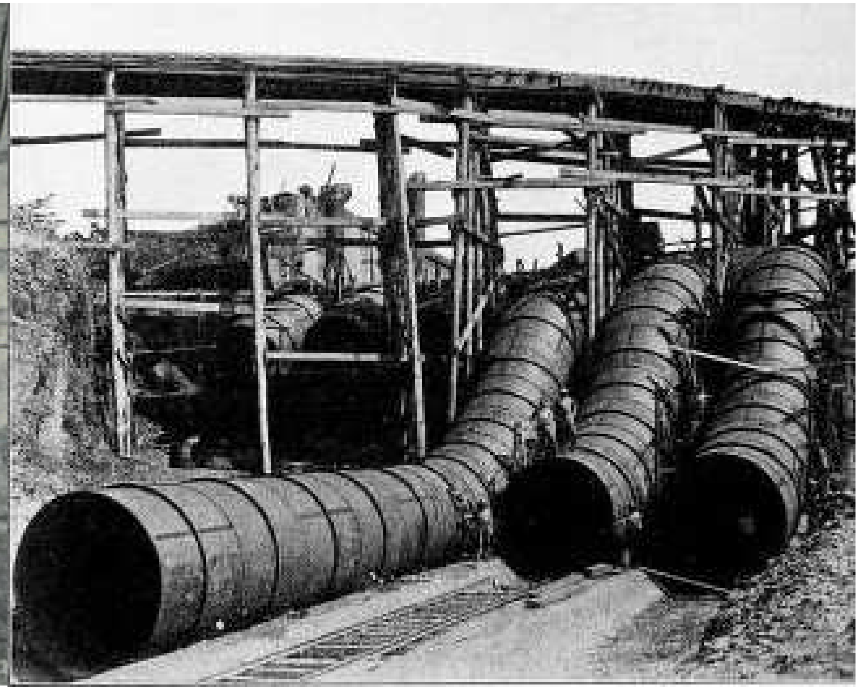
Running longitudinally through the *Spillway Dam* is a water-tight operating tunnel in which was placed all the operating machines that raise and/or lower the fourteen *Stoney Gates* forming the crest of the dam. The gates were operated from a switchboard located in the adjoining *Power-house*. In connection with the building of the Spillway Dam, a hydro-electric plant was built. This plant was operated with water from *Gatun Lake* which has an average fall of 75-feet. It was designed to provide all power necessary to operate the locks, light the canal, operate the *Panama Railroad* and other ancillary operations. Three 2K-kw units were initially installed with provision made for doubling the plants generating capacity provided the *Gatun Lake* water supply was sufficient to handle the extra units.

Left: sectional view of the hydro-electric station at Spillway Dam

"…In Gatun Lake a ship may steam at full speed for 24 miles, to Bas Obispo, where it enters the Culebra Cut. The channel through the lake is not a straight line, but passes around and between many islands. It is marked by buoys which are to be lighted at night. In fact, the entire length of the canal will be so brilliantly lighted as to make the passage by night almost as safe as by day…"

Popular Mechanics, **December 1913**





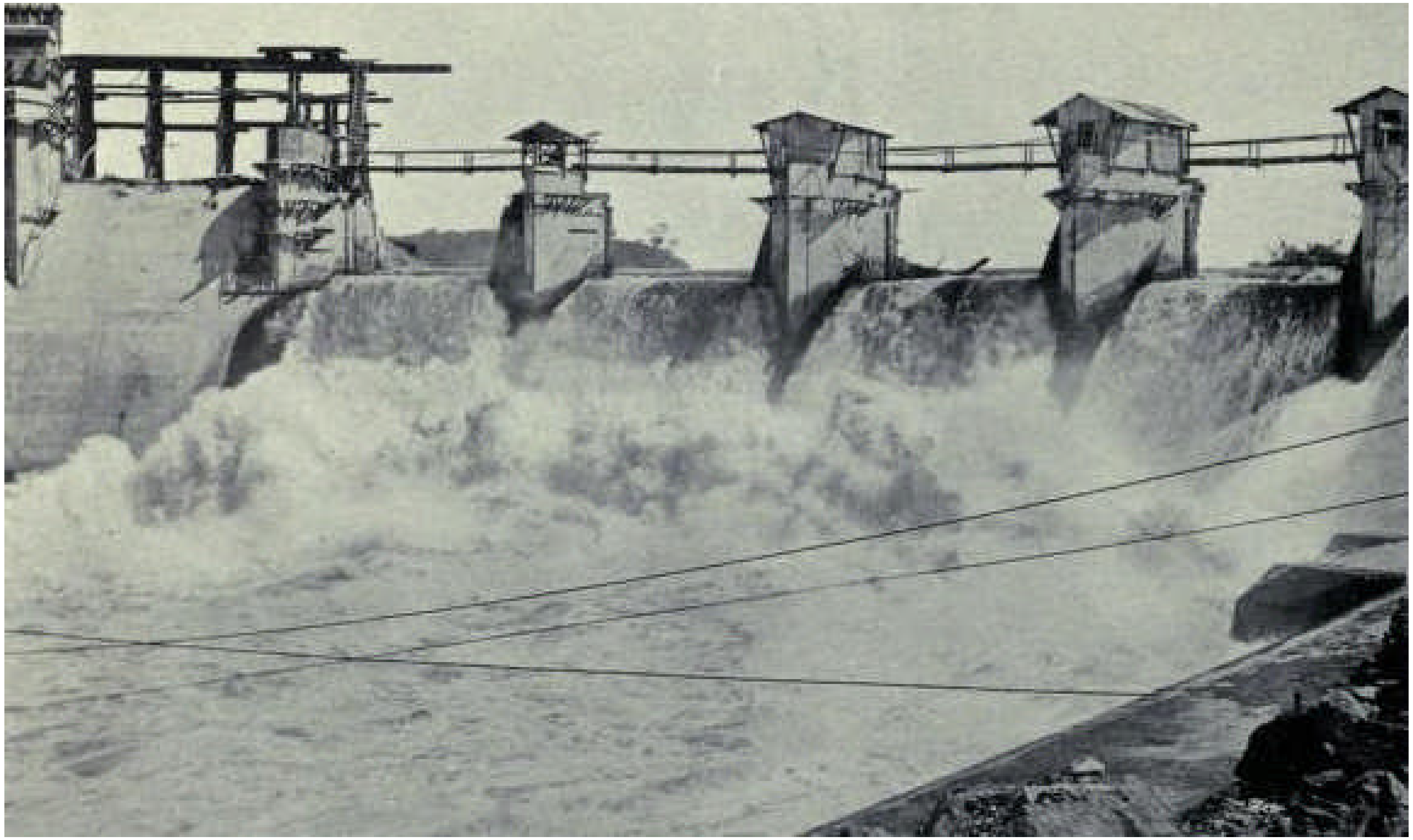
Electricity was the power that ran canal construction-era cableways, cranes, rock crushers and cement mixers. An all-electric canal was an innovation in the first decade of the *20th Century*. Lock operations required some 1,500 electric motors since all controls were electrical. The *General Electric Company* produced about half the electrical equipment needed during construction and virtually all of the permanent motors, relays, switches, wiring and generating equipment. They also built the original lock towing locomotives and all of the lighting.

Left: caption: 'Cylindrical valve machine, motor, and limit switch. Electricity is used to operate all gates and valves along the canal."

Right: caption: "The Giant Penstocks of the Spillway"

“The electric power distribution for the Panama Canal operation and lighting will require 246 miles of lead-covered cable. These cables will be carried through the lock walls in vitrified clay ducts. On account of the large amount of cable to be placed in the ducts, a special device using an electrically operated winch was employed.”

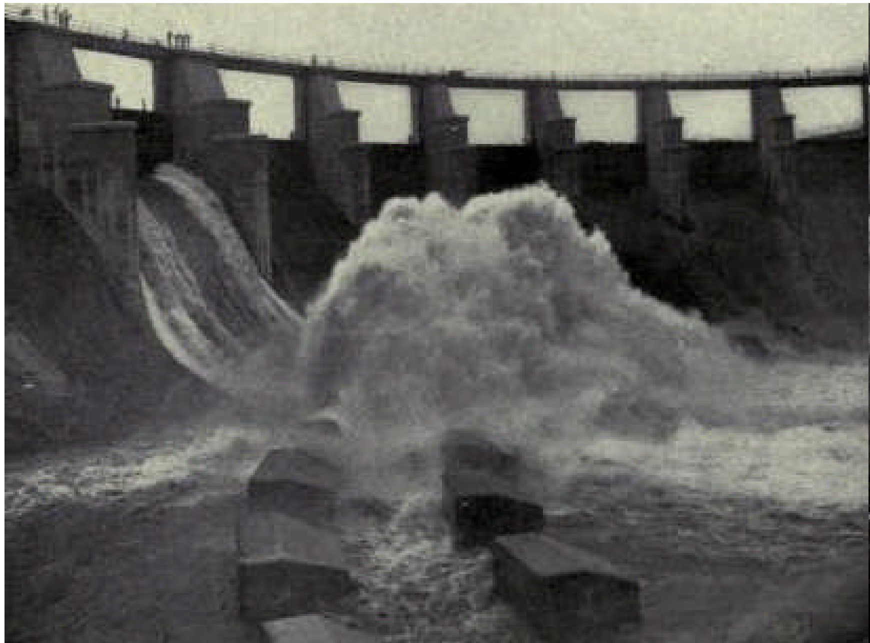
Popular Mechanics, **June 1915**

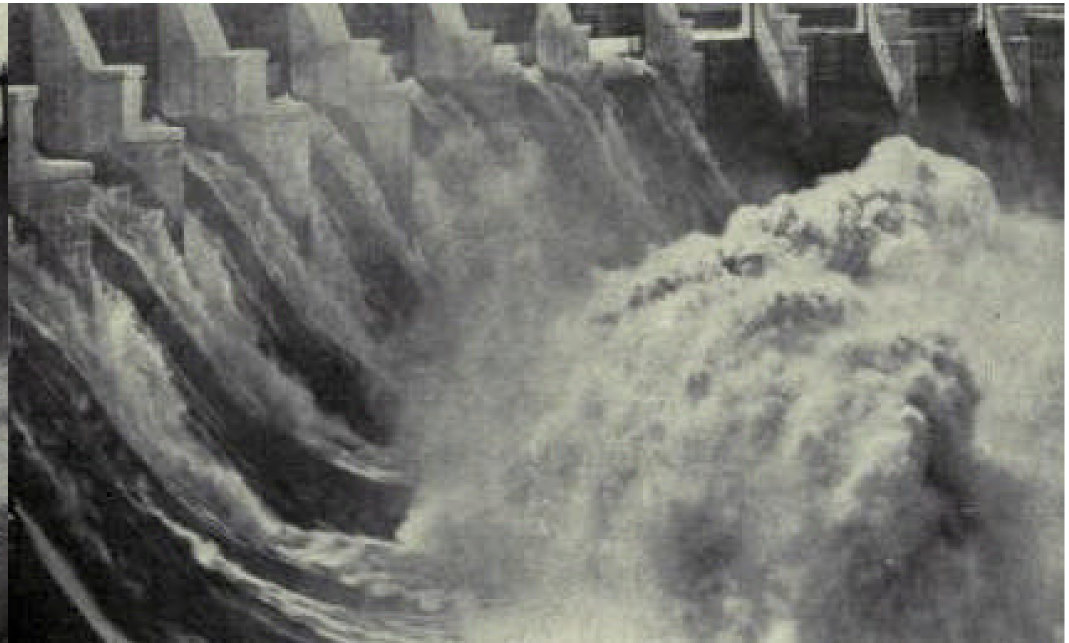


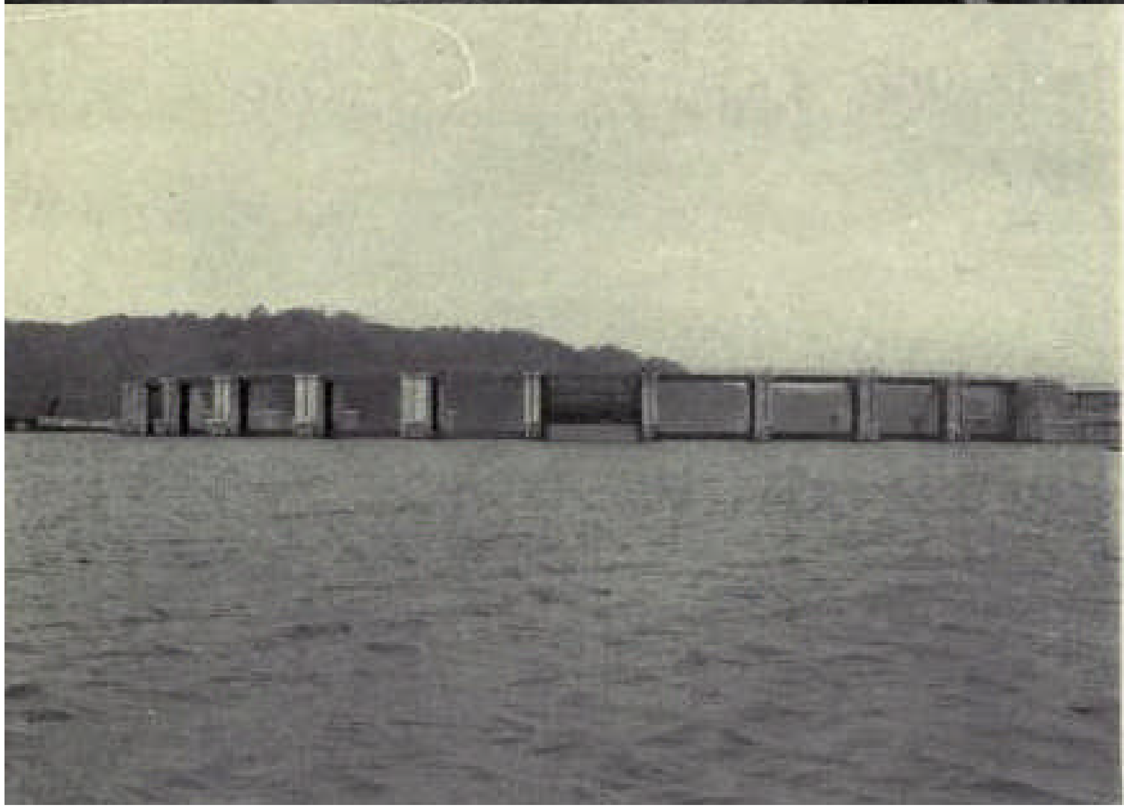
"Tremendous as is the volume of water constantly rushing over Niagara Falls, recent statistics indicated that it is exceeded by that passing through the eight spillways of the Panama Canal. It has been estimated by engineers that these gates pour out a flood amounting to 103,000 cubic feet of water every second…"

***Popular Mechanics,* July 1923**

<u>Above</u>: caption: "The 'Spillway' of Gatun Dam, where the surplus water escapes. Much of this will be used to operate the locks when the canal is open."







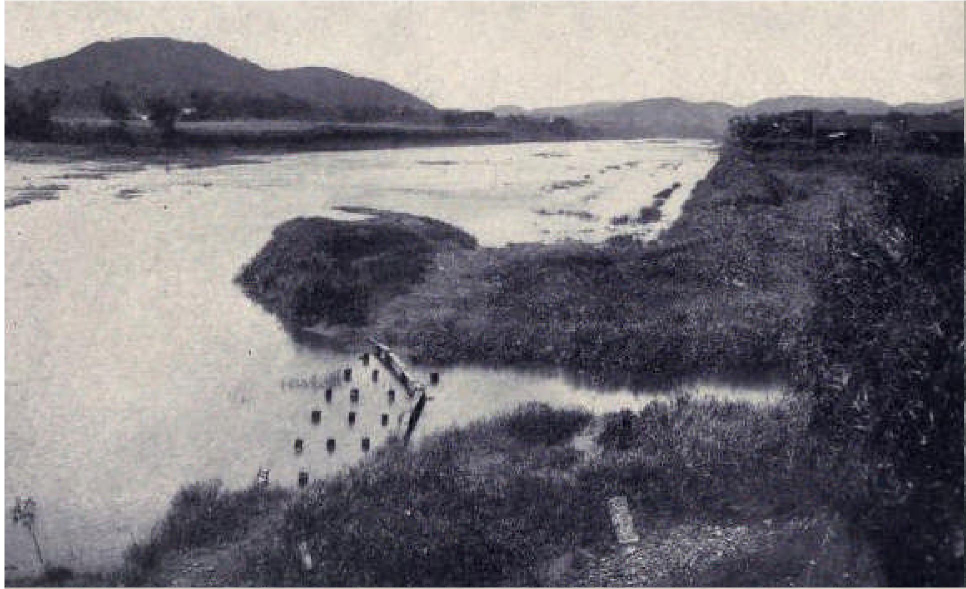
<u>Left</u>: caption: "The opening of the first gate, Gatun Spillway"
<u>Right</u>: caption: "Gatun Spillway with seven gates open"
<u>Left</u>: caption: "Gatun Spillway as seen from the lake"

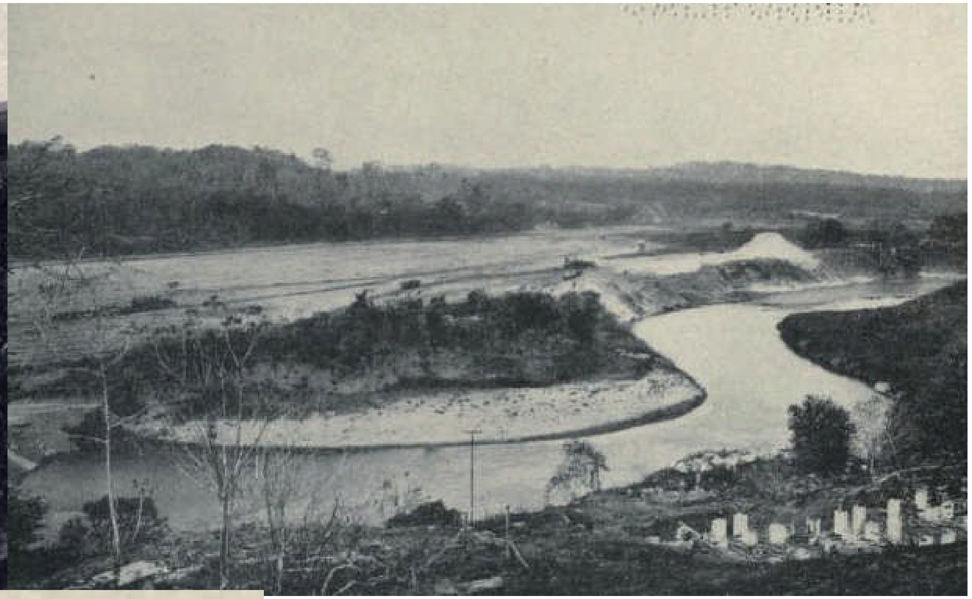
Gatun Lake

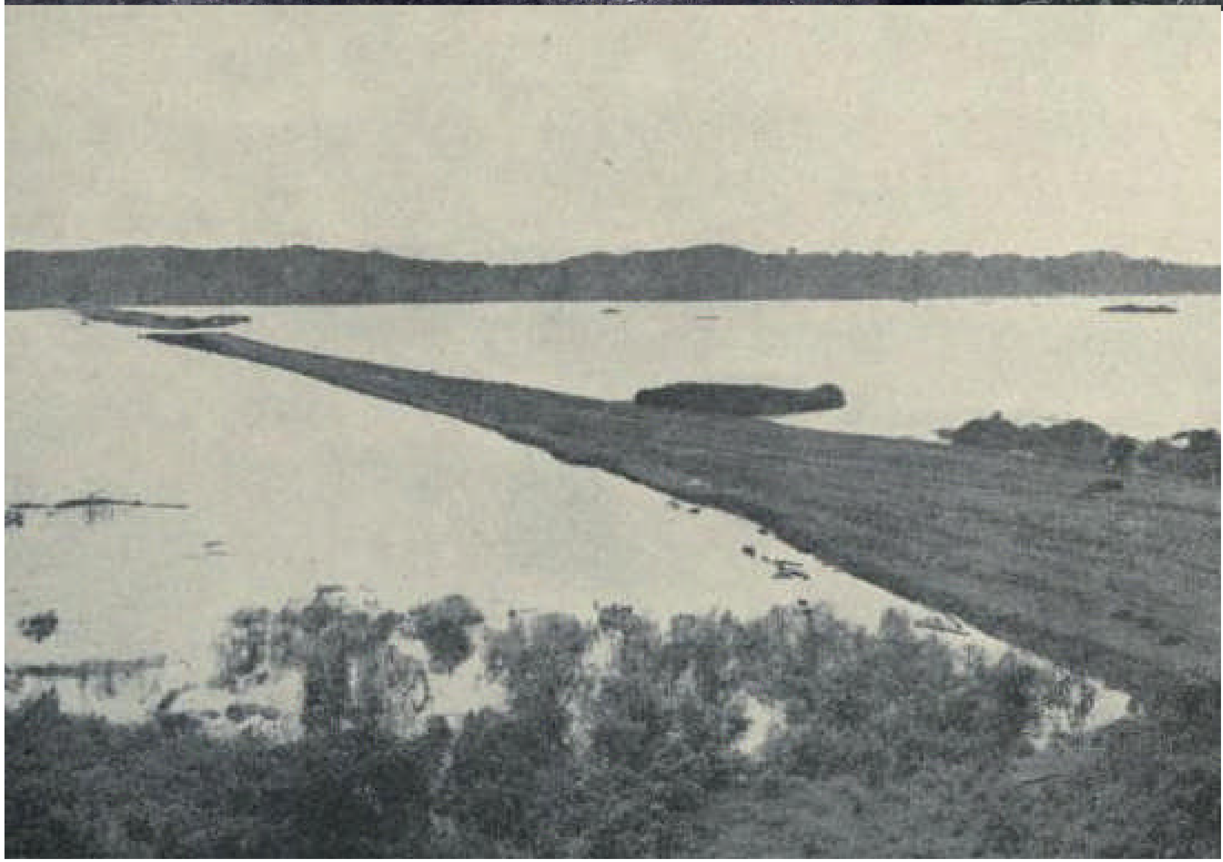
"…Gatun Lake has been formed by the dam before mentioned and when it stands at its normal level of 85 feet, the lake has a surface area of about 170 square miles…we proceed under our own steam, and soon we are moving at full speed through a channel dredged in the bottom of the lake, which is 1,000 feet in width for the first sixteen miles of our course. Then the channel narrows to 800 feet for about two and one half miles, 700 feet for the next mile, and 500 feet for the following three miles, which brings us to the great cut through the Culebra divide…"

***Scientific American Supplement,* November 23rd 1912**

RE: on June 13th 1913, the temporary sluice-ways through the *Spillway Dam* were closed and the lake, which had been held at approximately +48-feet for several months was allowed to rise to its normal height (+85-feet) which was achieved in December 1913. On the water-tightness of the lake basin depended the success of the entire project thus the rising lake was watched carefully. The fear was that there might be somewhere an exposed rock surface through which leakage might occur. It was with great satisfaction among the engineers that the lake rose to its full height without incident.





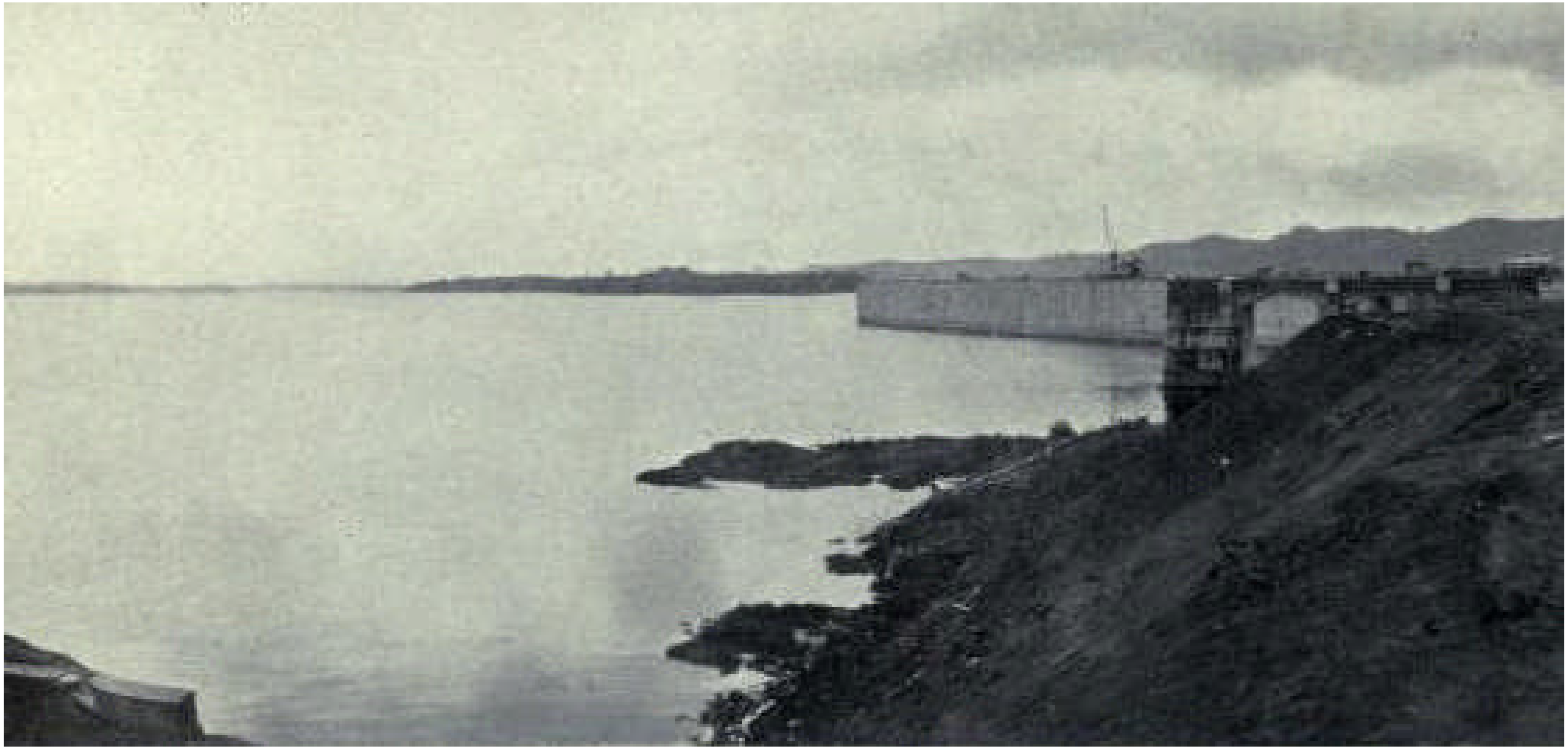


Top Left: caption: "Point No. 4, near Gorgona, looking south, showing completed Channel, 500 feet wide"

Top Right: caption: "Channel excavated at San Pablo during Dry Season, 1912. This channel is completed and is 800 feet wide, with bottom elevation at +40."

Left: caption: "Embankment of Old Panama Railroad excavated down to +35 in April and May, 1912"

The completion of *Gatun Dam* was a major accomplishment and, as predicted, creating *Lake Gatun* solved many problems. The raging *Rio Chagres* would no longer flood uncontrollably. When it rained, the water level of the lake would rise a foot or so and any excess water would spill over Gatun Dam and run out to sea. The temperamental Rio Chagres was finally tamed. Also, thanks to the creation of Lake Gatun, the *Chagres River* would not have to be deepened. The engineers saved a decade or more of digging that a sea-level canal would have required. Significant considering the fact that the bottom of the Chagres was hard rock. Once the dam was finished, the waters of the Chagres were trapped and slowly began to fill the valley using the waters of its watershed. Lake Gatun was created gradually between 1908 and 1913. When the waters finally touched the top of the dam, Lake Gatun had become the largest artificial lake in existence at 164 square miles with a shore line of 1,100 miles.

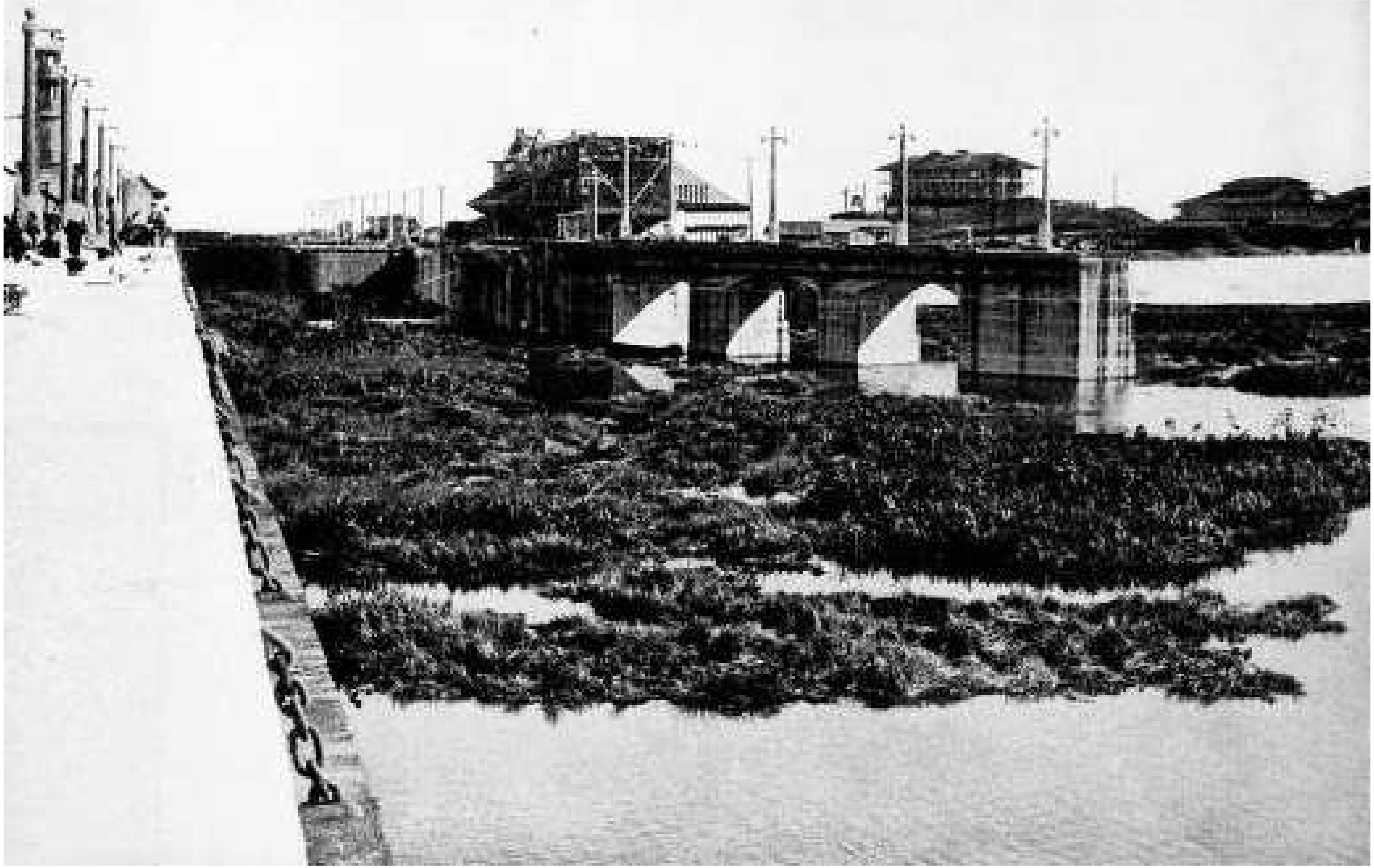


<u>Above</u>: caption: "Now turn away from the Locks, and look South from the top of the great dam over the rising waters of Gatun Lake. On the right are the guide walls to the Locks, and in the distance the many islands among which the ship channel makes its way. The Lake still has many feet to rise before its full and covers its maximum area of 164 square miles. Many native Panamans had to leave their houses as the water rose, and many miles of the Panama Railroad had to be moved to higher ground."

Approximating Switzerland's *Lake Geneva* in size, the *Chagres Valley* was not one large, level area. Rather, it consisted of many separate valleys with varying elevations. During the flooding process, it took several years for the rain to fill the topography of these separate valleys. Whenever one valley filled, the trapped *Chagres River* water would begin flooding the next lowest one. Before *Gatun Lake*, the Chagres Valley was a low-lying area that drained slowly when it rained. This vast swampland was ideal for two things; breeding cattle and breeding mosquitoes. The valley also had places that were heavily forested. In the process of flooding the valley, the waters killed-off all the low-lying forest. Submerged tree stumps form hidden hazards for any vessels that wander off the marked channels. Raising the waters 85-feet meant that all sorts of things were covered up. For example, several sections of the *Panama Railroad* were submerged. In 1908, Lieutenant *Frederick Mears* began directing the relocation of the Panama Railroad line to higher ground ahead of inundation of the existing tracks by the filling of Gatun Lake. Building the forty miles of new track was completed May 25th 1912, at a cost of nearly $9 million. The entire town of *Gatun* and many farms and native villages were submerged forever as well. Fortunately, *Panama* had a sparce population and relocation was not too much of a problem. Slowly but surely, the rising waters turned hills into islands; 100-foot hills became fifteen-foot islands. Some of Gatun's new islands were large while others just barely poked their nose above the lake's surface.

Floating Islands

Many square miles of swamp were permanently flooded by the lake, and a large portion of this old swamp bottom, made up of submerged logs and decayed vegetation (with high grass growing therein) rose with the lake and gave the appearance of large bodies of land, or islands in the lake. Acres of this old swamp bottom, with its green grass and small trees, would become detached and would be driven by the winds aimlessly across the waters (Deer were found on some of these islands). Where the ship channel through the lake crossed the area previously known as "Black Swamp," this floating material completely blocked the channel. It was in some places fourteen-feet thick and the snags, sticks and living vegetation were so completely matted as to be often immovable. The floating swamp bottom was, evidently, connected with parts that did not float. The only practical way to rid the lake of theses floating islands was to tow them to the *Spillway Dam* and let them be drawn over the dam out to the open ocean. It was no doubt an unusual sight to see a tug pushing acres of land of land towards the dam. However, it was impossible for small tugs to move the obstructions found in the shipping channel above the old Black Swamp. Larger, more powerful ships were used to tear the floating mass into pieces then the tugs pushed these loosened pieces to the dam. *Orchids*, which grew high up on the big trees, now became accessible from boats to the delight of flower lovers, but to the annoyance of hornets and bees.



<u>Above</u>: caption: ‘Floating Islands in Gatun Lock Entrance. These islands, formed of aquatic plants with entwined roots and a little soil, must be towed away by tugs and sent over the spillway lest they block navigation.”

The Unavoidable Daily Loss of Water

“The magnitude of the great lake at Gatun, on the Panama canal, which is now beginning to fill up behind the Gatun dam, is indicated by figures which have recently been compiled by the engineers on the unavoidable daily loss of water in the lake due to leakage at gates and locks, seepage through the lake bottom, evaporation, and the operation of the hydroelectric plant to obtain power and light. This daily loss will amount to 1,059,420,000 gal., or about 141,000,000 cu. ft. of water. The evaporation from the lake is placed at 1,000 cu. ft. a second; the leakage at 275 cu. ft.; the seepage at 85 cu. ft., and the amount used by the hydroelectric plant at 275 cu. ft…New York, Chicago and Philadelphia each use between 500,000,000 and 550,000,000 gal. of water per day for all purposes, or about half the daily wastage from Gatun lake.”

***Popular Mechanics,* January 1913**

“Conjectures as to how the level of Gatun Lake, and consequently the operation of the canal itself, will be affected by evaporation have been set to rest by the effects produced during the past dry season on the Canal Zone, during which time both the Gatun and Miraflores Lakes were practically at operating level with maximum surface exposed to evaporation, while the run-off from the watershed was the smallest known in 25 years. A careful analysis of the data obtained during this season shows that any fears that evaporation might have a serious effect on the operation of the canal are groundless. The run-off amounted to 17,000,000,000 cu. ft., which is only 61 percent of the water coming into the lake during a normal dry season. In spite of this fact it is estimated that if the canal had been open to traffic with 48 full lockages a day, and the Gatun hydroelectric plant in full operation, the water depth would not have fallen to less than 39 ft. in Culebra cut or the shallowest parts of the channel through Gatun Lake, a depth that is ample for any vessels that could be passed through the locks.”

***Popular Mechanics,* October 1914**

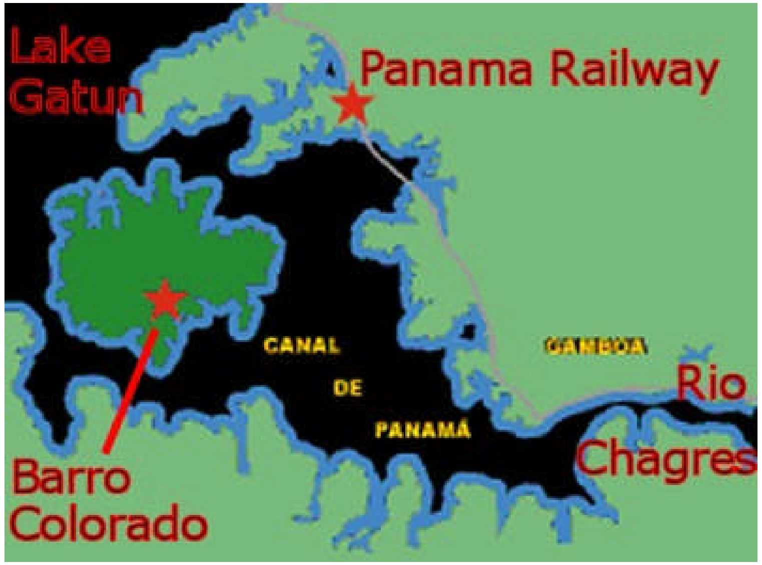
"It is interesting to note that the estimates that were made by French and American meteorologists before the Panama Canal was built regarding the available water supply in that region were substantially correct, as is shown by the careful check which has been kept since the canal has been in operation. Rainfall and evaporation stations have been established over the Gatun Lake watershed, which comprises a large area, and an account is kept of the gain or loss of water due to lockages, spillway waste, hydroelectric power generation, leakage, municipal needs, rainfall, evaporation, and increased or decreased storage water. In checking up it has been found that the estimates came within from 2 to 10 percent of the actual totals, which is considered reasonably accurate in view of many changes in the Canal Zone in recent years."

***Popular Mechanics,* April 1917**

Low Saddles

The rim of the lake at two places was only a foot or so above lake level and it was necessary to increase the height of the rim at these places. One of these "Low Saddles" was on the *Trinidad River* and no work was attempted at this saddle until the lake was near reaching its full height. The saddle was practically inaccessible by land. After creation of the lake, the necessary plant for building a dam could be transported to the site by water, provided a route could be located, cleaned out and blazed so that boats could safely follow it. It was no easy matter to locate this saddle. After much effort, it was finally located by having some native Indians go overland to the saddle and there they built fires, smoke from which could be seen long distances. The boats traveled through the tops of trees daily blazing a trail by boat to the saddle guided by the rising smoke. The rising water soon killed and rotted the trees creating a macabre atmosphere. The hilltops, which were now islands gave the native Indian huntsmen an ideal hunting ground. Game in the *Chagres Valley* consisted of *Deer*, *Tapir* and several members of the cat family. The Deer and Tapir were good swimmers and those that the hunters with their dogs didn't kill would, eventually, take to the highlands around the lake.

Barro Colorado



Since the flooding process was gradual, the flood posed little danger for native animals. When the waters grew high enough to pose a threat, the animals simply headed towards the nearest high ground. Not surprisingly, the most popular hill was the widest and tallest one; *Barro Colorado*. Once the animals made a new habitat there, they became permanently trapped as the waters continued to rise around them. Not that the animals minded since the island was soon surrounded by so much water it became a sanctuary for them - no predators could reach the island. Only larger animals like *Jaguars* disappeared from Barro Colorado after the lake was established. Because Barro Colorado was so isolated, the island became a perfect spot for a game preserve and a place to study nature undisturbed by humans. Thus, Barro Colorado became one of the world's first biological reserves.

The *Smithsonian Tropical Research Institute* has a permanent center on *Barro Colorado* island dedicated to studying rainforest ecosystems (above). Because the island's diverse ecosystem has been little altered by humans, Barro Colorado has been studied since the island's formation within a wide variety of biological disciplines. Many scientific studies have been conducted to document the changes in the species composition of the island. The lake itself is home to *Crocodiles* as well as *Manatees*. The favorite fish is *Peacock Bass*, a species introduced from *South America* that is popular with fishermen. Fishing charters for *Bass, Snook* and *Tarpon* can be arranged from the town of *Gamboa.*

Gatun Locks

"…To lift ships from the sea into Gatun Lake, over the dam, the great Gatun Locks have been constructed. Although these locks are perhaps the most wonderful engineering feature of the entire canal, no new principles were involved in their construction – they are simply hydraulic locks, working in the same manner as the first hydraulic locks designed by Leonardo da Vinci, more than 400 years ago…"

***Popular Mechanics,* December 1913**

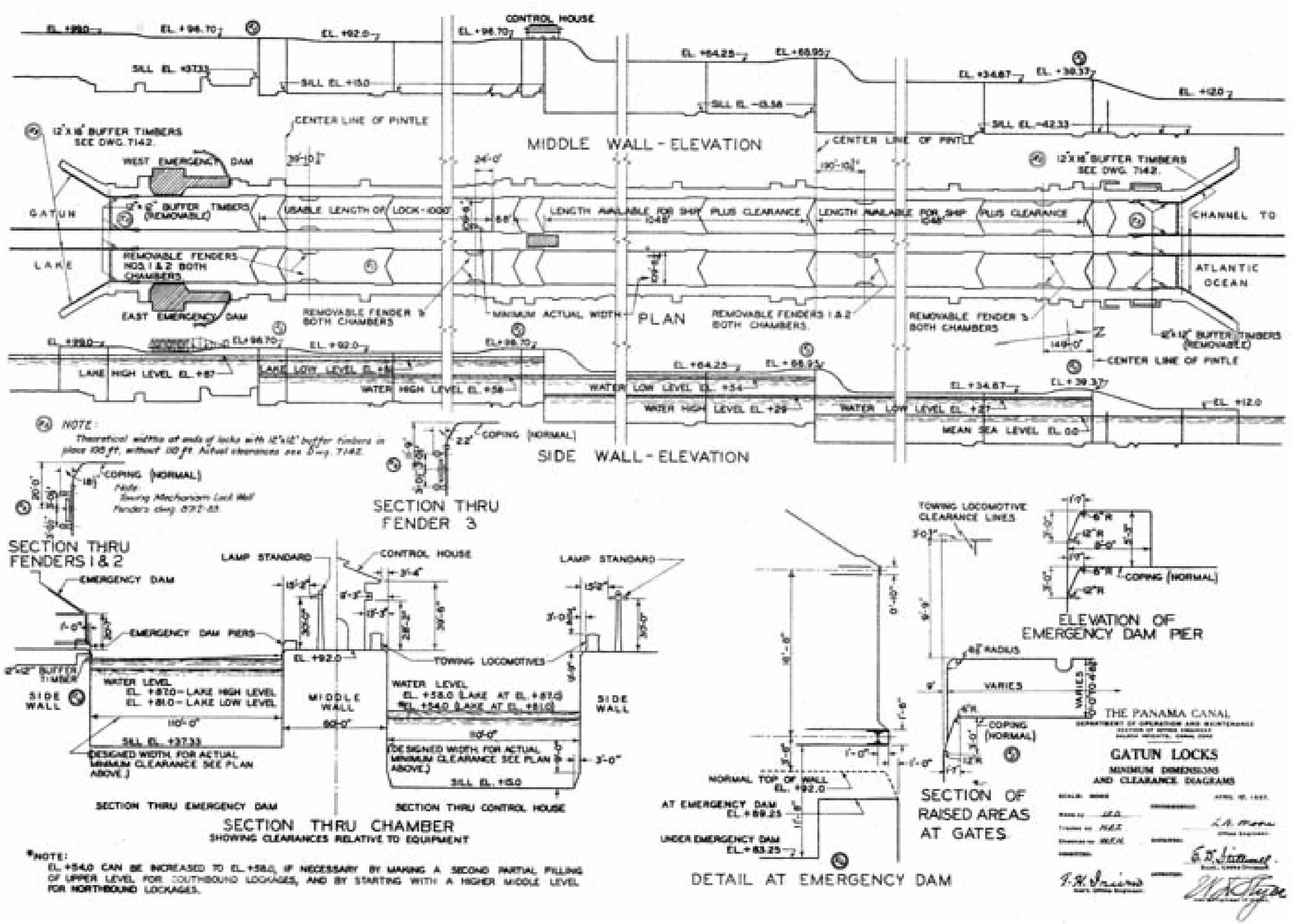
"…These locks, like the ones at the Pacific end of the canal, are built in pairs, so that the danger from accident is halved and the efficiency doubled…"

Popular Mechanics, **December 1913**

RE: the *Gatun Locks*, like the other locks at *Pedro Miguel* and *Miraflores*, took their name/s from geographic names already in common use before the canal was built. All lock chambers have the same 110-feet by 1K-feet dimensions and they were built in pairs. That is, two lanes of chambers run side-by-side to accommodate two lanes of ship traffic, either in opposite directions simultaneously or in the same direction, depending on transit needs. Gatun Locks consists of three steps or pairs of chambers. The locks have been called the structural triumph of the *Panama Canal* and are a unique aspect of the waterway. At the time of their construction, their overall mass, dimensions and innovative design surpassed any similar existing structures, and they are still considered to be an engineering wonder of the world.

“According to the report of the naval member of the Isthmian Canal Commission, the locks of the Panama Canal as first planned and even later enlarged will be too narrow to accommodate the big vessels now being built or planned. The building of the giant ‘Lusitania’ and ‘Mauretania’ and the knowledge that other Atlantic transportation lines have already made plans for even more huge vessels is believed to be the basis for the growing belief that the plans must call for longer and larger locks. The locks as originally planned by the commission were to have been 900 ft. long and 95 ft. wide. Later the engineers in their designs increased the width to 100 ft. and the length to 1,000 ft.”

Popular Mechanics, **December 1907**



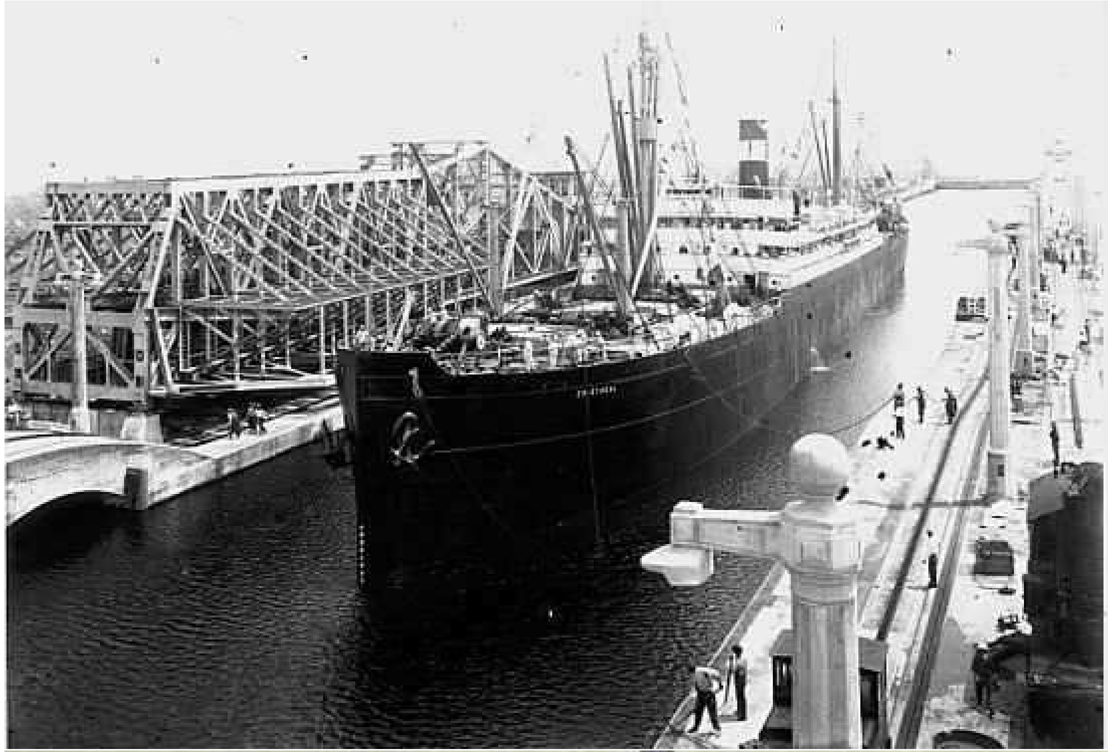
Above: **Gatun Locks Plan, Elevations & Sections**

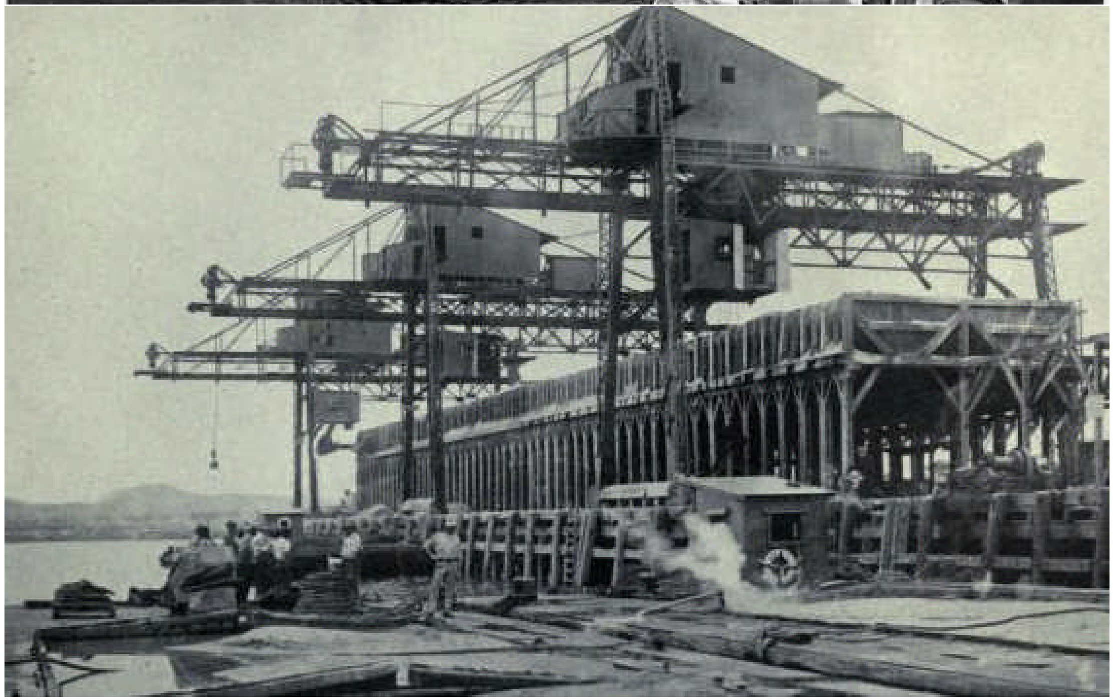
Interesting Instances

"…Concrete is not altogether a recent acquisition as a building material. The use of concrete and stucco was common thousands of years ago, and recent excavations in Mexico have brought to light interesting instances of the utilization of concrete in the building of houses and elaborate tombs, all of which had cement floors."

***Popular Mechanics,* May 1908**

The first concrete for the *Gatun Locks* was laid on August 24th 1909; it took four years to construct. Until the late 1800s, concrete - a combination of sand, gravel and cement, had been little used in building and then mostly as a leveling and/or fill material. There was still a great deal to be learned and numerous decisions to be made in the science of concrete which requires specific, controlled measurements of water/cement/sand ratios and aggregate size as well as careful timing for a streamlined delivery system from source to site. The concrete work in *Panama* was an unprecedented challenge that would not be equaled in total volume until construction of *Hoover Dam* in the early 1930s. In spite of the newness of the science, the results were extraordinary. The concrete of the *Panama Canal* locks and spillways is in near perfect condition after decades of hard use in a tropical climate, which to present-day engineers is among the most exceptional aspects of the entire canal. Canal commission ships; the *Ancon* and the *Cristobal*, brought all of the cement to build the locks, dams and spillways from *New York*. On the *Atlantic*-side, gravel and sand came by water from areas east of *Colon*, the gravel from a large crushing plant in *Portobelo* and the sand from *Nombre de Dios*. For the *Pacific*-side, rock was quarried and crushed at *Ancon Hill* and the sand came from *Punta Chame* in *Panama Bay*.

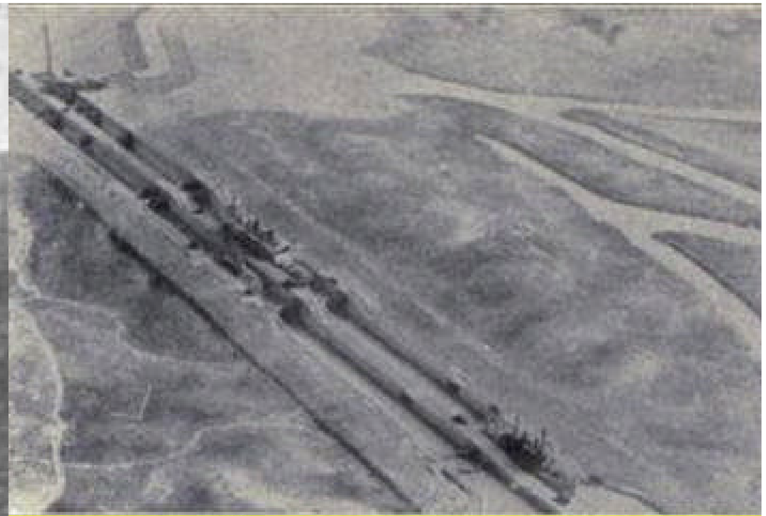




<u>Top Left</u>: *S.S. Cristobal* passes through *Gatun Locks*, August 1914

<u>Top Right</u>: *S.S. Ancon* passes through *Pedro Miguel Locks*, August 1914

<u>Left</u>: caption: "Sand for making concrete is dredged out of the sea bottom and loaded on barges, as shown in the foreground. This machine transfers it to sand trains, which take it wherever needed."



The *Panama Canal* has six sets of locks. The three locks at *Gatun* lifts ships a total of 85-feet up or down, about the height of an eight-story building. The largest ships that can fit in the locks are called "Panamax" ships.

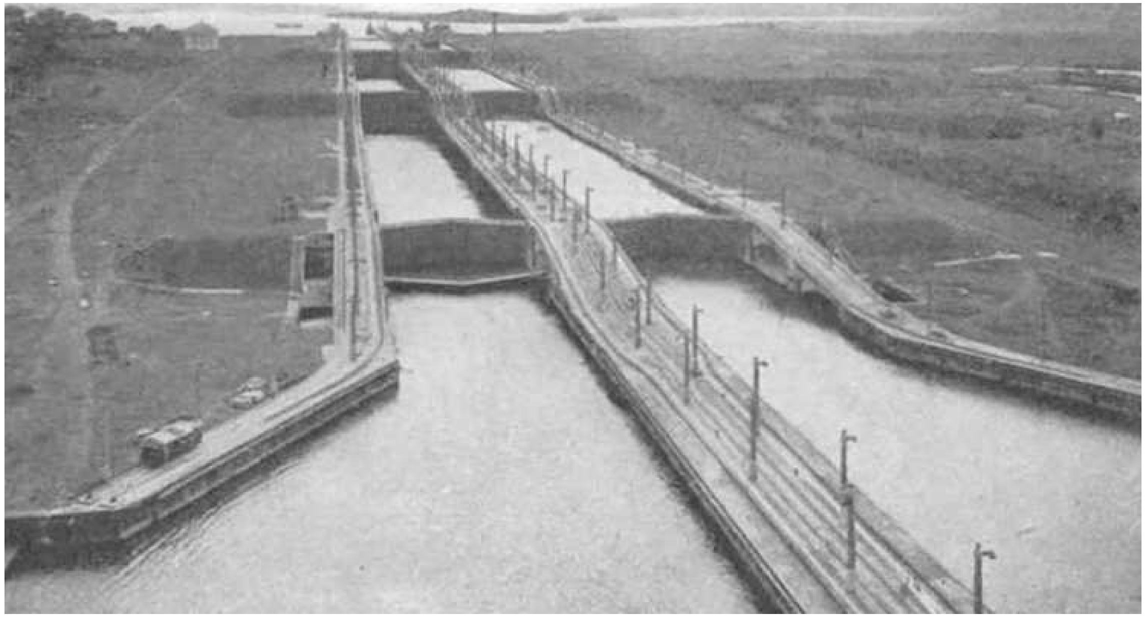
<u>Above Top</u>: caption: "Model of Gatun Locks, with Gatun Dam in the distance"

<u>Above Bottom</u>: "Panamax" diagram

<u>Left</u>: caption: "View of how the Gatun Locks should look, Scientific American, Nov. 9, 1912."

“…A vessel entering from the sea passes first into the lower chamber. The great gates are closed behind the ship by electric power, two leaves, each 65 ft. long, swinging in to form a V-shaped gate, the point of the ‘V’ being toward the stern of the ship, while ahead of it another gate towers high above the level of the water in the second chamber. The ponderous gates once closed, the powerful electric machinery, operated from pits left in the solid concrete of the lock walls, turns the valves that lets the water from the higher levels flow into the lower chambers. Culverts formed in the concrete – tunnels large enough to let a railroad locomotive through – carry the water down. Through ‘wells,’ or openings in the floor of the lock chamber, the water flows in, filling the chamber to the level of the next higher one, and lifting the ship with it. The second set of gates is then opened, the ship floated into the second chamber, the gates closed behind it, and again it is lifted. Once more this process is repeated before the ship reaches the level of Gatun Lake…”

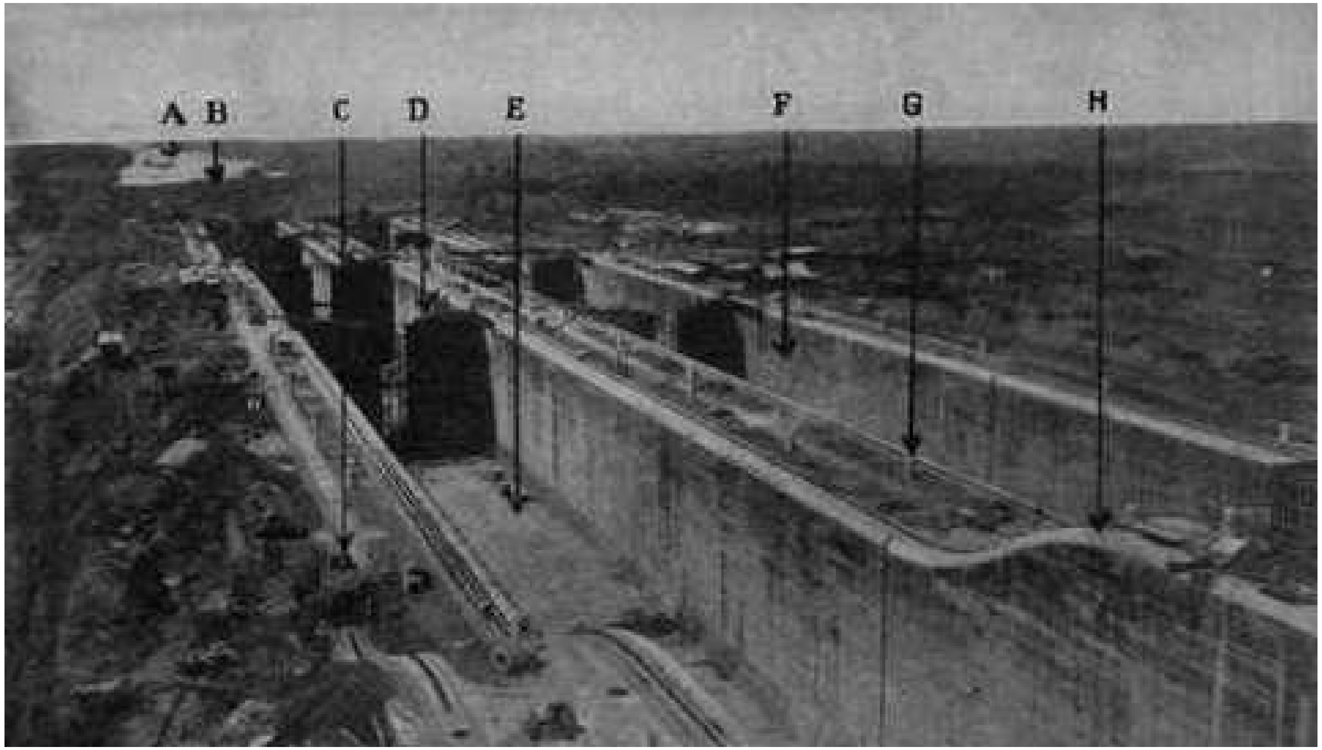
***Popular Mechanics,* December 1913**



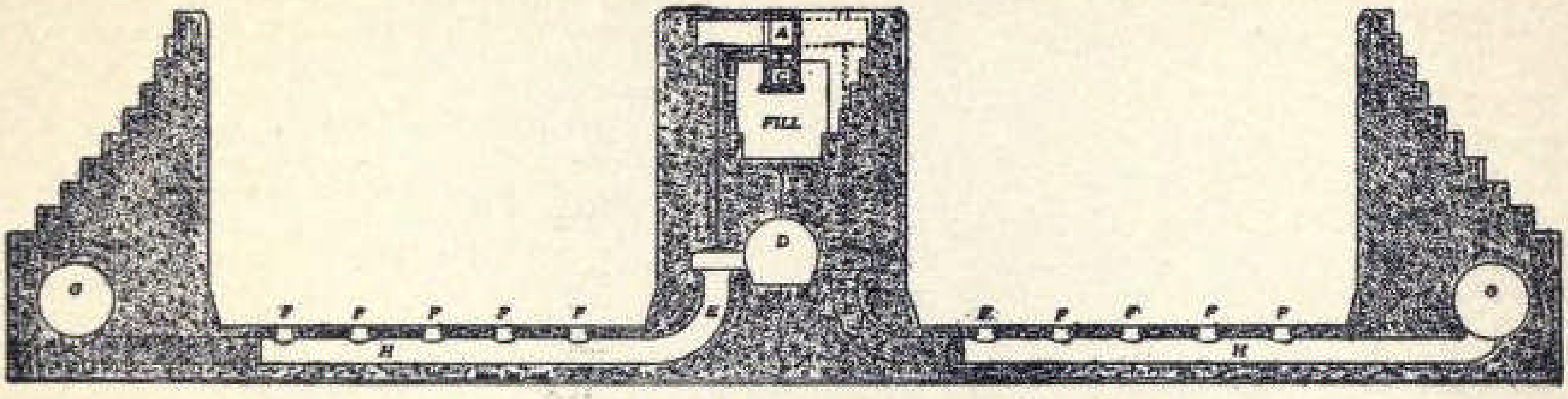
<u>Above</u>: caption: "General view of the Gatun Locks, looking south" (ca. 1920). The *Gatun Locks* on the *Panama Canal* raise or lower ships 85-feet in three stages. In theory, two sets were built to allow simultaneous traffic in opposite directions, but in reality some sections of the canal are too narrow for ships to pass in opposite directions, so traffic tends to be one way in two lanes. Three men; Lieutenant Colonel *Harry Hodges*, *Edward Schildhauer* and *Henry Goldmark*, were largely responsible for the engineering design of the locks. The work took years of advanced planning. Hodges was an Army officer and an invaluable assistant to Colonel Goethals. He had overall responsibility for the design and construction of the lock gates, arguably the most difficult technical responsibility of the entire project. Goethals was to state that the canal could not have been built without Hodges. Schildhauer was an electrical engineer and Goldmark was in charge of lock gate design.

“…These Gatun Locks are not only the largest of their kind, but together comprise the largest monolithic concrete structure ever built, exceeding in volume the great Assouan Dam and bulking two-thirds as large as the Great Pyramid, which is still the world’s largest masonry structure…”

Popular Mechanics, **December 1913**



<u>Above</u>: caption: "'Gatun Locks.' A. Completed sea-level section of canal, seven miles long from Atlantic Ocean to Gatun Locks, where by a series of three locks vessels are raised to Gatun Lake 85-feet above sea-level. B. Small area of land to be dredged away as soon as Gatun Locks are completed. C. Electric towing motor, four of which will tow each vessel entirely through the locks. They run on cog rail along the lock walls. D. Lock gate under construction. E. Floor of first lock from Atlantic-side. Note holes in floor for admitting the water. F. Lock for vessels coming from Pacific-side. G. Base on which concrete posts will be erected for electric lights. A row of lights on all sides of the locks will make operation at night as safe as day. H. Incline from locks of different levels up and down which the towing motors run on cog rails."



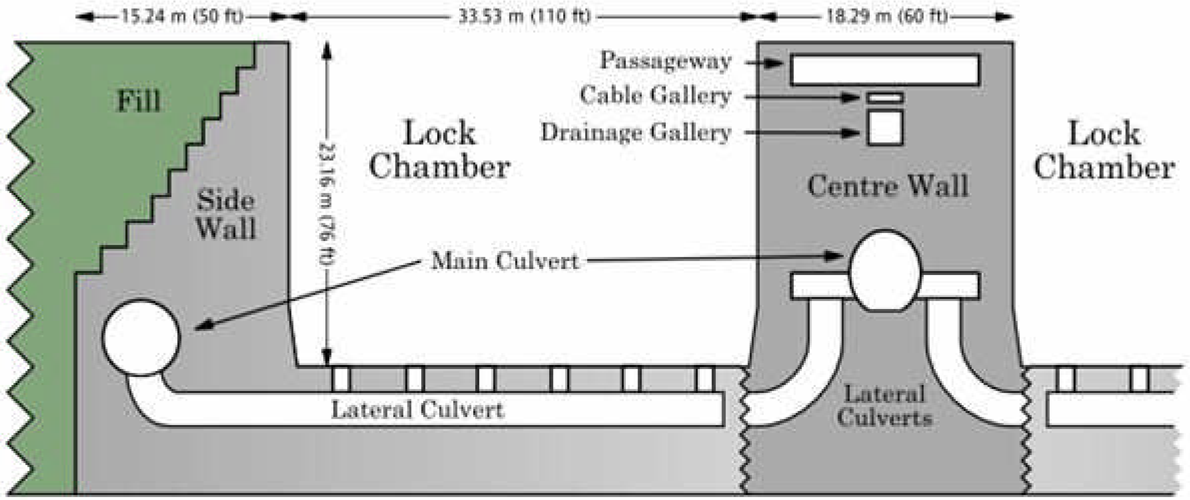
Cross Section of Lock Chamber and Walls of Locks.

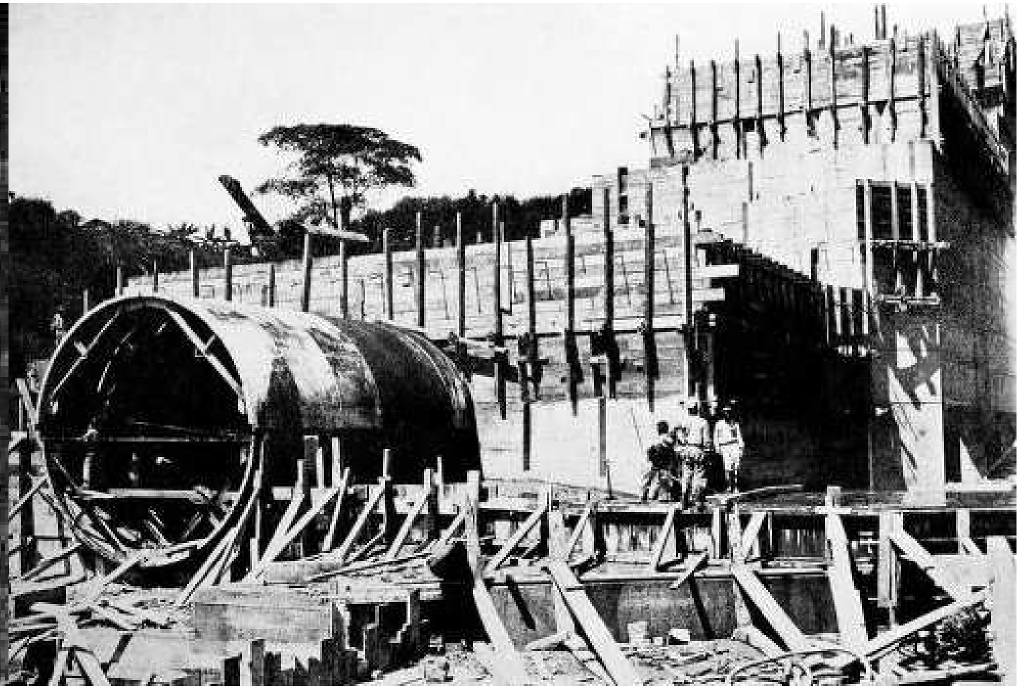
A—Passageway for operators.
B—Gallery for electric wires.
C—Drainage gallery.
D—Culvert in center wall.
E—These culverts run under the lock floor and alternate with those from sidewalls.
F—Wells opening from lateral culverts into lock chamber.
G—Culvert in sidewalls.
H—Lateral culverts.

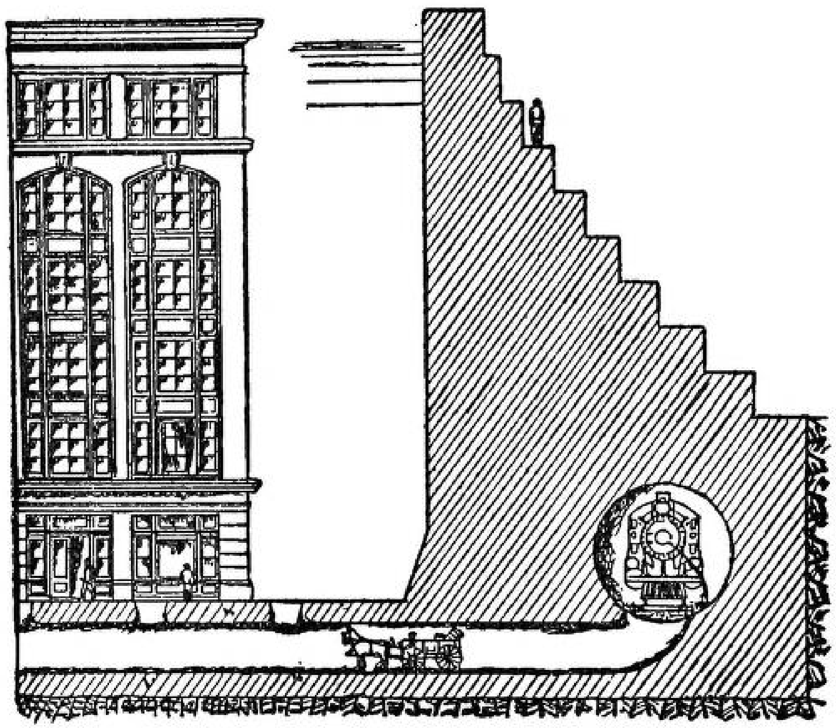
No pumps are used at the *Panama Canal*, the water does its work by force of gravity alone. Water is admitted or released through giant tunnels, or culverts, eighteen feet in diameter, running lengthwise within the center and side walls of the locks. Branching off at right angles to these culverts, smaller culverts run laterally under the floor of each lock chamber, twenty to each chamber. Each cross culvert has five openings for a total of one-hundred holes in each chamber for the water to enter or drain, depending on which valves are opened or closed. This large number of holes distributes the water evenly over the full floor area of the lock to control turbulence.

Cross-section of Lock Chamber and Walls, Panama Canal

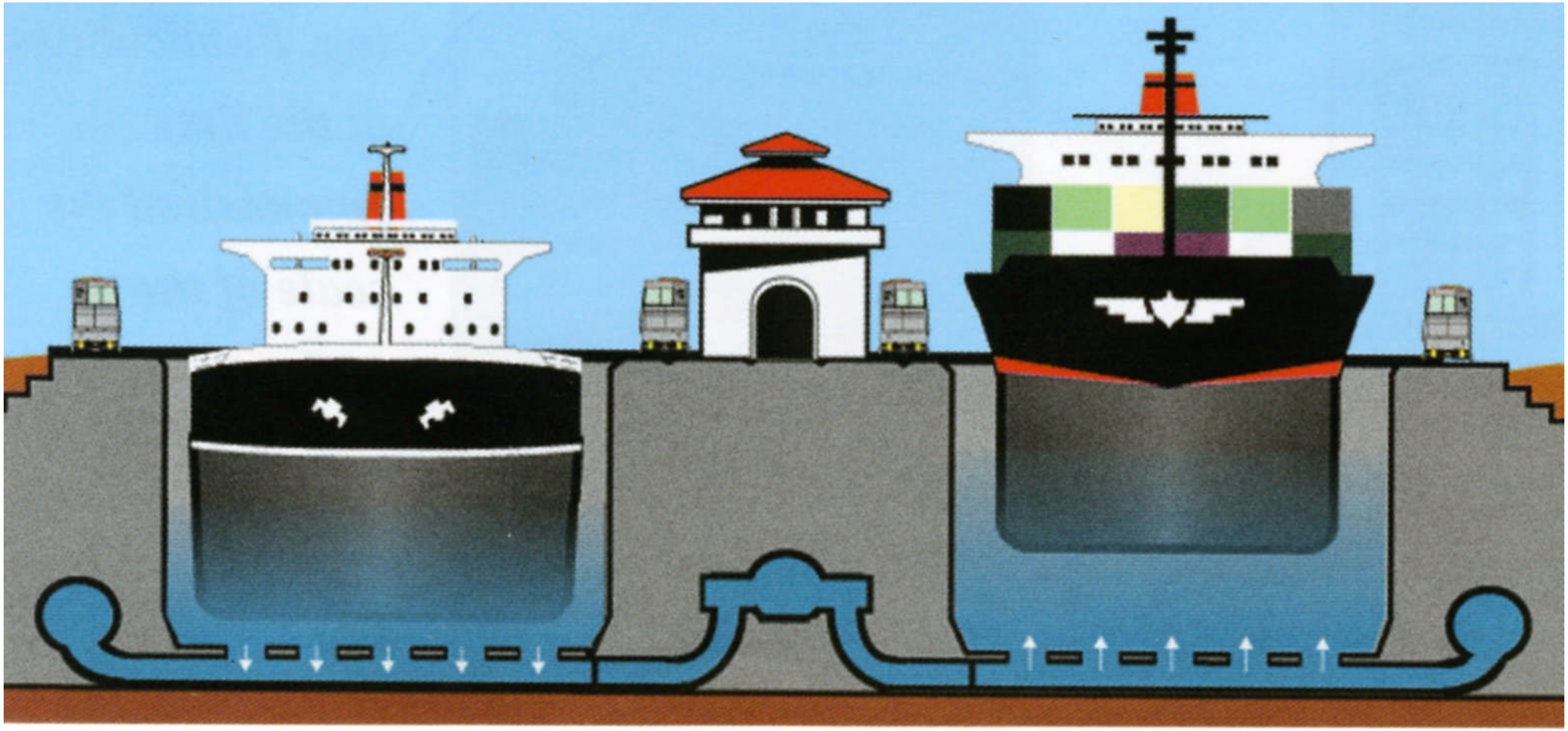
A section across the width of the locks, showing the culverts for filling and draining the chambers. One side is shown; the other is the same.







<u>Top Left</u>: caption: “A Culvert in the Lock Wall”
<u>Top Right</u>: caption: “‘Detail Construction of a Lock.’ The great tube, later covered by concrete, carries the water for filling the chamber.”
<u>Left</u>: caption: “Comparison between side wall of lock and a six-story building”



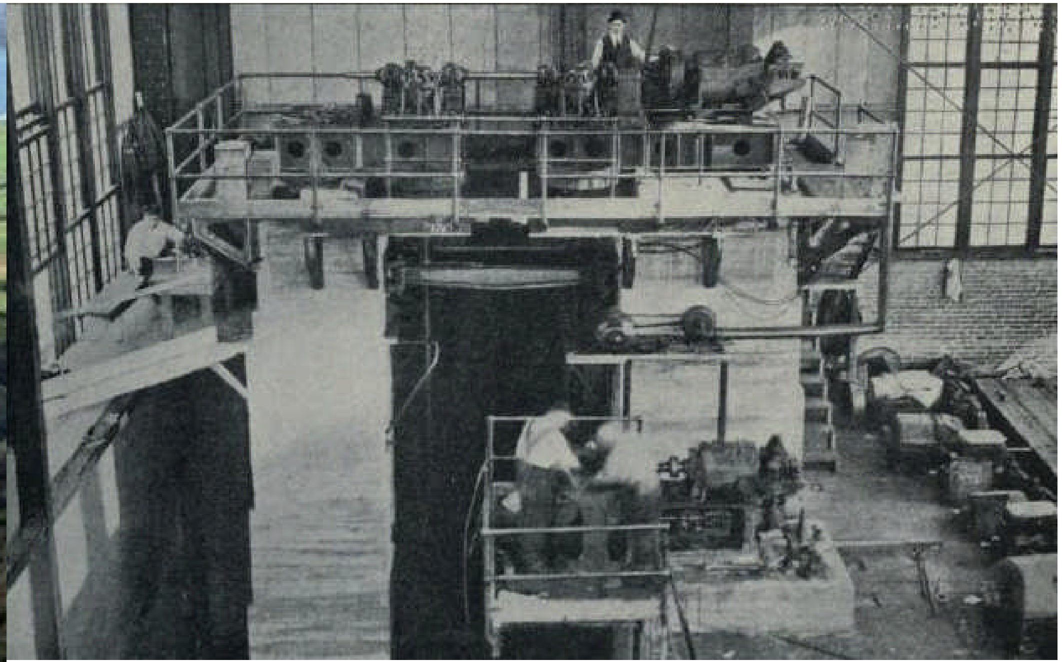
"…Vessels will be lifted or lowered in the locks at the rate of 3 ft. a minute, and the total time for passing the Gatun Locks will be about an hour and a half…"

***Popular Mechanics,* December 1913**

RE: to fill a lock, the main valves at the lower end of the chamber are closed, while those at the upper end are opened. The water pours from the lake through the large culverts into the cross culverts and up through the holes in the chamber floor. To release the water from the lock, the valves at the upper end are closed while those at the lower end are opened.

"Ninety-eight electric motors will be in operation twice during each lockage at the Gatun Locks, in raising a ship through a vertical distance of 85 ft. from the sea-level to the level of the lake. These motors are used in lowering fender chains, opening and closing six pairs of gate valves, 30 cylindrical valves, and six pairs of gates."

***Popular Mechanics,* July 1912**



Above: caption: "Rising Stem Gate Valve Machine. The average time of filling and emptying a lock will be about fifteen minutes. The valve system will furnish perfect control of the water flow."

Left: the lifting or lowering process is done in three stages on both ends of the canal since 85-feet would be too much to do at one time; the weight of the water would cause tremendous hydrostatic pressure against the steel gates. By using three stages to lower or raise a ship, the combined weight of the ship and the water is sufficiently reduced to minimize pressure on the gate doors.

Plimsoll Marks

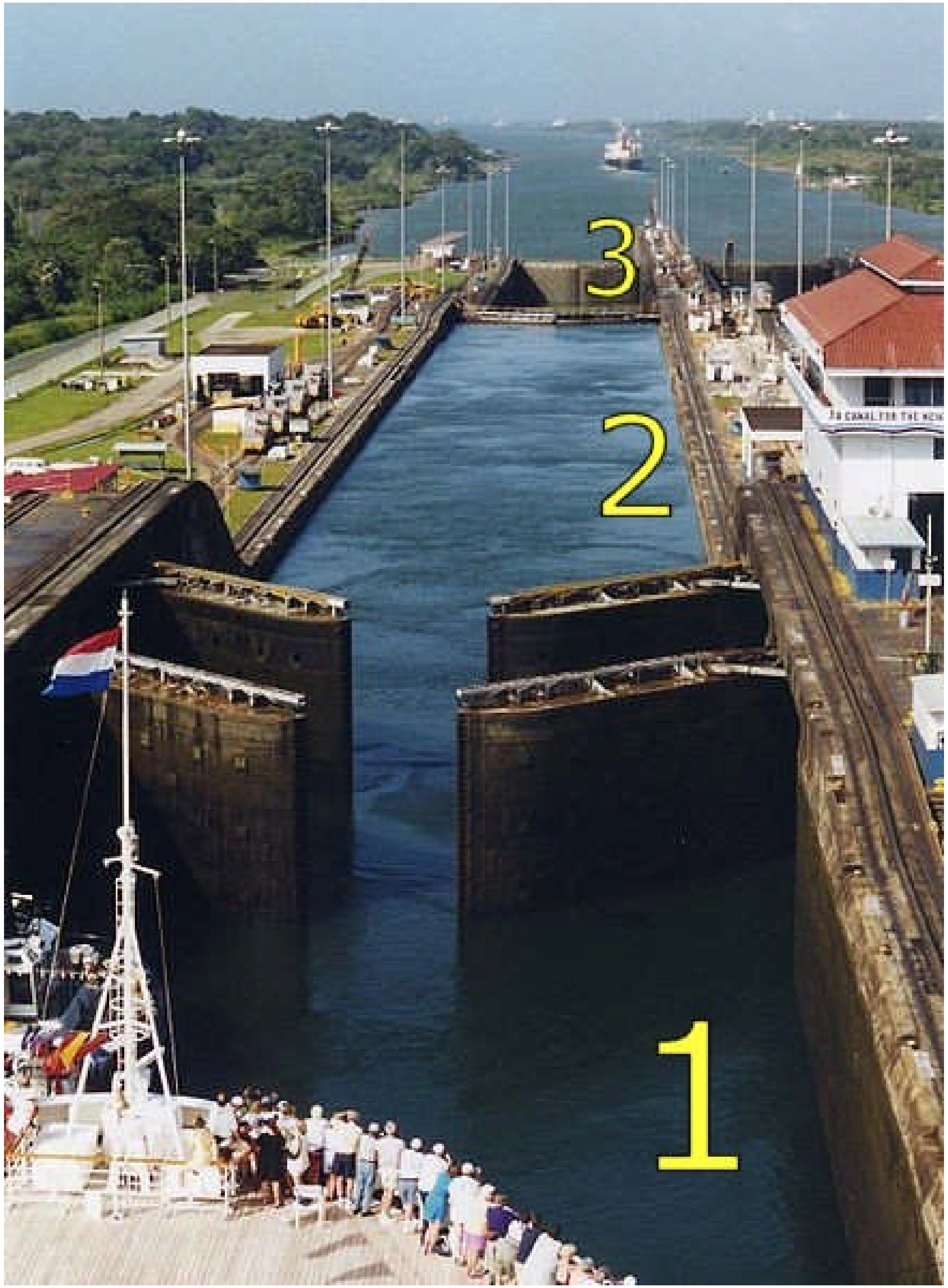
“…Once in Gatun Lake the ocean-going ship finds itself in fresh water – as, indeed, it has been since entering the second lock chamber. Instead of 40 ft. of water over the sills, the upper lock chambers have 41.5 ft., since a ship drawing 40 ft. in salt water will sink under the same load to about 41.5 in fresh. Ships loading for passage through the Panama Canal will have to carry two ‘Plimsoll marks.’ These are marks painted on ships’ sides indicating the depth to which it is safe to load. The fresh water load line is from 8 to 15 in. below that for salt water, depending on the draft of the vessel. Another effect of the fresh water in Gatun Lake will be to remove the barnacles from the ship’s bottom. One of the most troublesome and expensive drawbacks to salt-water navigation is the accumulation of these marine molluscs, which in time may seriously retard the speed even of a high-powered steamship unless it is sent to dry dock and scraped after each voyage. But barnacles die and drop off in a few hours in fresh water, and before the ship has passed through the canal to the Pacific Ocean it will have lost this outboard burden…”

Popular Mechanics, **December 1913**

A Haircut and a Shave

“…When a ship is docked merely for inspection and cleaning the shipyard workers call the job a ‘haircut and a shave’ and that’s exactly what it amounts to, on a vast scale. As much as seventy or eighty tons of sea grass and barnacles may attach themselves to a hull between inspection periods. Such growths slow down the ship’s speed and it is cheaper to trim them off than it is to drag them through the water. Marine parasites grow fastest on ships traveling in the tropics and they flourish when ships are laid up for long periods in still water. Occasionally shipyard men find that an oyster bed has started to grow on a hull. Now and then live fish that have been feeding on the growths refuse to leave and are found as water in the dry dock recedes. Most marine paints contain large amounts of poison that slow down such growths. A trip through the Panama Canal, into the Great Lakes or up any fresh water stream kills the salt-water growths.”

***Popular Mechanics,* October 1939**

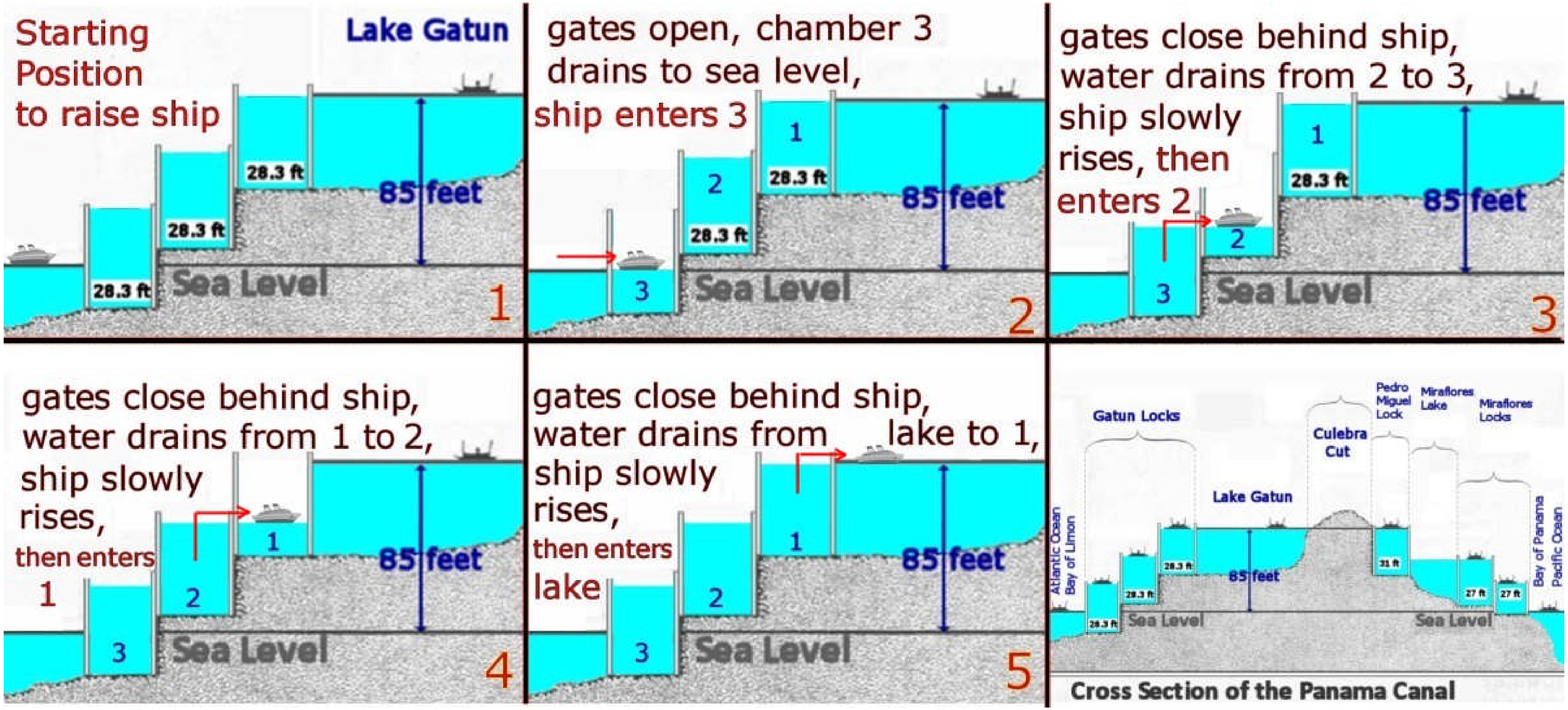


In the photograph at left, a cruise ship (foreground) is headed out to the *Bay of Limon*. Chamber 1 has just drained down to the level of Chamber 2. Since the water level/s between Chamber 1 and Chamber 2 are equal, the iron gates open to permit the ship to move forward into Chamber 2. Once the ship is in Chamber 2, those same gates will close behind the ship. Chamber 3 ahead appears empty. Once the ship has moved completely into Chamber 2, the waters in Chamber 2 will drain down into Chamber 3. The ship will sink in Chamber 2 until the water levels become equal, only then will it move into Chamber 3. Chamber 3 will then sink to match the sea-level to allow the ship to exit the locks.

Achilles Heel

"…Eight wet months and four dry months are shown by the tables of 22 years' observations on the Isthmus, and these observations indicate that from January to April of each year the aggregate losses of water from the lake will be greater than the inflow. Making an allowance for the water used in 48 lockages a day, which is the most that can be handled in the canal, the engineers find that the lake will always have enough water, even in the dry season, to allow 30 ft. in the canal…"

***Popular Mechanics,* January 1913**



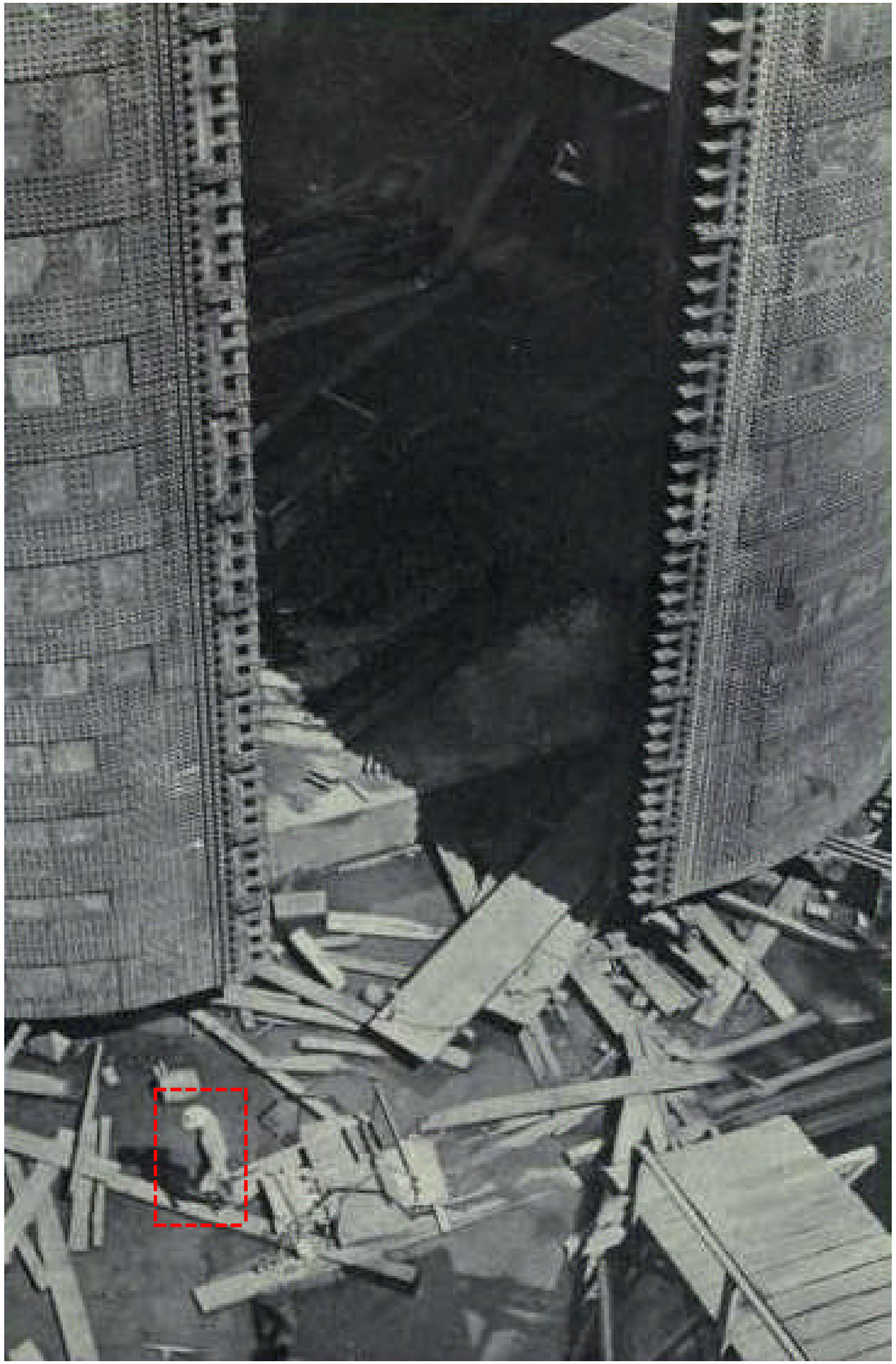
The weakness in the system is water. There are six locks total at *Gatun* and each one measures 110-feet across and 1K-feet in length, with solid steel gates six-feet thick. Each passage through the canal requires 52 million gallons of freshwater to float the ship through the locks. This is the equivalent of filling two-hundred Olympic-size swimming pools (an Olympic-sized swimming pool holds 253,125 gallons of water). Whether a ship is raised or lowered, the water used in the process will eventually go out to sea. Before it was dammed, the *Rio Chagres* flowed out to sea. However, now water has to serve the *Pacific*-side locks as well. In other words, the demand on *Chagres River* water has doubled since the canal opened. The big question is: *does it rain enough to replace the water?* Changing climate patterns, deforestation and increased shipping demands are very real concerns for the future of the canal's fragile water supply.

"Steady growth of traffic through the Panama canal, expected to increase at the rate of 1,000,000 tons a year, is responsible for government plans to construct another dam twelve miles above Gatun Lake. The project includes a dam 2,700 feet long and thirteen small saddle dams, and will cost $15,500,000. It will be known as Madden dam and will insure a reserve water supply sufficient to care for all canal traffic for the next century. Useful reservoir capacity in Gatun Lake is 32,000,000,000 cubic feet and the new reservoir, to cover twenty-one square miles, will add 22,000,000,000 cubic feet for the operation of the locks, and at the same time will help control floods on the Chagres river and supply hydroelectric power for the Canal Zone…The reservoir level of Madden dam will be 240 feet above the sea."

Popular Mechanics, **July 1931**

Above: in 1935, the *Corps of Engineers* built *Madden Dam* in the *San Blas Mountains* to create *Alahuela Lake*. This reservoir traps the *Chagres River's* waters closer to its source. It has become an essential element in assuring that the canal has an adequate water supply. The lake has a maximum level of 250-feet above sea-level and can store one-third of the canal's annual needs.

Lock Gates

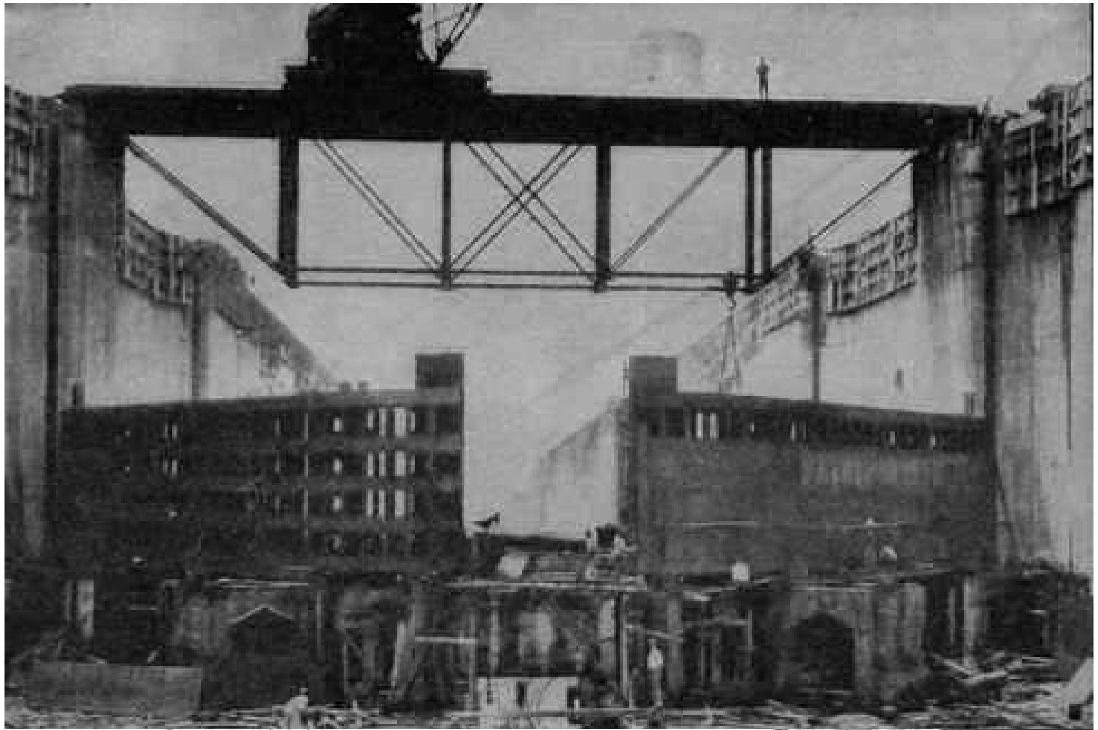


"…In all there are 46 lock gates at Panama. These are made of steel plates riveted to structural steel frames, and so strongly have they been constructed and so carefully braced that the largest of them, weigh 1,483,700 lb., droops less than one-eighth of an inch at the extreme end, 65 ft. from its pintle, or hinge. The total weight of the gates is 118,488,100 lb., and their cost, including the cost of erection, was $5,374,474, or more than four cents a pound…"

***Popular Mechanics,* December 1913**

Left: caption: "Look down at a pair of the enormous gates, and notice how small the man in the white hat looks. Millions of rivets are necessary for these gates."

The lock gates (a.k.a. "miter gates" - because they close in a wide "V") are the canal's most dramatic moving parts swinging like double doors. The hollow, watertight construction of their lower halves makes them buoyant in the water, greatly reducing the working load on their hinges. All gate leaves are 64-feet wide by 7-feet thick. However, they vary in height from 47 to 82-feet, depending on their position in the lock. For example, the *Miraflores Locks'* lower chamber gates are the highest because of the extreme variation in the *Pacific* tides. The design and manufacture of all of the lock gates was one of the canal's great engineering challenges and one of its greatest triumphs. The simple yet powerful gate operating mechanism was designed by *Edward Schildhauer*. In its design he had no established model to go by yet every aspect of this critical mechanism had to be precision engineered and manufactured to work flawlessly and dependably. The gates had to swing easily, yet withstand enormous hydrostatic pressures.

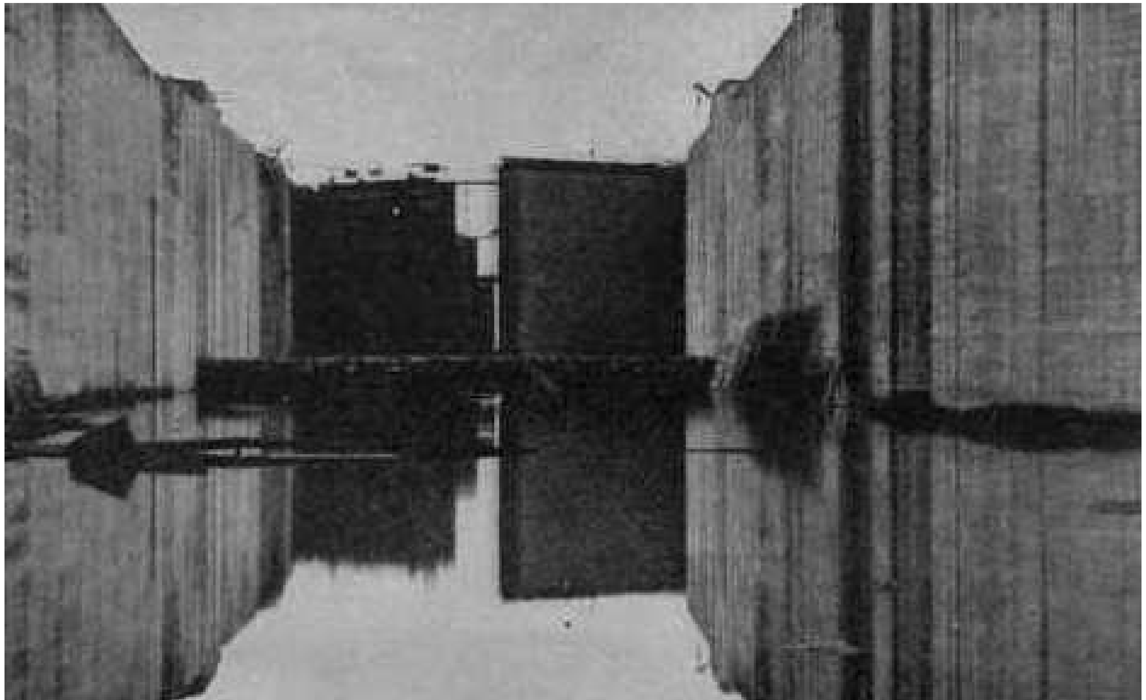


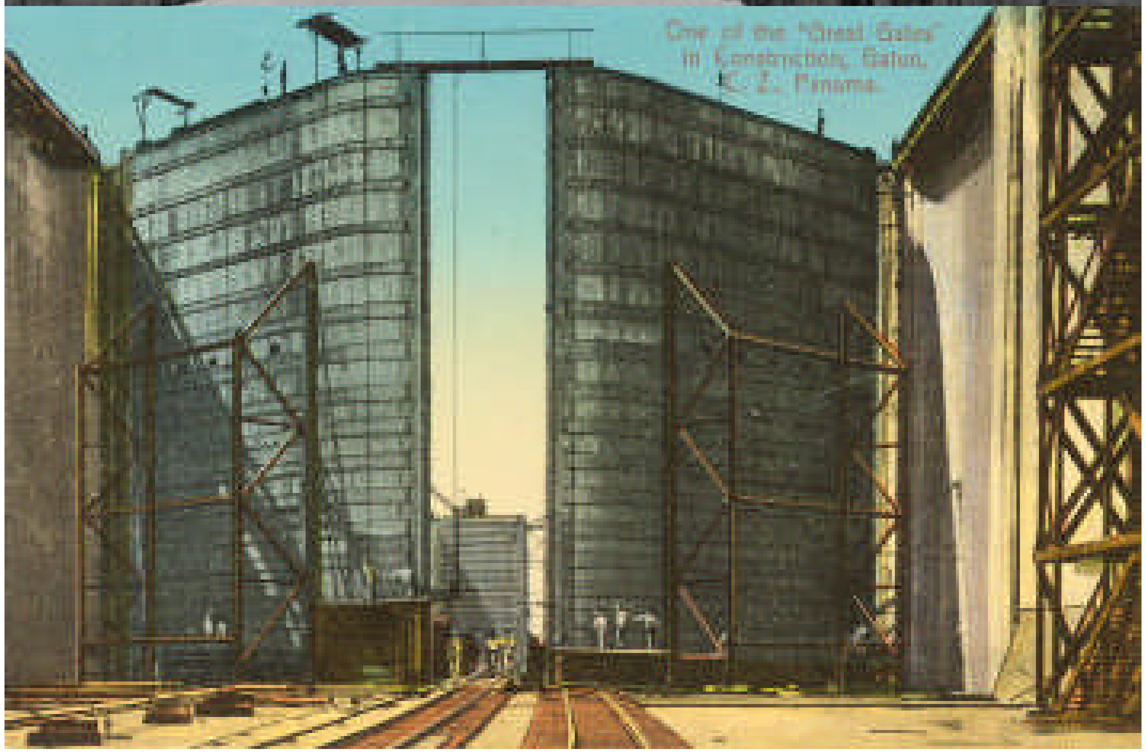
"Sixteen electric machines have been specially built for use in drilling and reaming rivet holes in the lock gates of the Panama Canal and are now in operation…Each of the machines weighs 6 tons and is designed to run on a standard-gauge track which is placed on a stage and swung from the top of the big steel gate on chains and brackets. It is claimed that each machine does the work of five ordinary reamers…The two disting-uishing features of the machine are the range of nine speeds, and the fixed spindles arranged to space the rivet holes in the lock gates uniformly."

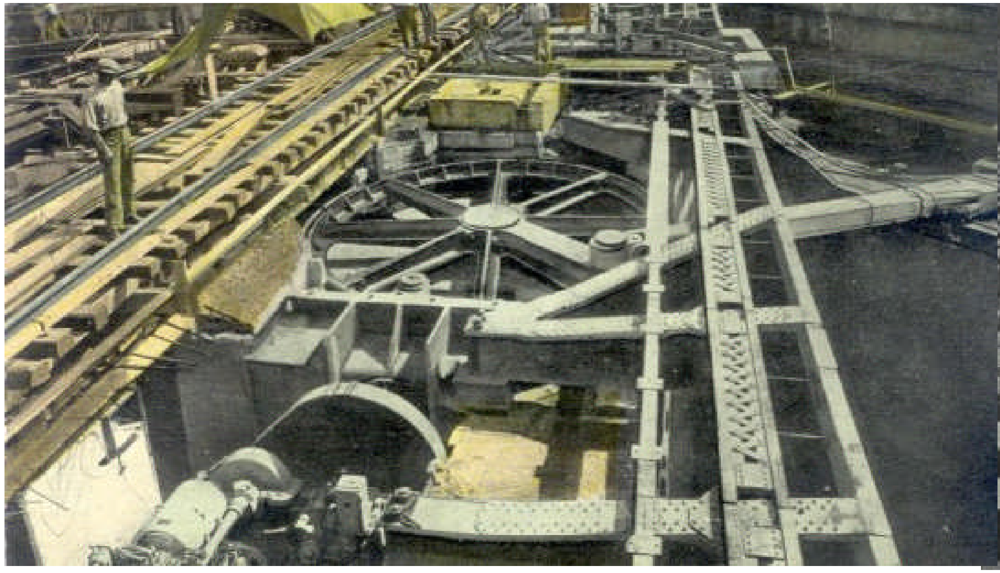
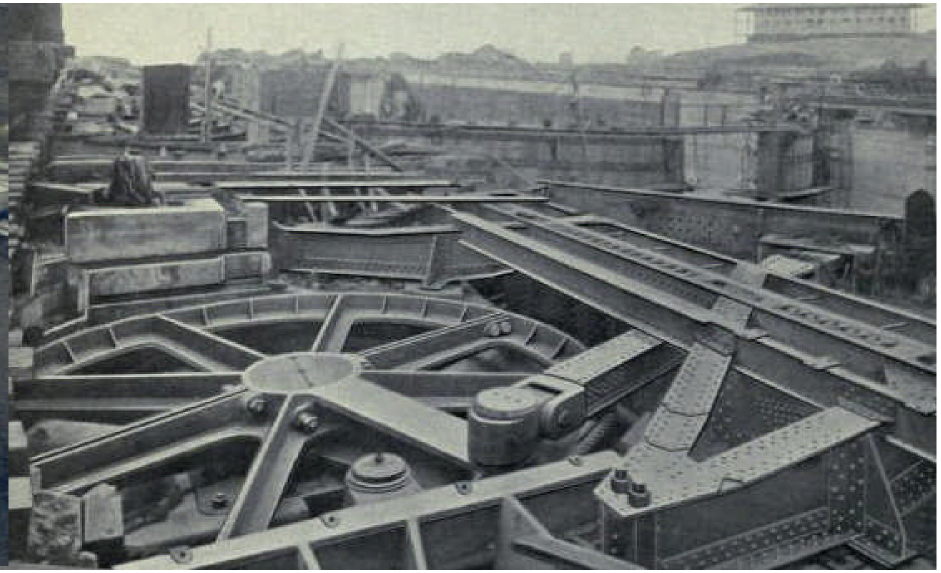
Popular Mechanics, Sept. 1912

“The sills and fenders of the Panama Canal locks are made of British Guiana greenheart, a wood which, according to the Department of Agriculture, outlasts iron and steel when placed in water. It is used in ship and dock building, trestles, bridges, shipping platforms, flooring, and for all purposes involving great wear and tear. The woods of two species of West African trees have been introduced into British markets as substitutes for greenheart under the name of African greenheart, but both are inferior to the South American tree…Though it grows in parts of British, French, and Dutch Guiana, Venezuela, Brazil, Columbia, Peru, Trinidad, Jamaica, and Santo Domingo, it is being cut only in British Guiana, where it is found along the seacoast and watercourses, seldom extending more than 50 miles inland…Constant drain for more than 100 years upon the most accessible stands of greenheart in British Guiana has stripped the forest of its best material, and the wood now obtained is of inferior quality…Only the heartwood of the tree possesses the peculiar durability desired, and the best wood is found in old trees. The wood of three other species of the same botanical family is occasionally cut and sold with the genuine greenheart. These are the white cirouballi or sirauballi, the yellow cirouballi, sometimes called ‘black cedar,’ and the keritee or kretti.”

Popular Mechanics, **April 1913**



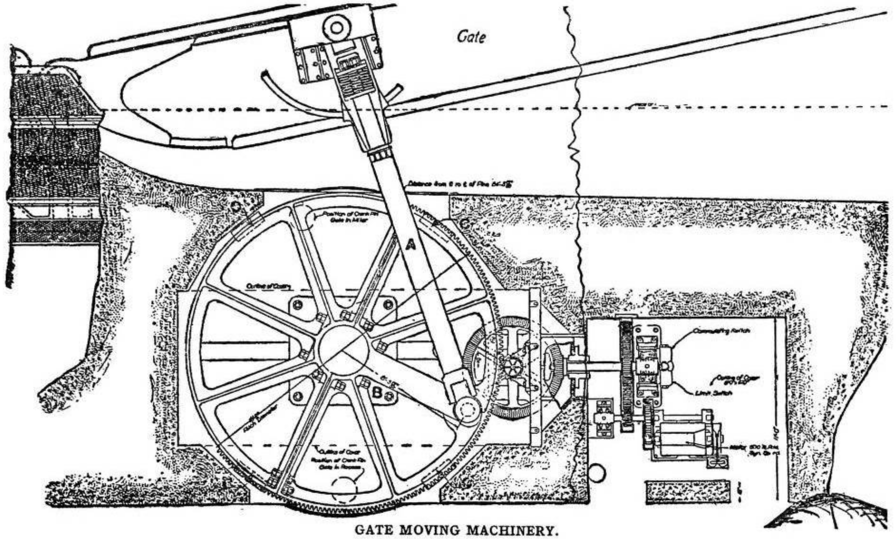

One of the "Great Gates"
in Construction, Gatun,
C. Z., Panama.

To operate, the lock gate/s leaves were connected by steel arms, called "Struts," to huge "Bullwheels" constructed within the lock walls. Each twenty-foot diameter, horizontal-lying Bullwheel was geared to an electric motor. When in operation, wheel and strut work like the driving wheel and connecting rod on a railroad locomotive to open and close the gates.

<u>Left:</u> caption: "Gatun Upper Locks, Miter gate moving machine, June 1912"

<u>Right</u>: caption: "The powerful mechanism which will open and close the great Gates of the Locks. All machinery will be electrically driven."



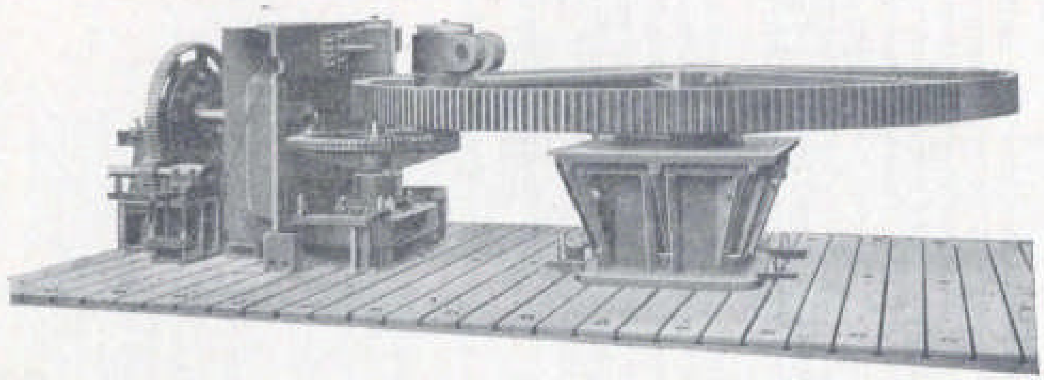
GATE MOVING MACHINERY.

This shows the relation of the bull wheel to strut and gate. A. Strut or connecting rod. B. Bed plate. C. Bearing wheel.

The movement of a gate leaf was accomplished through a huge connecting rod, one end of which is attached to the leaf about midway between the wall and the other end of the leaf; the other end was attached to a huge master wheel which lies flat on the top of the lock wall. This master wheel weighed 34K pounds and turned on a huge center pin which was keyed in a heavy casting, anchored securely to the concrete. The casting and the center pin weighed 13K pounds. The rim of the great master wheel was so heavy that its weight would break the spokes, and so it was supported in four places by rollers. One-half of this rim is cog geared. Through these it was revolved by an electric motor which drives a train of gears and pinions. These turn the rim of the wheel, which moves the connecting rod to the gate, causing the gate to open or close in two minutes. The action was just the reverse of the action of the connecting rod on the driving wheel of a locomotive. By visualizing a locomotive suspended in the air and the driving wheel moved by power applied to the rim, the resulting movement of the connecting rod with the piston will represent, in general outline, the method by which the gate leaves were moved back and forth. The motor was remotely controlled by an operator stationed in the controlling house near the lower end of the upper locks, a simple pull of a small switch being sufficient either to close or open a 700-ton gate. In 2001, the *Panama Canal Authority* changed over to a hydraulic system and installed new operating motors.

<u>Left</u>: caption: "Gate Moving Machinery"

<u>Right</u>: caption: "Discarded Bullwheel halves at Miraflores Locks"



MITRE GATE MOVING MACHINE FOR THE PANAMA LOCKS

We are furnishing **NINETY-FOUR** of these, with a total weight of 9,970,000 pounds. Main gear 19′ 3″ pitch dia.

ALL GEARS CAST STEEL, CUT TEETH

WHEELING MOLD & FOUNDRY CO. WHEELING, W. VA., U. S. A.

WHEELING MOLD & FOUNDRY CO.

WHEELING, W. VA., - - - - - - - - - U. S. A.

Pittsburgh Office: FARMERS' BANK BLDG.

New York Office: SINGER TOWER

In addition to Mitre Gate Moving Machines, which we are building for the Canal as shown on opposite page, we are furnishing 114 STONEY GATE VALVE MACHINES for controlling water supply to the Locks. These machines weigh about 55,000 pounds each.

Also we are building 130 CYLINDRICAL VALVE MACHINES which operate valves in middle wall to control water for either side.

We have two other contracts with the Government for the cast steel, iron and bronze, together with the rolled material, for Stoney Gate Valves, Frames and Runner Track.

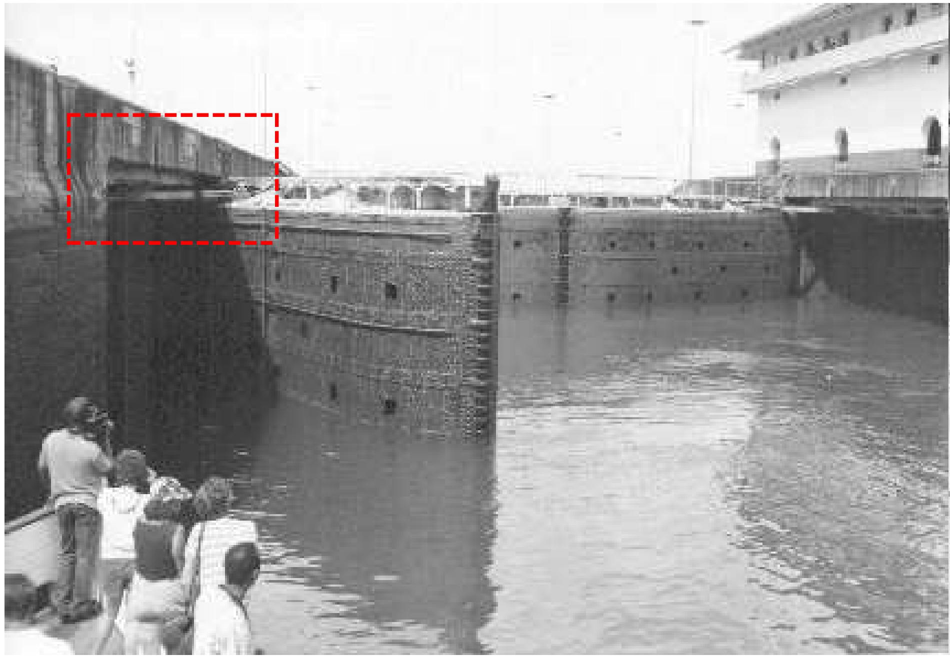
One other contract calls for $165,000 worth of copper conductor bar of our own design.

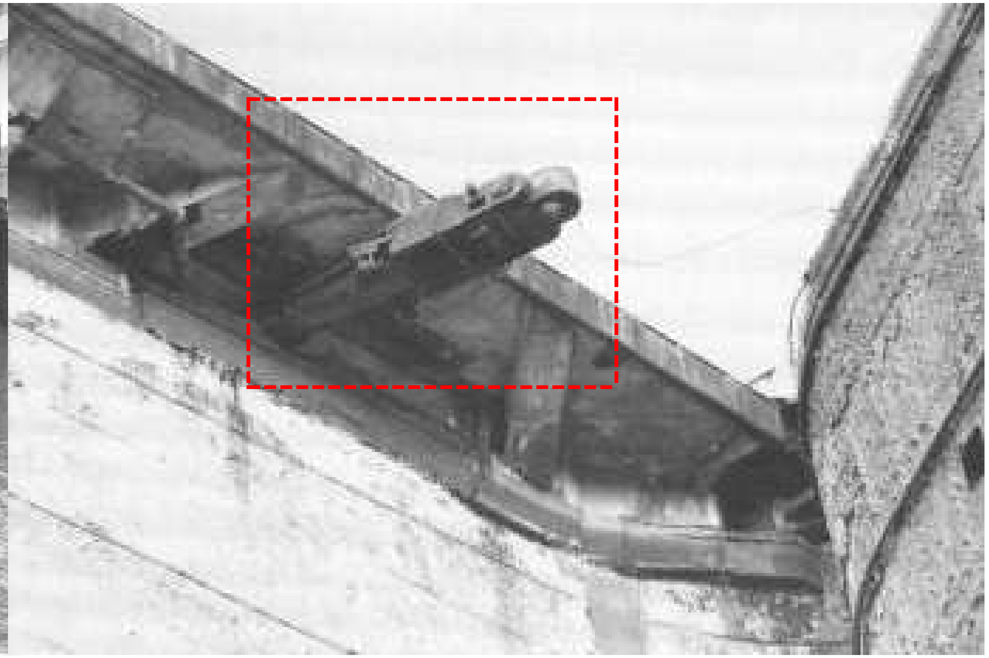
Other equipment which we are making consists of steel castings for the Gate Hinges—the Steel Reaction Castings for Gate Hinge weigh 5,500 tons alone—upper and lower Pintle castings, Heel and Yoke Castings for the Gates. The upper Pintle and Yokes are of vanadium steel—Manhole Covers and Frames, Rolled Nickel Steel Bearing Plates.

Altogether we are furnishing about 19,000 tons of machinery for the Panama Canal; 14,000 tons of which is cast steel made in our own works.

We are prepared to design and build heavy machinery of all kinds for Power Dams, Sugar Machinery, Rolling Mills, Steel Works, etc.

.... ESTIMATES CHEERFULLY FURNISHED ....





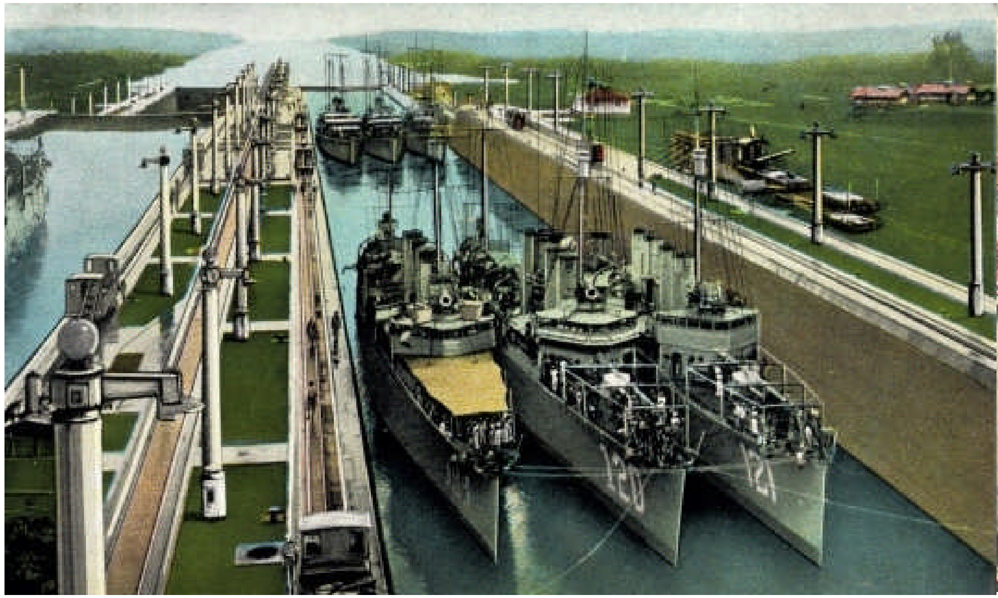
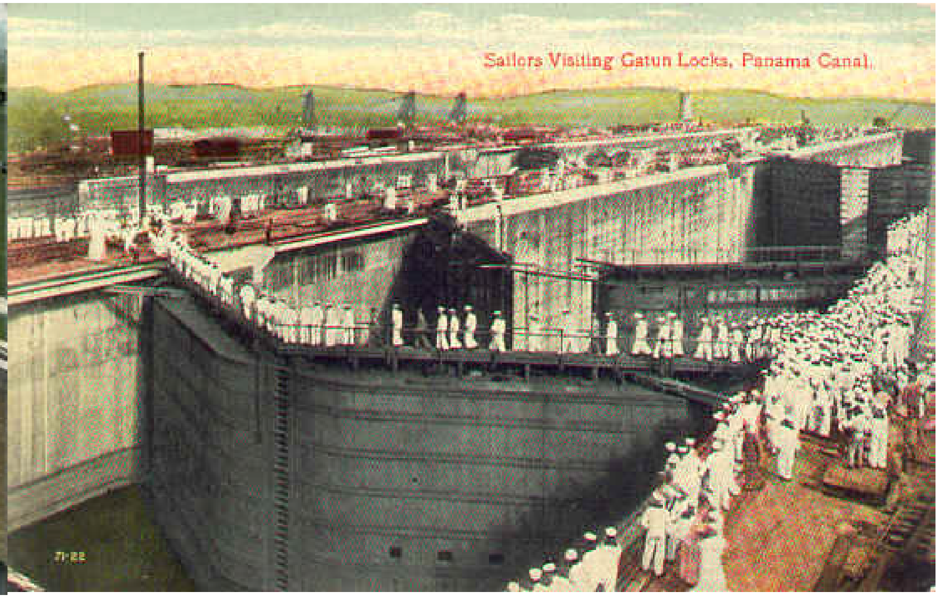
<u>Top Left</u>: caption: “Strut Arm (top of gate) attached to working Bullwheel machinery, Gatun Locks”

<u>Top Right</u>: caption: “Close-up of Strut Arm - Gatun Locks”

<u>Left</u>: caption: “Bullwheel at Miraflores Locks”

"…For preventing leakage around the ends of the lock gates of the Panama Canal the most careful fitting and adjustment is required. The lower guard locks at Gatun are completed and in service…Each of the four leaves of these gates is 65 ft. long, 47 ft., 4 in. high, and 7 ft. thick, and weighs 390 tons. The leaves swing on heavy steel upright pins anchored in the floor of the lock. To make a water-tight joint with the wall a heavy steel casting with a recess in its outer surface was set in the lock wall as it was built. A bearing plate was then set in the recess of the casting and held in place by 1 in. bolts. The end of the leaf was prepared in the same way, the steel casting being permanently attached by means of bolts. After the plates were closely adjusted, hot babbitt metal was poured into the spaces between the bearing plates and the castings, forcing them together to form a water-tight joint. The same method was followed in securing an exact fit in the swinging ends of the leaves…"

***Popular Mechanics,* December 1913**



"Permanent painting of the lock gates of the Panama Canal is now being carried on. The process involves two operations, the preliminary application of a solution to the steel to fit it for the adhesion of the enamel, or marine paint, to an average thickness of about one-sixteenth of an inch."

***Popular Mechanics,* June 1913**

<u>Left</u>: (postcard) caption: "U.S. Destroyers entering Middle Chamber, Gatun Locks, Panama Canal"

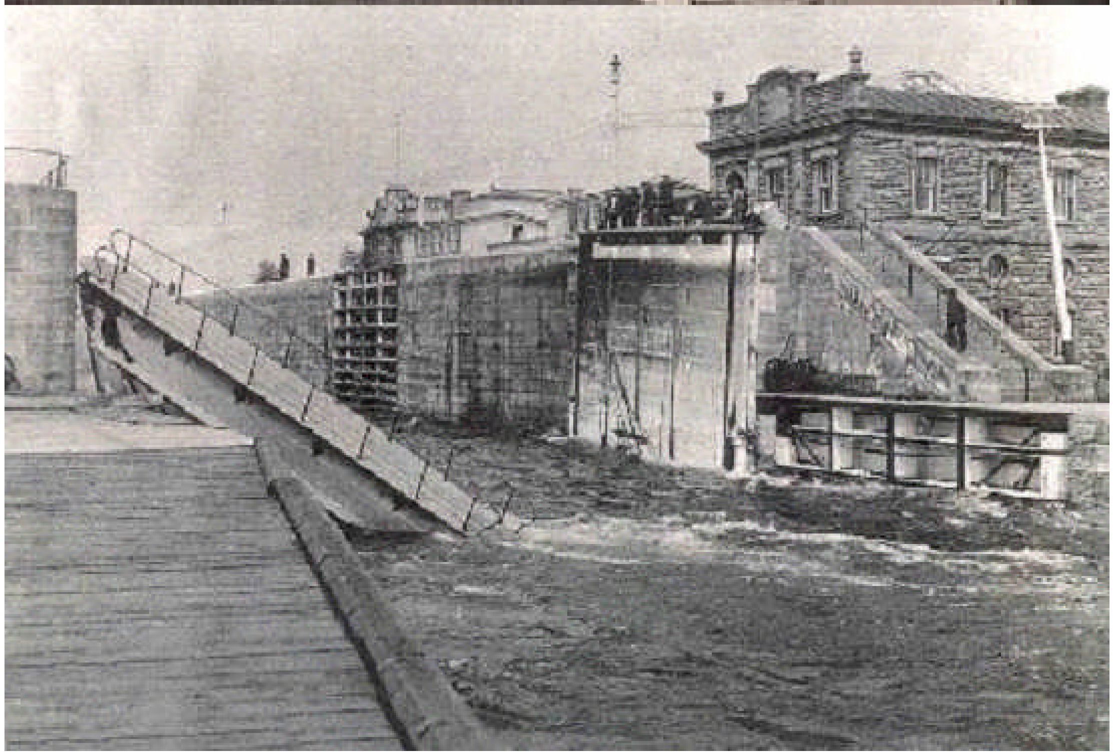
<u>Right</u>: (postcard) caption: "Sailors visiting Gatun Locks, Panama Canal"

Safety Features

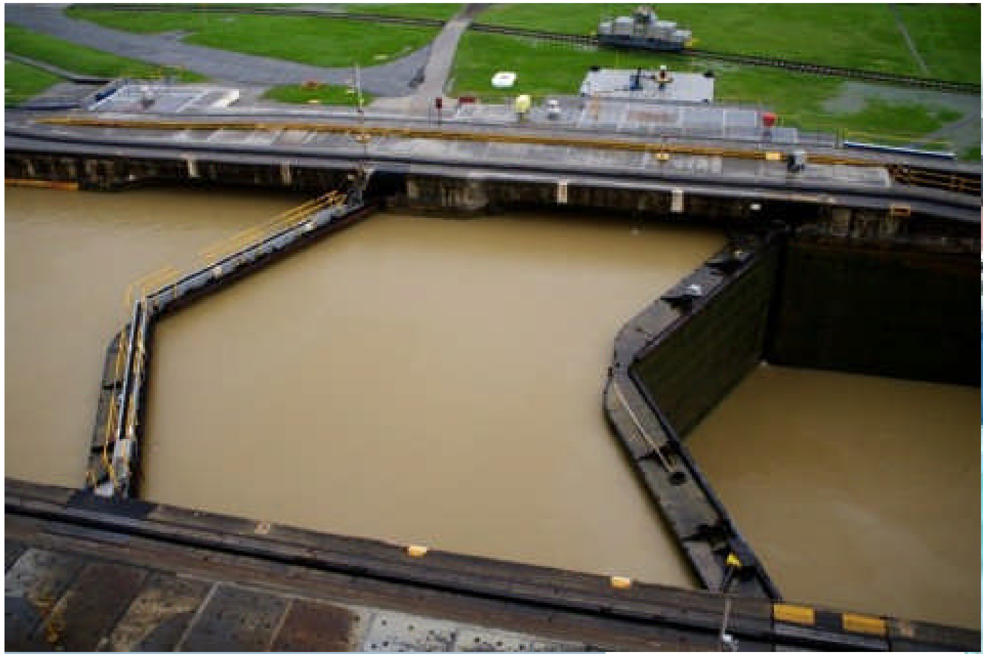
"Since navigation around the rapids in the St. Mary's river by canal and locks began, more than 50 years ago, speculation has been rife as to what would happen if, through an accident to one of the huge gates which holds back the waters of Lake Superior, the flood should be released and come surging through the canal. The answer was supplied on Wednesday, June 9th, when the freighter 'Perry G. Walker' rammed the lower gate of the Canadian ship canal at the Soo and precipitated the dreaded condition which, up to that time, engineering science had met in theory only…When the 'Walker,' moving slowly, had approached as near to the lock as was permitted, the captain signaled his engineer to reverse his engines. The signal was misunderstood and the engines, instead of being reversed, were set in motion, full speed ahead…the big ship was under strong headway and before her speed was appreciably checked, she collided with one of the lower lock gates, smashing it down before her, and instantly releasing the waters held in check…In the ship canal the waters of Superior raced through unimpeded, converting the lock into a very maelstrom, with two distinct falls and a whirlpool…"

Popular Mechanics, **August 1908**

RE: accident on June 9th 1909 at the *Canadian Ship Canal* at *Sault Ste. Marie, Ontario, Canada*



Guard Gates



Since the lock gates themselves are a form of dam and are above sea-level, precautions were taken to protect the *Gatun Lock* gates from damage that could allow the lake water to escape and flow out to sea. One measure was to have double gates ahead of the vessel; an *operating gate* and a *guard gate*, at points where damage to a gate could join the two levels, that is, at the upper and lower ends of the upper lock in each flight (at both ends of the *Pedro Miguel's* single-step lock). This "double door" fail-safe system prevents an errant ship to sustain damage to one set of doors thus allowing the other set to maintain the lock's integrity.

“Guard gates are used at the Panama Canal to accommodate vehicular traffic. When these were first so used it was found that, while the width permitted the passage of an automobile, the gates at their meeting point formed too sharp an angle for an auto to turn safely. To overcome this difficulty, removable triangular plates were made to fit into the corner. When the gates are to be opened, the plate, of course, has to be removed and it is then hung on the railing of one of the gate leaves.”

***Popular Mechanics,* August 1924**

Fender Chains

"…Should a ship for any reason become unmanageable while in a lock chamber, through the breaking of a towing line or otherwise, it can be prevented from bumping into the gates by the chain fenders 100 ft. ahead of each gate. These are 24 heavy chains, resting in grooves in the bottom of the lock, which can be quickly hauled taut by electric winches so as to form a barrier across the bow of any ship and effectually stop its drift…"

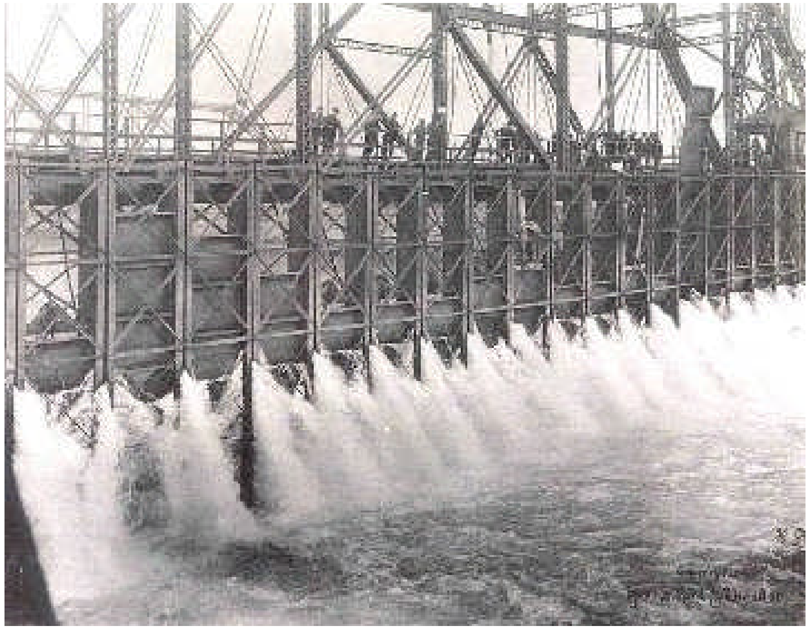
***Popular Mechanics,* December 1913**

RE: another safety feature were iron *Fender Chains*, installed to stretch across the chambers between the lock walls to protect the guard gates. Only after a ship was in proper position and under towing locomotive control was the chain lowered. The idea was that if a ship went out of control and struck the chain, an automatic release would let the chain out slowly until the ship came to a stop, thus limiting possible damage. The expense of their upkeep against the unlikelihood of their use caused the canal's *Board of Directors* to approve Fender Chain removal in July 1976, except at the upper ends of *Gatun* and *Pedro Miguel Lock/s*; these remaining chains were removed in October 1980.

"The links of the chains to be used as part of the gear of the locks of the Panama canal have withstood 147,000 lb. pressure under tests."
Popular Mechanics, May 1909

"The chains that are to be stretched across the Panama Canal locks to protect the lock gates from ships that may get beyond the control of the electric towing locomotives are an innovation in construction as well as in canal operation, and considerable difficulty is being experienced at the Boston Navy Yard in making links of the required strength. The links are made of wrought-iron bars, 3 in. in diameter, and are 17 in. long and 10.75 in. wide. All links are tested to about 275,000 lb., and the weaknesses found so far have been mostly at the welds. The chains have an average length of 427 ft., and weigh 85 lb. to the foot."
Popular Mechanics, **July 1914**

Emergency Dam

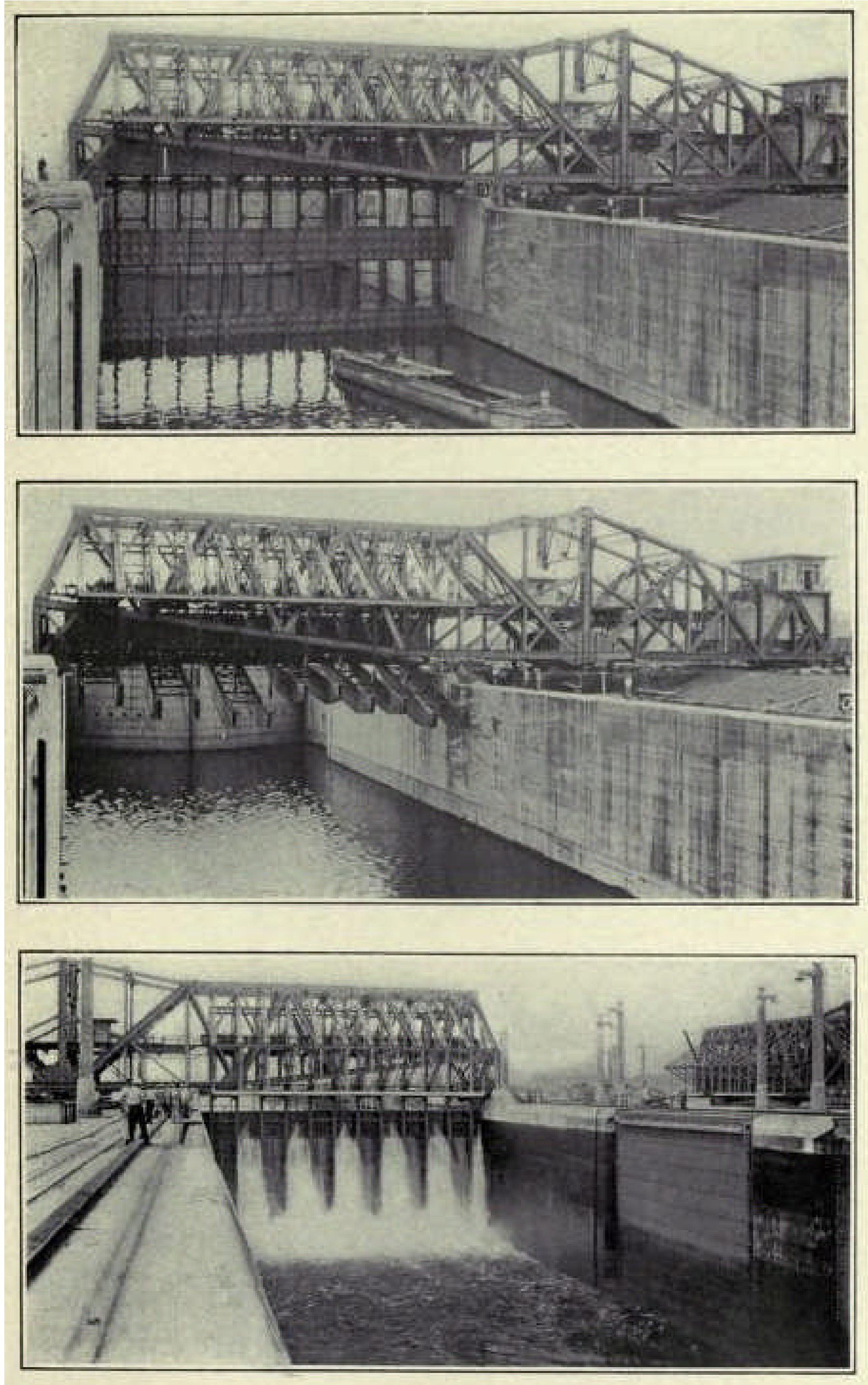


"…Above the canal lock on the bank of the upper approach stood the movable, or emergency dam, specially constructed for just such a catastrophe. It had been unmoved for so long a period that the mechanism for swinging it into place was found useless and a team of horses supplied the motive power which finally swung the heavy structure across the canal…"

***Popular Mechanics,* August 1909**

RE: accident on June 9th 1909 at the *Canadian Ship Canal* at *Sault Ste. Marie, Ontario, Canada*

<u>Above</u>: *Emergency Dam* in-place, June 9th 1909



"…And in the event of damage to the gates from any cause, emergency dams can be swung into place. These are swing bridges which can be thrown across the lock chambers, from which wickets are let down filling the width of the lock…"

***Popular Mechanics,* December 1913**

RE: another devise stood as safeguard should a ship break through a *Guard Gates*. It was called an *Emergency Dam* and they were installed on the side-walls at the entrance of each Upper Lock (between the *Fender Chain* and the Guard Gates). It was a big steel apparatus mounted to swing across the lock entrance in about two minutes in case of emergency. A series of wicket girders would descend forming runways down which huge steel plates would be dropped until the channel was sealed off. Never used, the Emergency Dams were removed in the mid-1950s.

Left: caption: "Views of Emergency Dam at Gatun in action"

"Just prior to the opening of the Panama Canal the east emergency dam, guarding the Gatun lock approaches, was tested to ascertain its action under a full head of water, with Gatun Lake at normal level on one side and an empty chamber on the other. The greatest leakage occurred at the bottom of the gates at the pockets into which the girder ends were fitted. Under the maximum head of 45 ft., the 400-ft. section of the lock filled in two hours and fifty minutes. Naturally this was as nearly a final test as can be made, for the primary purpose of the dam is to halt a rush of water through the chambers in the event of an accident to the Gatun gates. The dam is built on a steel truss bridge and so pivoted that, when not in use, it may be swung free from the canal and rested on the side wall. When it is necessary to use it, it is swung around, and a series of wicket girders are lowered into the channel. These fit into pockets in the floor and, when firmly in place, act as runways for the gates which are lowered one at a time until a solid wall of steel has been built up from the bottom of the canal."

***Popular Mechanics,* November 1914**

RE: the *Emergency Dams* designed by *Otis Ellis Hovey*. As the assistant chief engineer of the *American Bridge Company*, Hovey worked on some of the biggest projects of his era, including designing and building the six Emergency Dams for the *Panama Canal*. Hovey was also the authority on moveable bridges. He wrote the subject bible; *Moveable Bridges*, published in 1926, and held patents on three moveable bridge designs which he dubbed Types O, E, and H (which just happen to be his initials).


"Resembling a large draw-bridge, the movable emergency dam at Gatun, on the Panama Canal, can be swung across the channel whenever needed. Supported by heavy steel trusswork, the mechanism with which it is equipped may be made to lower metal plates into the bed of the canal as a barrier to cut off a section of the stream. Despite the great weight, the huge structure is easily controlled from a tower, and when idle rests on sturdy foundations to relieve the strain on the girders. The apparatus it is said, enables repairs and inspections to be accomplished in much less time than would be required where the ordinary method of damming off the water is employed."

***Popular Mechanics,* June 1924**

Floating Caisson Gate

"A floating caisson gate that is believed to be the largest of its kind ever built has been completed at San Francisco and towed to the Panama Canal, where it is to be used, when required, as a dam across the entrance to any of the locks when the gates are to be repaired or painted, or when a lock is to be dewatered for any reason…"

***Popular Mechanics,* January 1915**

RE: to permit inspection, cleaning, painting and/or repairing the lower *Guard Gates* of the locks, the *Stoney Gates* of *Spillway Dam* and for access "in the dry" to the sills of the *Emergency Dam/s*, floating *Caisson Gates* of the "molded ship" type were provided. The Caisson Gates were towed into position in the forebay of the upper lock, above the emergency dam or between the piers of the Spillway and sunk.

Above: caption: "Tug 'Hercules' towing caisson for Panama Canal, probably in San Francisco Bay. Bethlehem Shipbuilding photo."

"…The caisson is built of steel and is 113 ft. 10 in. long, 66 ft. deep, and has a molded breadth of 36 ft. Its light draft is 32 ft., and its maximum draft when in service, 62 ft. The keel is horizontal and the ends vertical, the gate being designed, when resting on the bottom of the lock, to make a watertight dam fitting between cast-iron plates fixed to the masonry of the lock walls. The caisson is equipped with a powerful pumping plant that is to be used in dewatering the locks as well as in raising or lowering the caisson, by decreasing or increasing the amount of water in the water-ballast compartments…The electric current is supplied from power cables installed within the lock walls, and the motors, therefore, cannot be operated except when the caisson is placed in working position at one of the locks, or when it is moored at a station in Gatun Lake or Miraflores Lake. The building of the caisson required 1,500 tons of structural steel, and 800 tons of permanent ballast was placed in the bottom to stabilize the caisson when in light-draft condition."

Popular Mechanics, **January 1915**

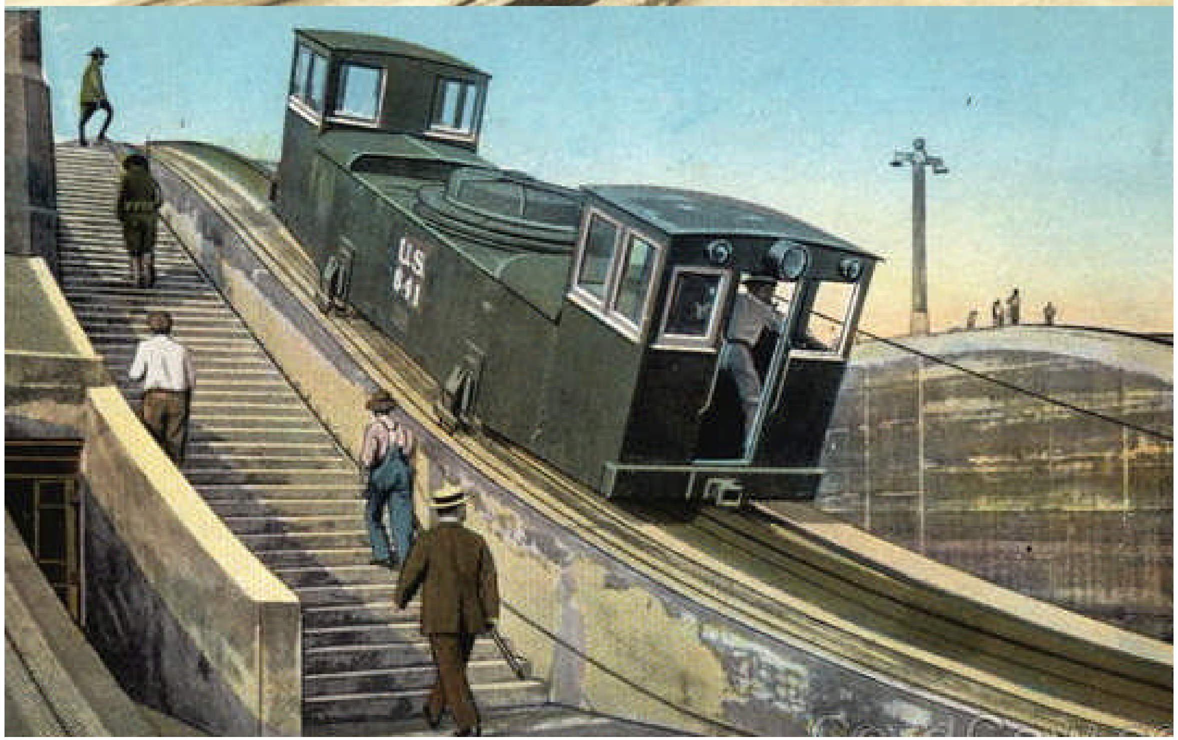
Electric Mules

"…Ships will not be allowed to pass through the locks under their own power, for fear of damaging the lock gates by collision. Instead, they will first tie up at piers formed by the extension of the center wall of the locks, where electric locomotives will take them in tow, four locomotives to a ship, two on each side, one forward and one astern. These locomotives will run on tracks laid on the lock walls, and have gear wheels operating on racks between the rails, to keep them from being pulled off the tracks by the towing strain. Forty of these locomotives are being built at a cost of $13,217 each…"

Popular Mechanics, **December 1913**

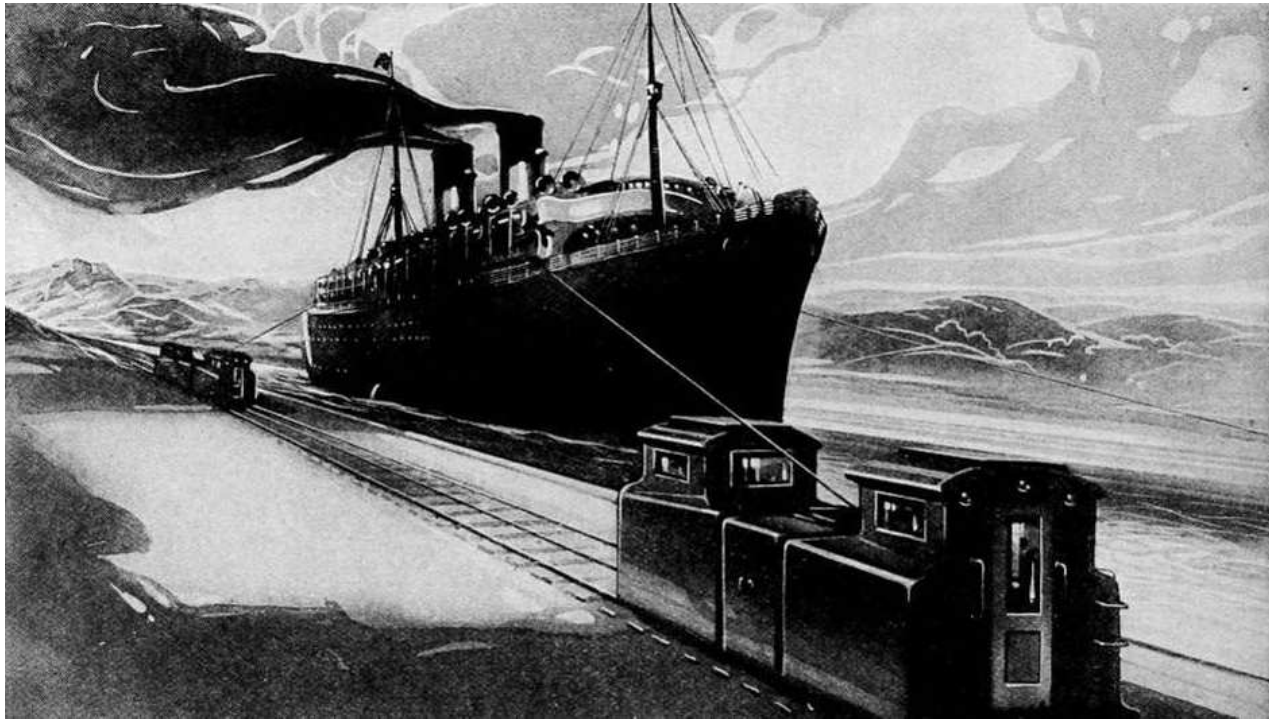
“Several of the 40 locomotives or ‘electric mules’ to be used in towing ships through the locks of the Panama Canal have been delivered and are in service. The design has been considerably changed since the first plans were made. Each of these machines weighs 82,500 lb. and is capable of a tractive force of 47,500 lb., and each is equipped with windlasses capable of exerting a pull of 25,000 lb. Four locomotives will ordinarily be used in hauling a ship through a lock, but in handling the largest vessels six locomotives will be required, two being attached in all cases to the stern, for steering the ship and acting as a brake on its movements…”

***Popular Mechanics,* July 1914**



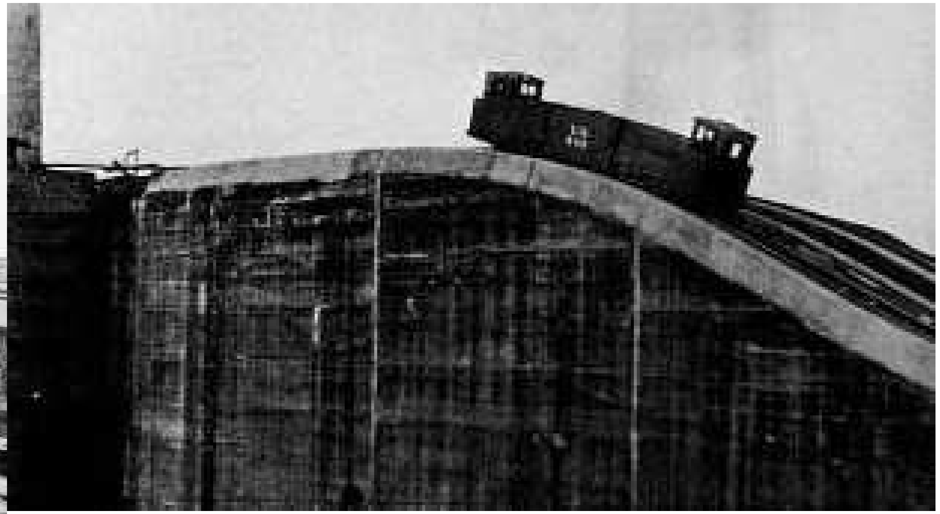
"The electric towing locomotives which handle the vessels through the Panama Canal locks were originally designed to run at a maximum speed of two miles an hour. In towing very heavy vessels, however, this speed is excessive, and according to the Canal Record, it has been found feasible so to alter the electrical connections of the two main traction motors of each locomotive that their speed is halved and the vessel is propelled at only one mile an hour."

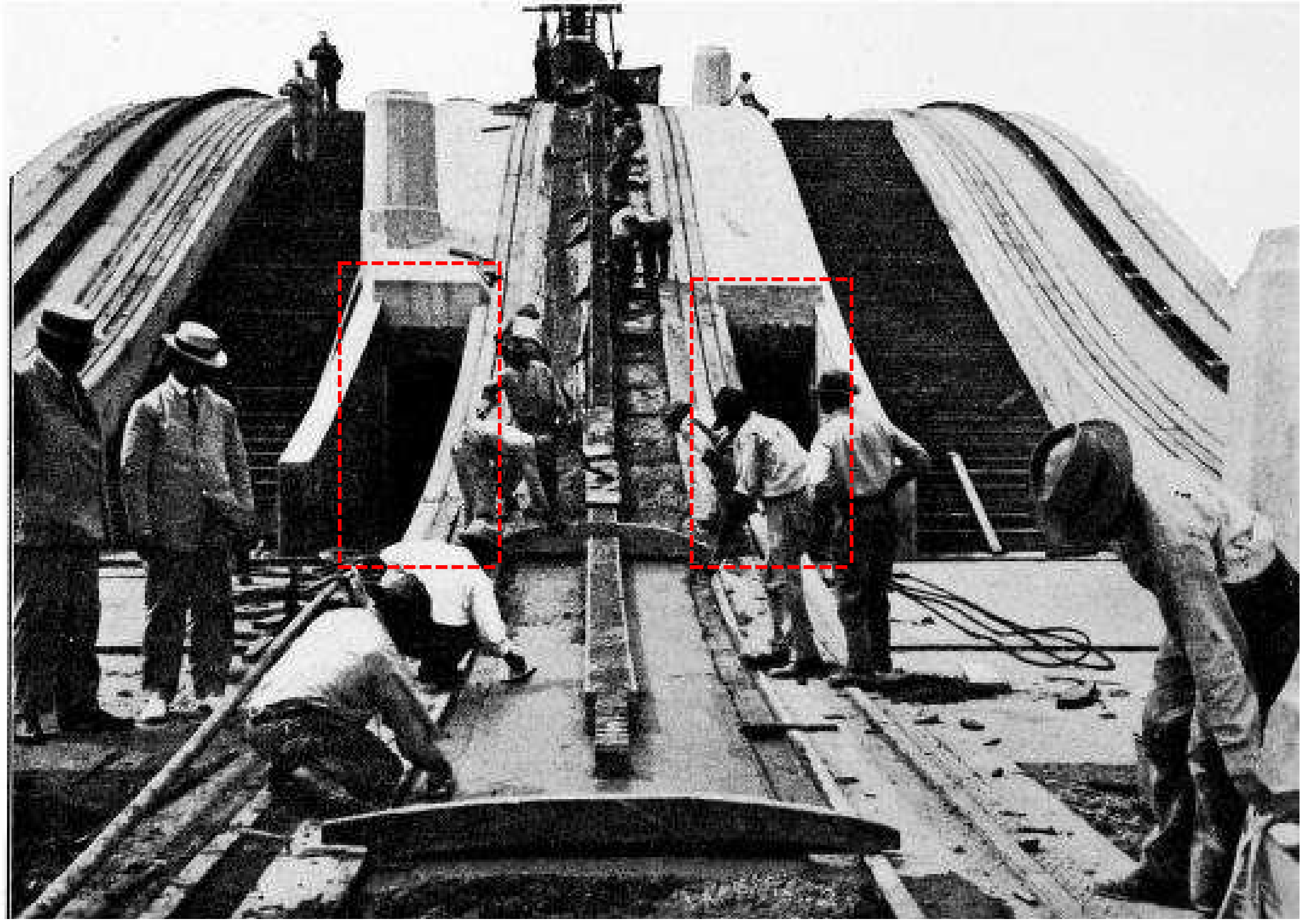
***Popular Mechanics,* September 1917**



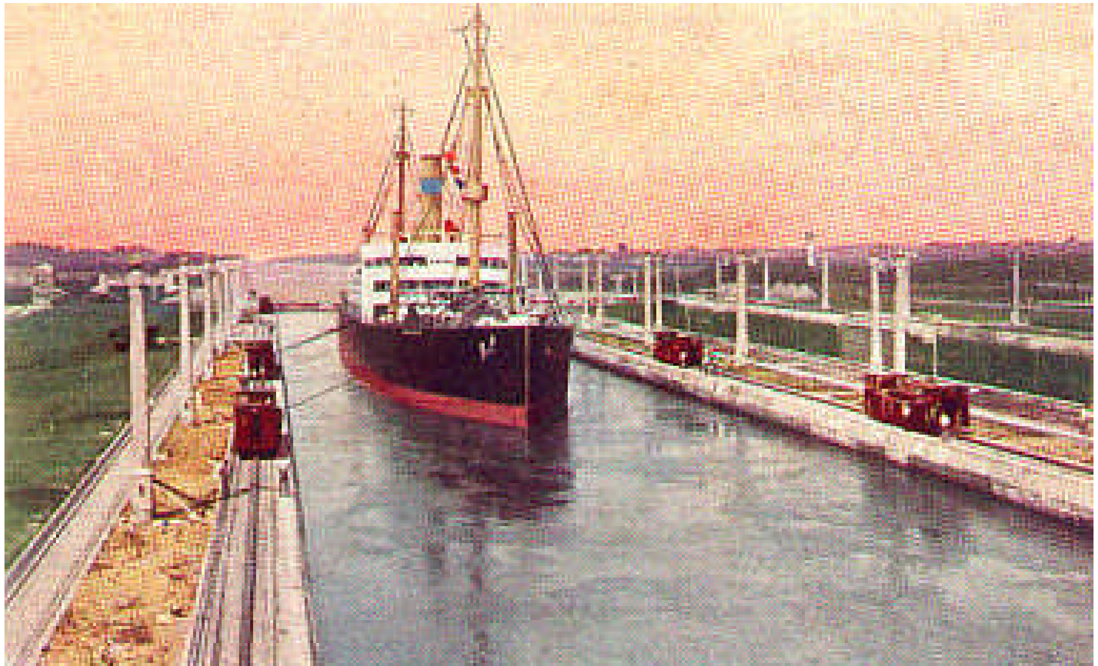
The electric towing locomotive system was designed to provide complete control over the movement of vessels transiting the locks. Designed by *Edward Schildhauer*, the locomotives work on track built atop the lock walls operating at a speed of about two miles per hour. An important design factor was that they had to travel the 45-degree incline between the lock chambers. The locomotives were built by *General Electric* in *Schenectady, New York*, at a unit cost of $13K/each.

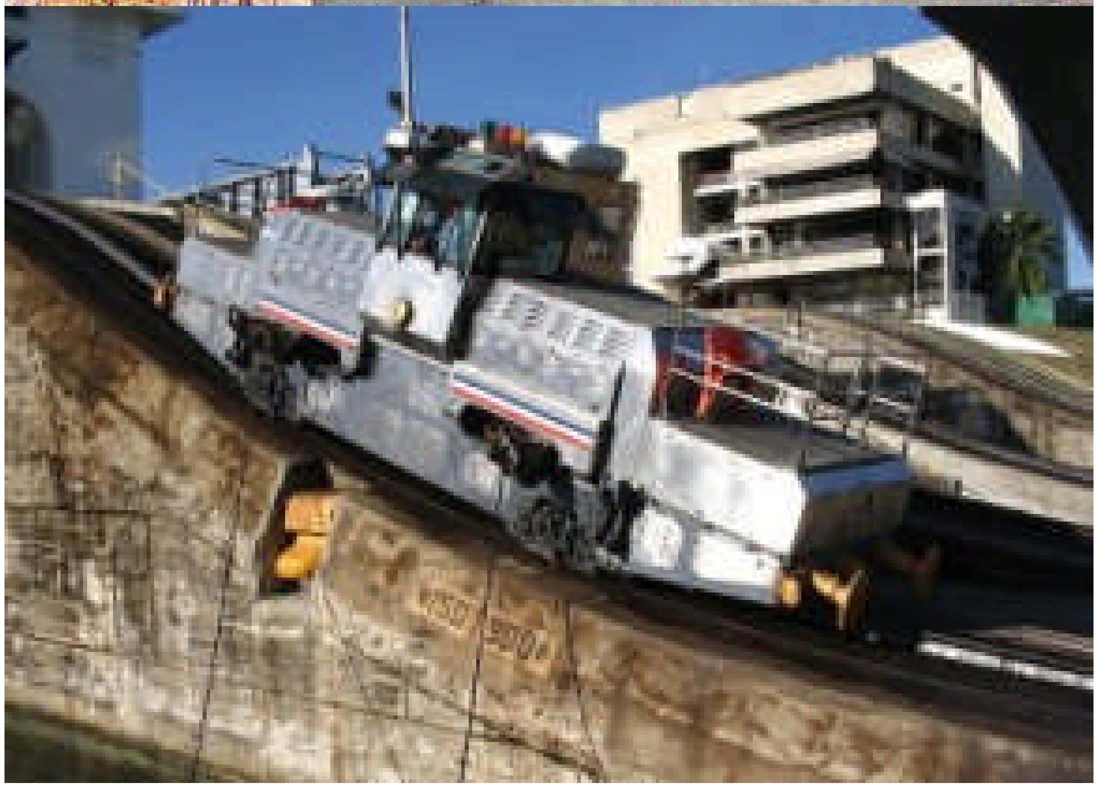
<u>Above</u>: caption: "'Vessel Being Towed Through Locks By Electric Locomotives.' In order to avoid risk of accident to the lock gates through a misunderstanding of signals between a ship's bridge and engine room, no ship will be allowed to use her own power in the locks. As she approaches the lock entrance two electric locomotives are run out on the guide walls at either side, cables are attached and the ship is drawn into the lock where two more locomotives may be coupled to the stern to draw the vessel through the lock."





<u>Top Left</u>: caption: "Electric towing locomotive on a Lock"
<u>Top Right</u>: caption: "Towing locomotive climbing to upper lock"
<u>Left</u>: caption: "Tracks ascending from lower to upper lock. Doors giving access to service tunnels are shown at either side of the central ascent."





"…While towing or going up or down the steep grade between the lock levels, a locomotive will propel itself at a speed of two miles an hour by a pinion working on a rack rail, but when running idle, on level track, the pinion will be thrown out of gear and propulsion will be by ordinary traction methods at a speed of five miles an hour…"

***Popular Mechanics*, July 1914**

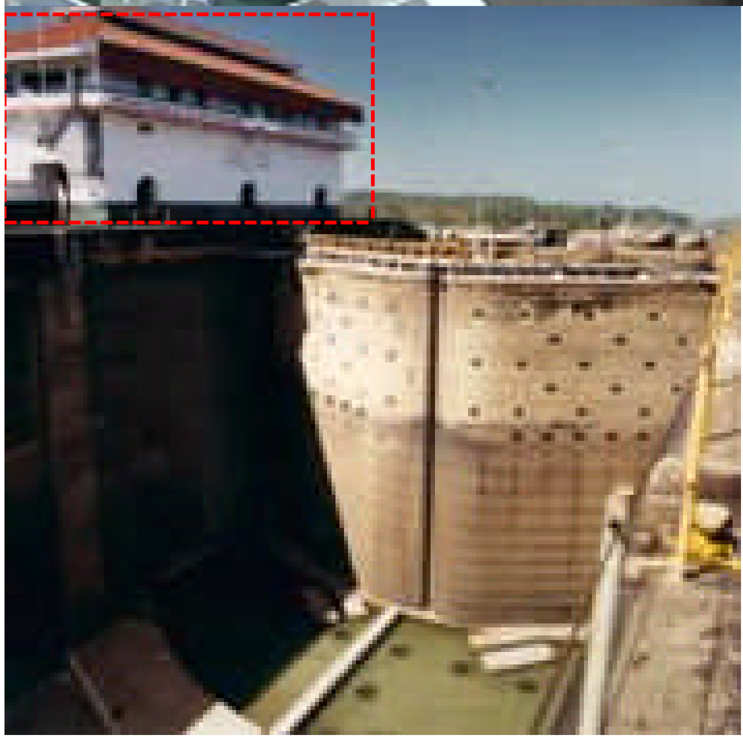

CANAL ZONE
15c

"… An interesting discovery in connection with the towing operations is the effect of the mingling of fresh water and salt water in the lower locks at Gatun and Miraflores. At the stage of a downward lockage when the water in the lower chamber has been brought to a level with that on the seaward side of the lock, more than half of the water in the chamber is fresh. When the gates are opened the heavier sea water thrusts itself in against the water in the chamber, causing a current opposed to the outward passage of a ship. The current, while of a pronounced character, lasts for only a short time and causes no inconvenience in the towing operations, except to necessitate greater caution."

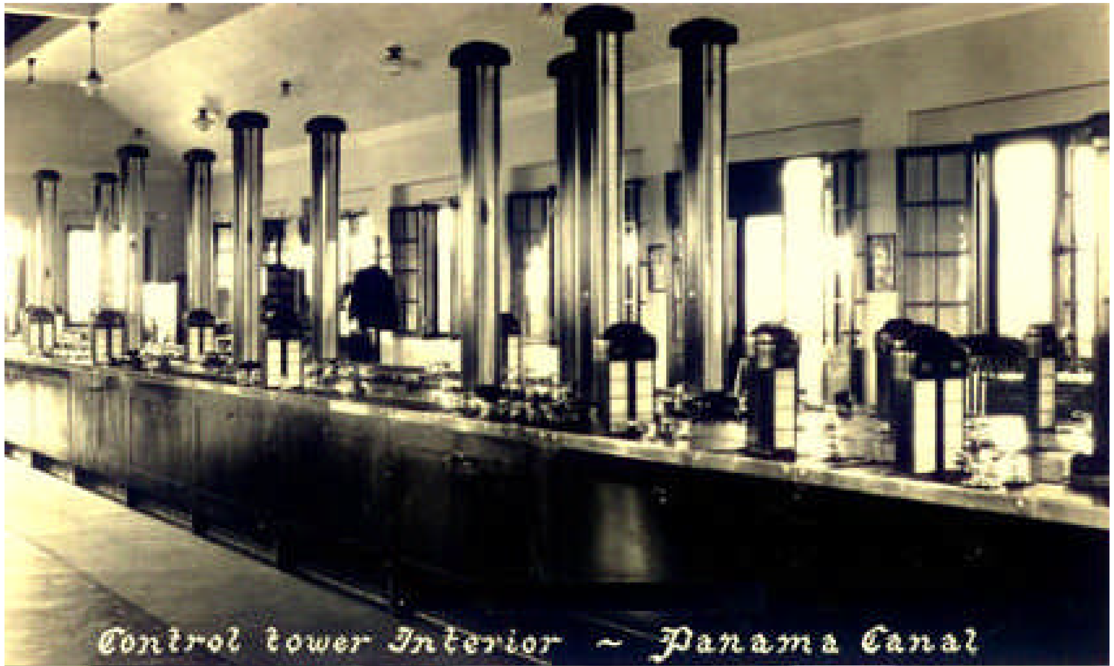
***Popular Mechanics,* July 1914**

“As the result of a curious and unexpected hydraulic action in connection with the operation of the locks, it is now more probable that the entire Panama Canal, including Gatun and Miraflores lakes, will in the course of time become salt, this action having already progressed so far that Mirflores Lake has been rendered brackish and unfit for the water supply planned in connection with it. In addition to this, the currents caused by the mixing of the fresh and salt water have brought about a rather difficult problem in the passage of ships through the locks. The double flight of locks at Miraflores is located about eight miles inland from the Pacific, while the surface of the lake is 55 ft. above mean sea-level. As a ship enters the lower lock from the Pacific there is a mingling of the fresh and salt water, so that after the gates are closed the water in the lock chamber is about 75 percent salt water. Fresh water is then let into the culverts to raise the ship to the next higher level. Owing to the difference in density of the fresh and salt water the resulting mixing sets up currents that often make it difficult to handle ships passing through the locks. The same process, with the salt water greatly diluted, takes place when the ship enters the upper lock, and when the upper gates are finally opened a small quantity of salt water finds its way into the lake. This process has doubtless been going on in the same way at the Gatun Locks, but it has not yet advanced far enough to cause any noticeable proportion of salt in the water of Gatun Lake.

Popular Mechanics, April 1915

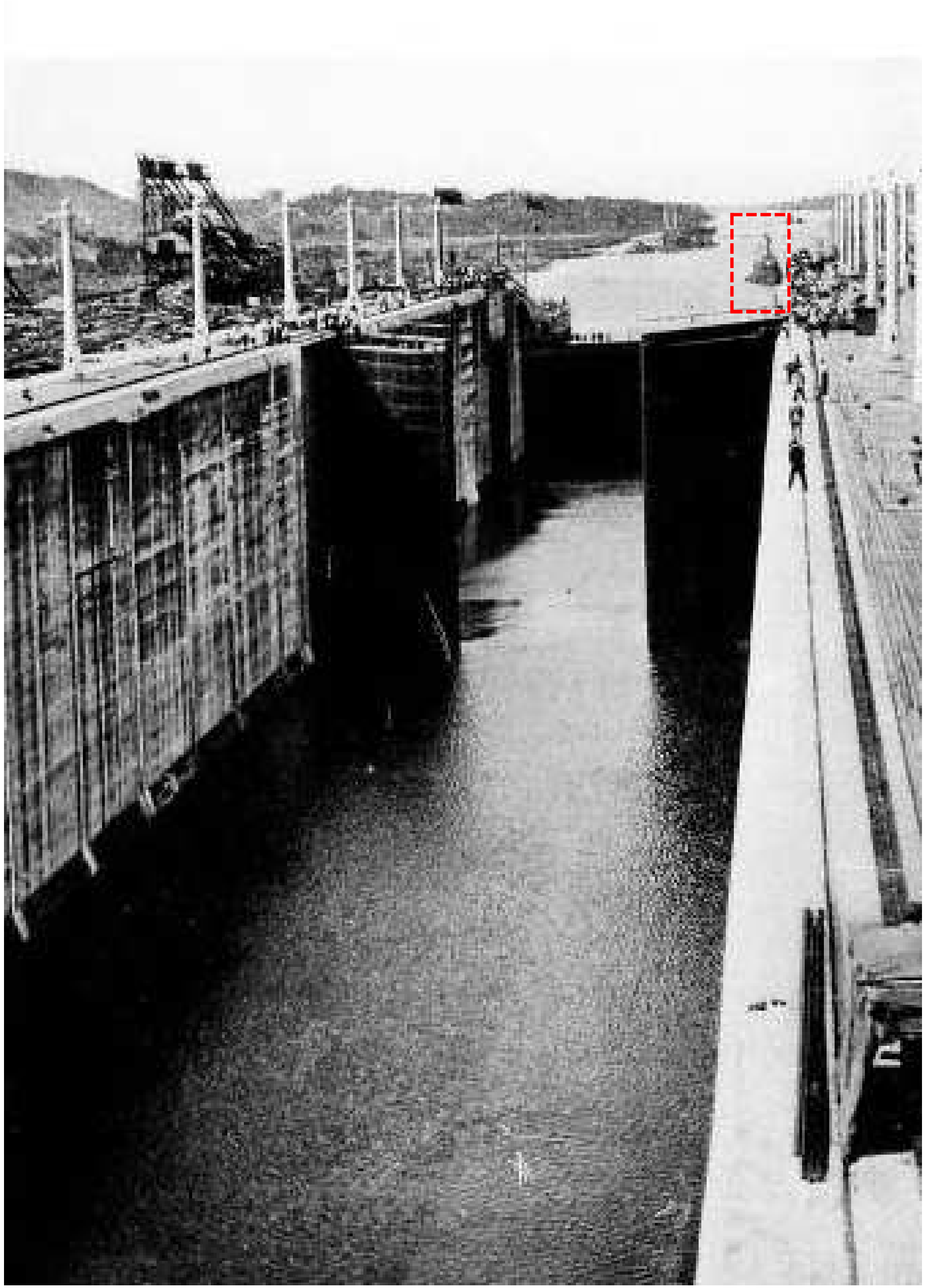


Edward Schildhauer **also designed the basic concept of the locks control system, though its development was a joint effort with** ***General Electric*****. All lock/s operation is accomplished from a control house built on the center wall of the upper lock chamber. Here, from an unobstructed view of the entire locks flight and a cleverly designed control board, a single person can run every operation in the passage of a ship (except towing locomotive movement).**

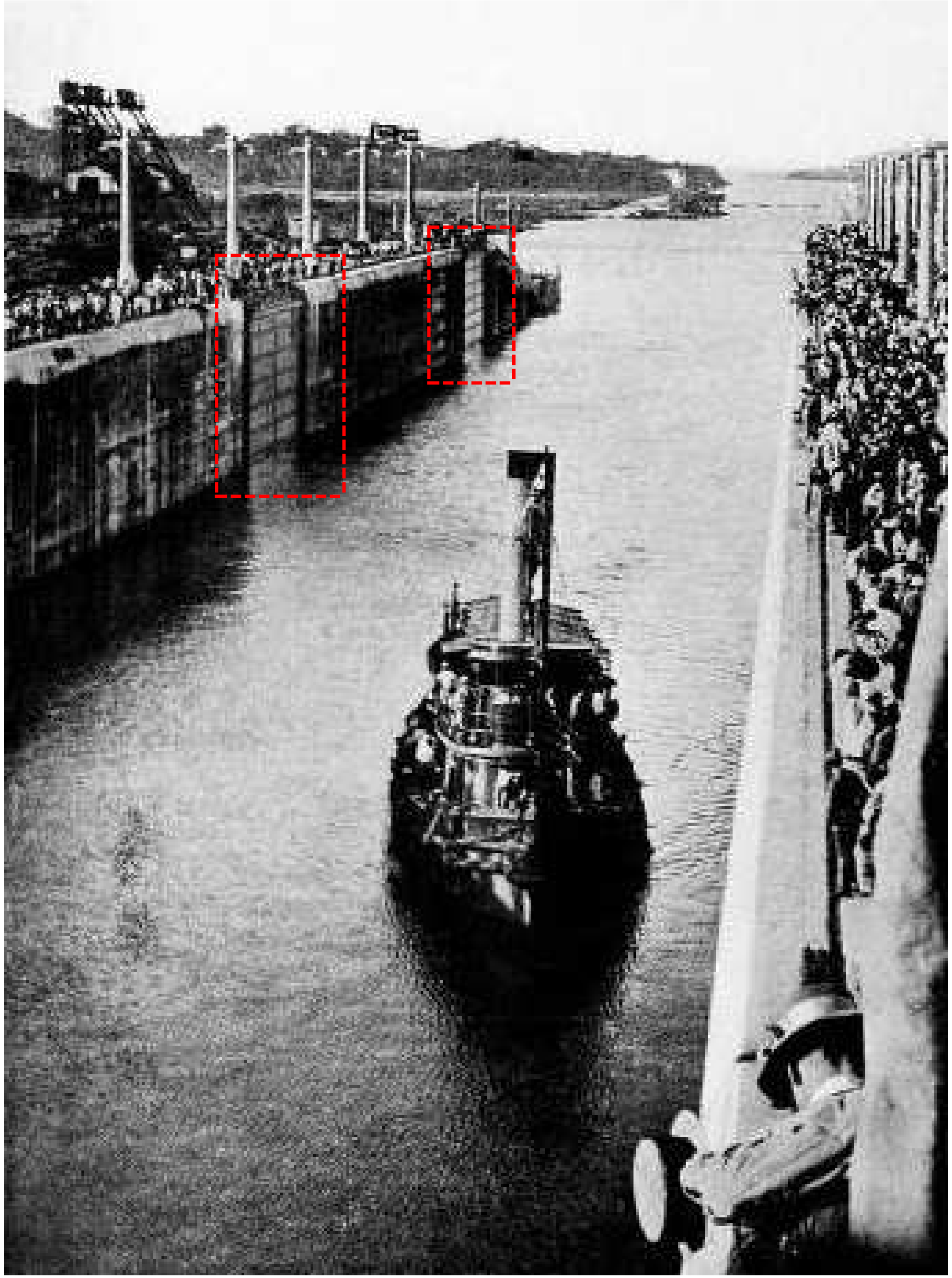


A control board is a waist-high working representation of the locks in miniature. Everything that happens in the locks happens on the control board simultaneously. The switches to work the lock gates and the other system mechanisms are located beside the representation of that devise on the control board. To lift a ship in a lock chamber, the operator has only to turn a small handle. Another ingenious part of the system are elaborate racks of interlocking bars installed unseen below the control board to make the switches mechanically interlock. Each handle must be turned in proper sequence or it will not turn. This eliminates the possibility of doing anything out of order or forgetting a step. Only in an electrically run system could the locks have been controlled from a central point. This system has been in use virtually unchanged since 1914 and still works flawlessly.

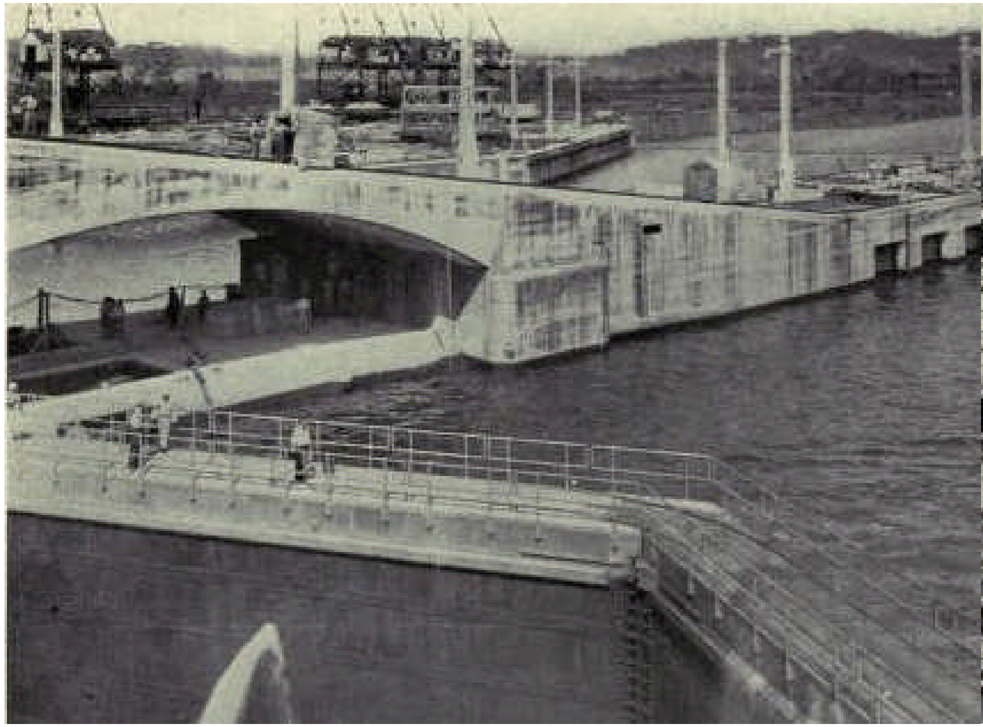
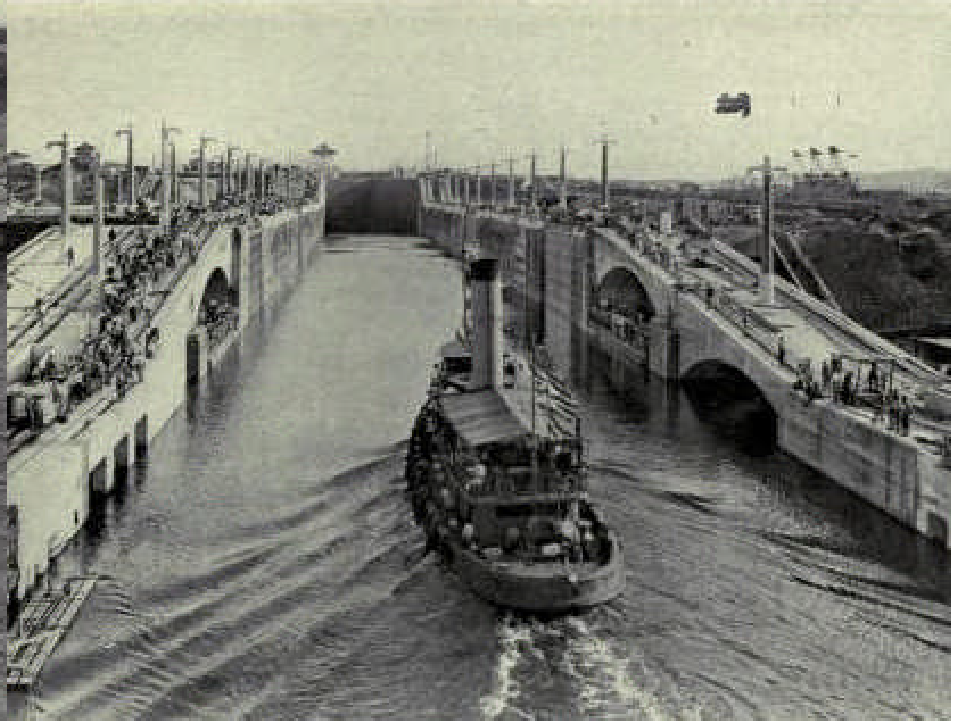
The First Boat Through



<u>Left</u>: caption: "'The First Boat Through. 1.' The commission tug *Gatun*, with members of the commission aboard, is approaching the lower Gatun lock from the Atlantic end of the Canal. The two pairs of gates are opening for her admission."



<u>Left</u>: caption: "'The First Boat Through. 2.' The *Gatun* is in the lock, but the gates are not yet closed. They can be seen folded flush with the wall. When closed water will be admitted from the sides and bottom of the lock, raising the boat 28.33 feet to the next lock."

Guard Gates **at** ***Gatun Locks*** **performed flawlessly the second week of June 1913 and on June 27th, the last of the** ***Gatun Dam Spillway*** **gates was closed, allowing the lake to rise to full height. The seagoing tug** ***Gatun*** **- an** ***Atlantic*** **entrance working tug used for hauling barges, had the honor on September 26th 1913 of making the first trial lockage of Gatun Locks. The lockage went perfectly, although all valves were controlled manually since the central control board was still not ready.**

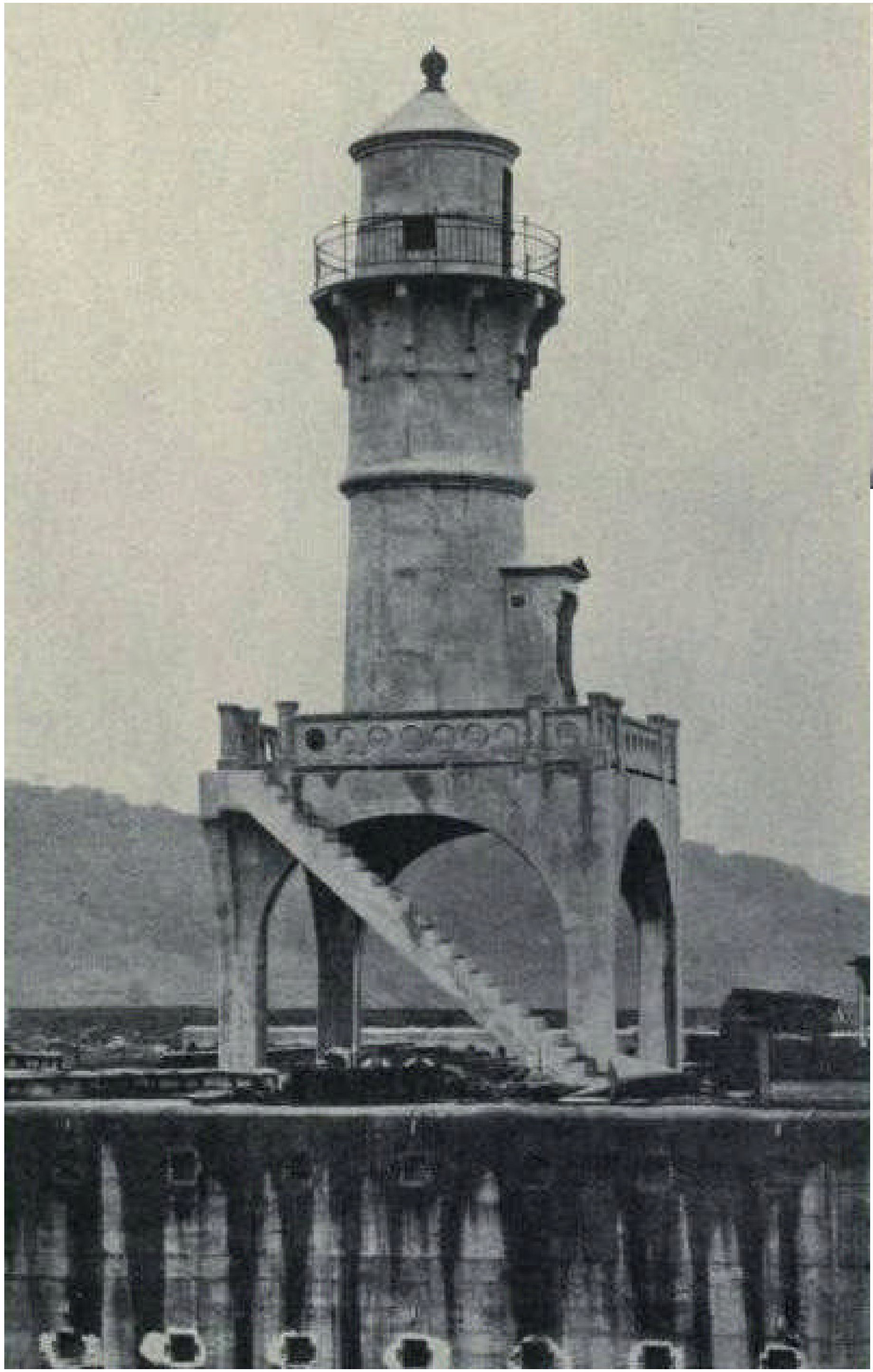
Left: caption: "Sea Gates, Gatun Locks, under pressure for the first time"

Right: caption: "Tug Gatun, the first boat to pass from sea-level to summit-level of the Panama Canal. September 26, 1913."

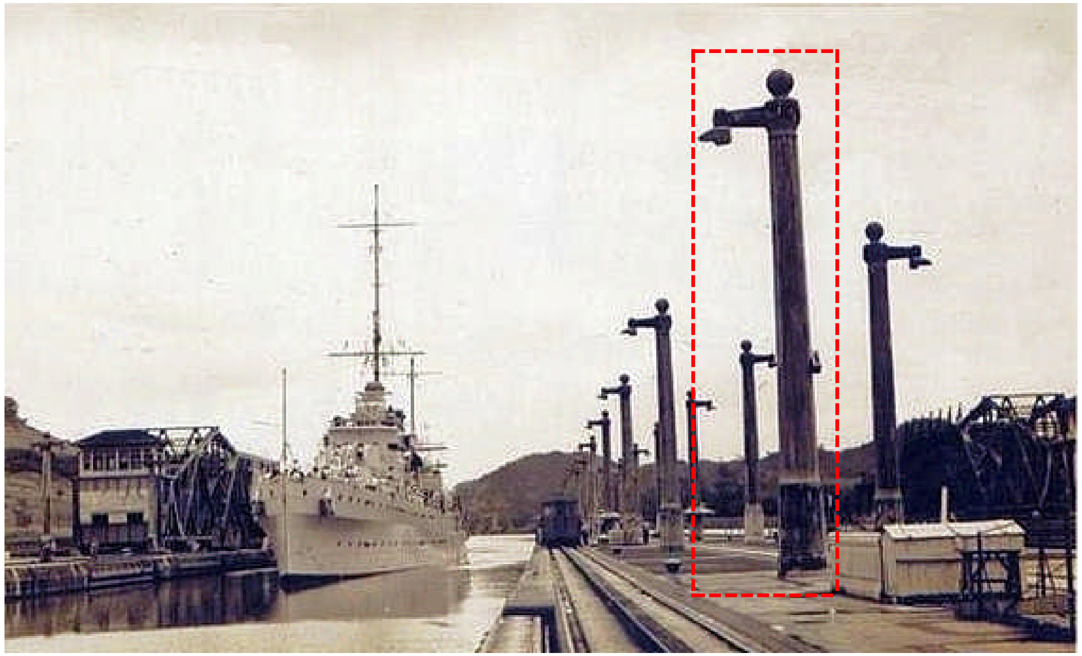
An Avenue of Brilliant Lights

"…For the first time two great oceans will be connected by an unbroken avenue of brilliant lights, through which the world's commerce will pass, for this canal will be in service every hour during every day in the year. Like stately sentinels standing at attention, a double line of buoys, beacons and lighthouses will enable the pilots to safely follow the zigzag course from Atlantic to Pacific. In the lighting scheme both gas and electricity will be used; the gas lights will burn continuously, which is found to cost much less than attendance to light and extinguish, and, moreover, guards against hours of untimely darkness and fog. The beacons are of two sizes, 15 and 30 ft., respectively, and are built of concrete. The lighthouses are 74 ft. high to the light, and are of the usual exterior form, being ascended by means of a steel spiral stairway with an outside observation platform extending all around the lantern. The lights are placed in pairs, directly opposite each other, and the navigator has only to keep in the middle of the 'road' to proceed with safety and dispatch."

Popular Mechanics, **February 1913**



<u>Above Left</u>: caption: "Front Tower. Range 5-6, Atlantic Division. An elaborate system of Range Lights assists Navigators through the open waters of the Canal"
<u>Above Right</u>: "Rear Tower, Range 9-11, Pacific Entrance. Looking Northwest, November 7, 1911."
<u>Left</u>: caption: "'The Front Tower on Approach Wall of Gatun Locks.' These range lights are used to guide ships in the channel of the Gatun Lake and aid them in reaching the entrance to the locks at night."



"Final designs for the lamp standards, brackets and reflectors to be used in lighting the locks of the Panama Canal have been made and have received the approval of the Fine Arts Commission. The posts, including the ornamental ball, will be of reinforced concrete cast in iron forms manufactured in the Gorgona shops, and a total of 511 standards carrying single or double-arm brackets will be required. The reflectors will be placed 29 ft. 6 in. above the ground and 4 ft. 3 in. from the center of the standard. Each concrete double-arm bracket with reflectors will weigh approximately 1,610 lb., and the solid ball, weighing 730 lb., will be used to counterbalance the weight of the single-arm brackets on the middle locks."

***Popular Mechanics,* November 1913**

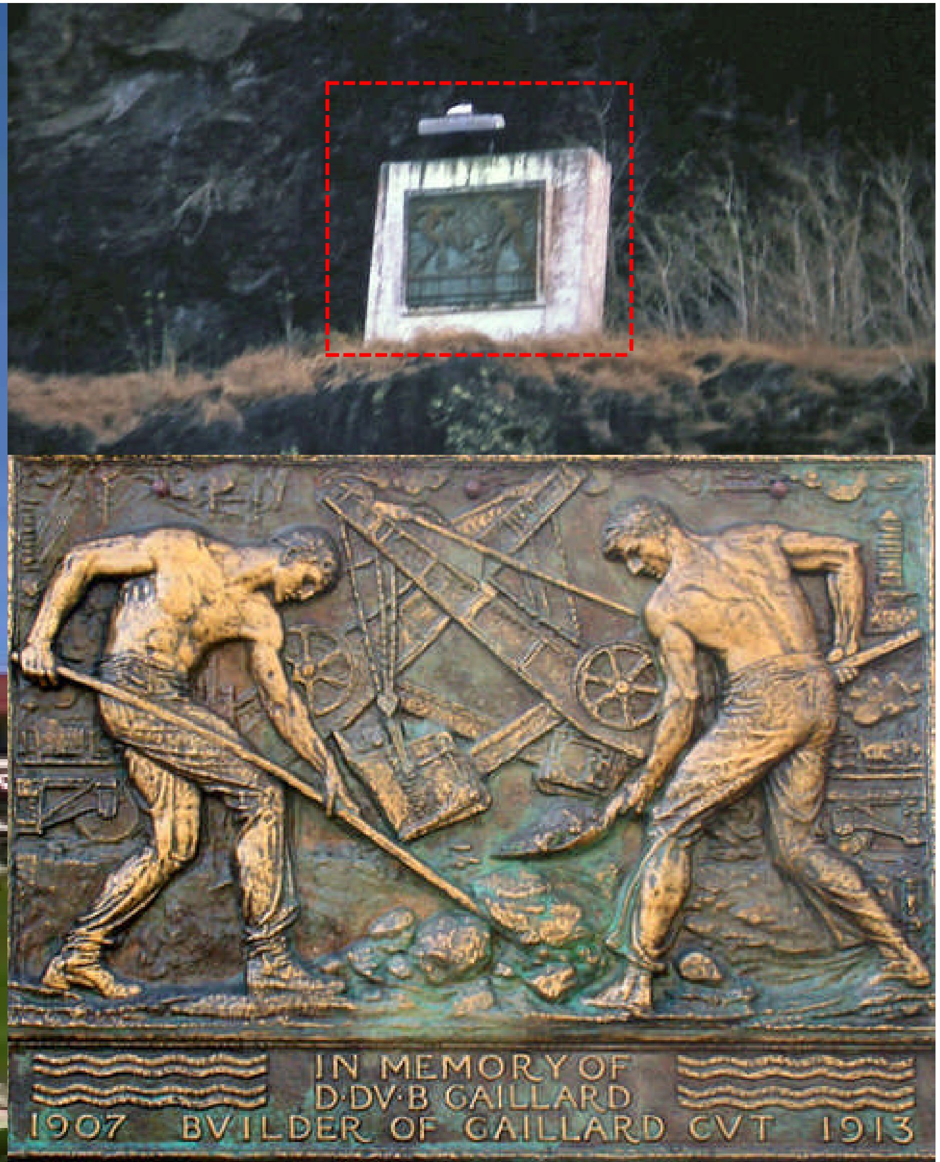
"Seattle, Wash., has been one of the first cities in the country to adopt the new nitrogen-filled electric lights for street lighting purposes. The contended advantage of the lamp is its efficiency, for it requires less energy per candlepower than other similar lights. The presence of nitrogen at ordinary pressure in the bulbs also protects the metallic tungsten, preventing the blackening of the glass. Great brilliancy is produced by the lamp, which will be used for illumination along the Panama Canal."

Popular Mechanics, **August 1914**

A Touch of the Esthetic

“Although the Commission of Fine Arts has found the Panama Canal devoid of ornament with no evidence of the esthetic in the architectural features of the construction work, it does not minimize the natural beauty of the location, the tropical foliage, the broken skyline and the glimpses of the ocean, lake and bay through the purple haze. The commission has outlined a plan for the erection, at suitable points along the canal, of monuments and arches, commemorative of the completion of the project, which, it is urged, shall give a touch of the esthetic to an otherwise crude, although impressive, engineering feat. A monument 100 ft. high is proposed for Culebra, where the canal passes through the continental dIvide, and another at Gold Hill, the highest point in the Culebra Cut, and some suitable structure in the form of an arch at the point where the channel from Limon Bay ends and the canal actually begins, with a replica at the Pacific end.”

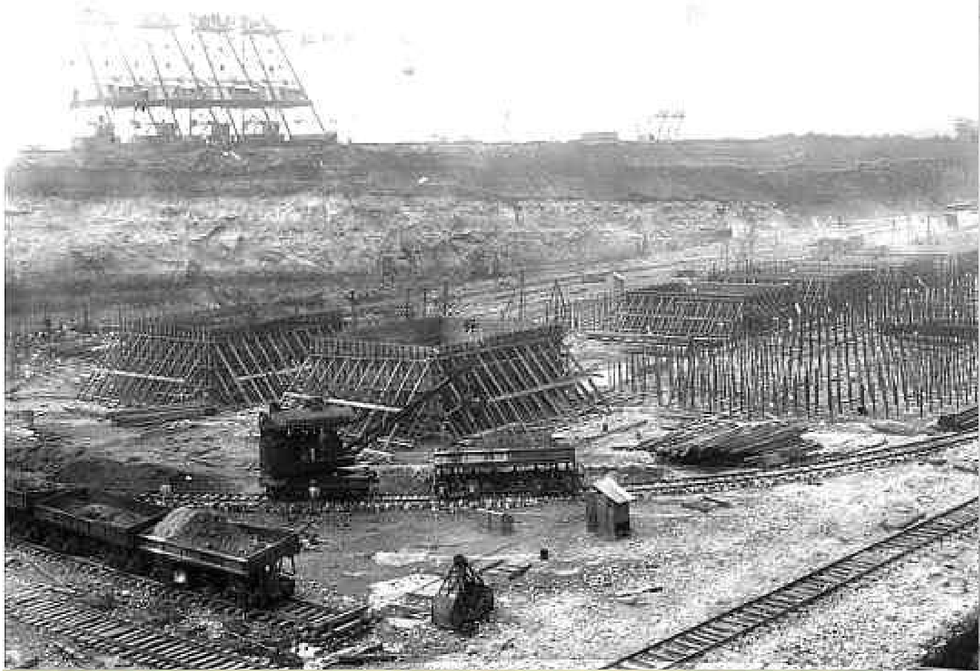
***Popular Mechanics,* February 1914**

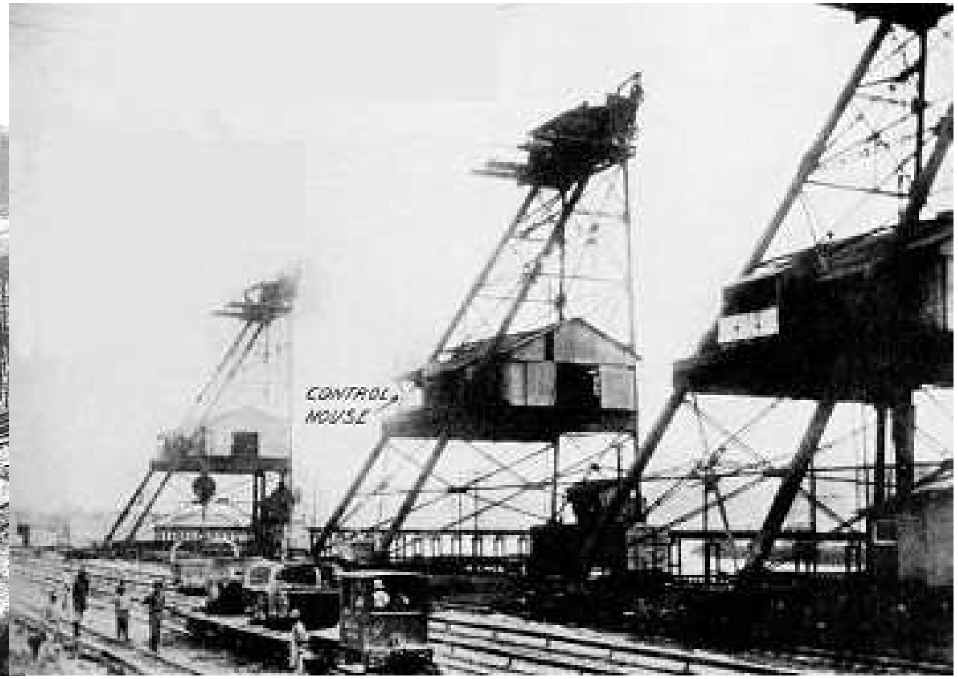


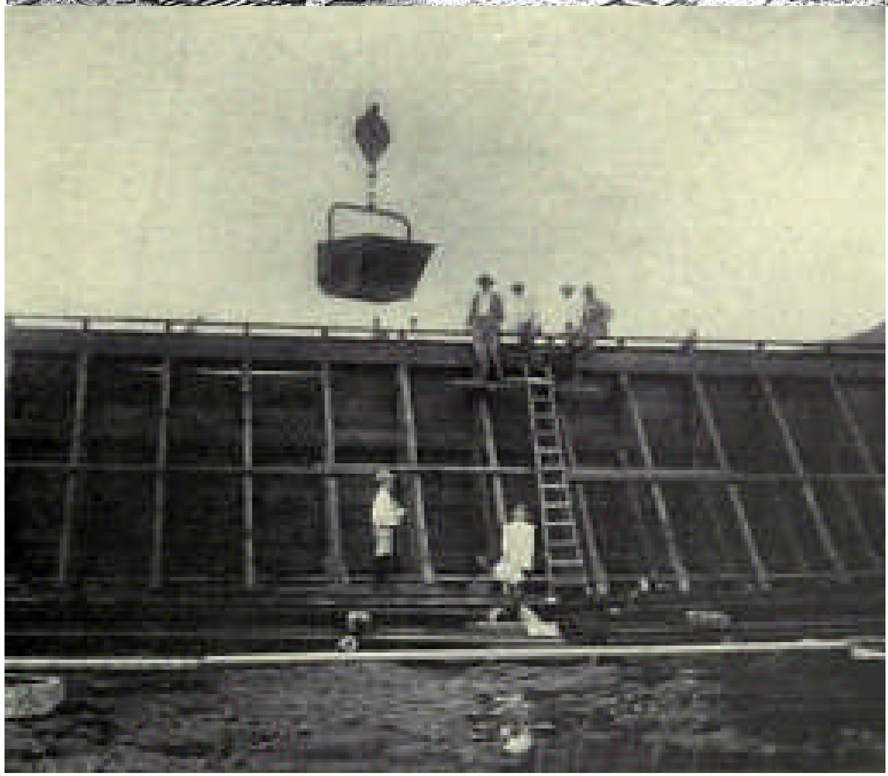
Above: ***Gaillard Memorial Plaque*** **(in *Culebra/Gaillard Cut*)**

Left: ***Goethals Memorial*** **in front of the *Panama Canal Administration Bldg.***

Lock Construction



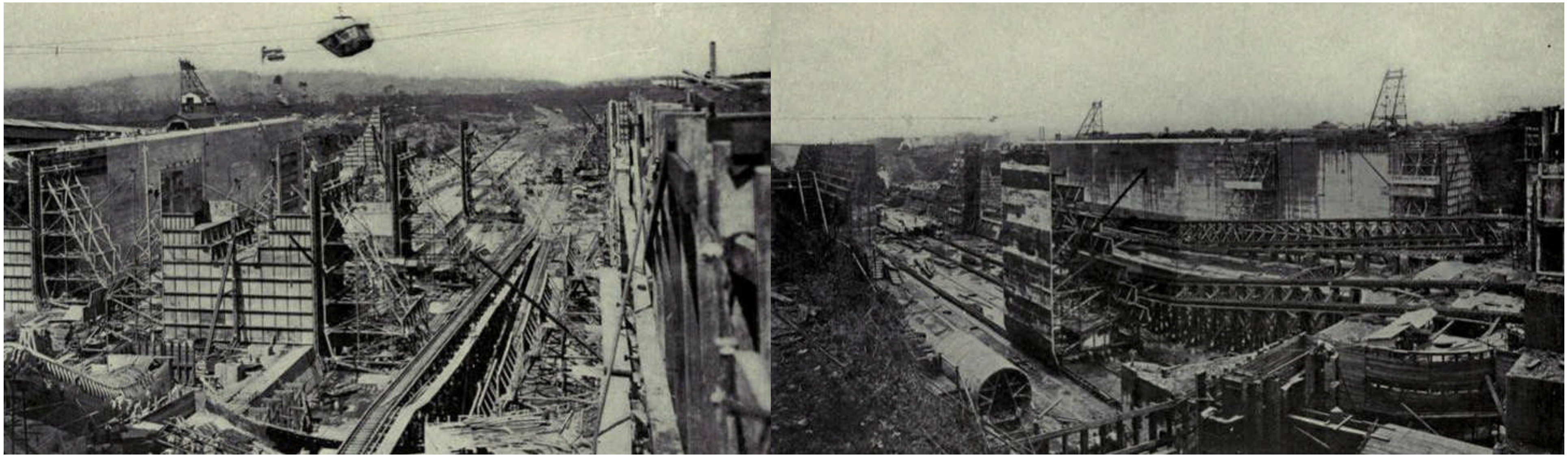


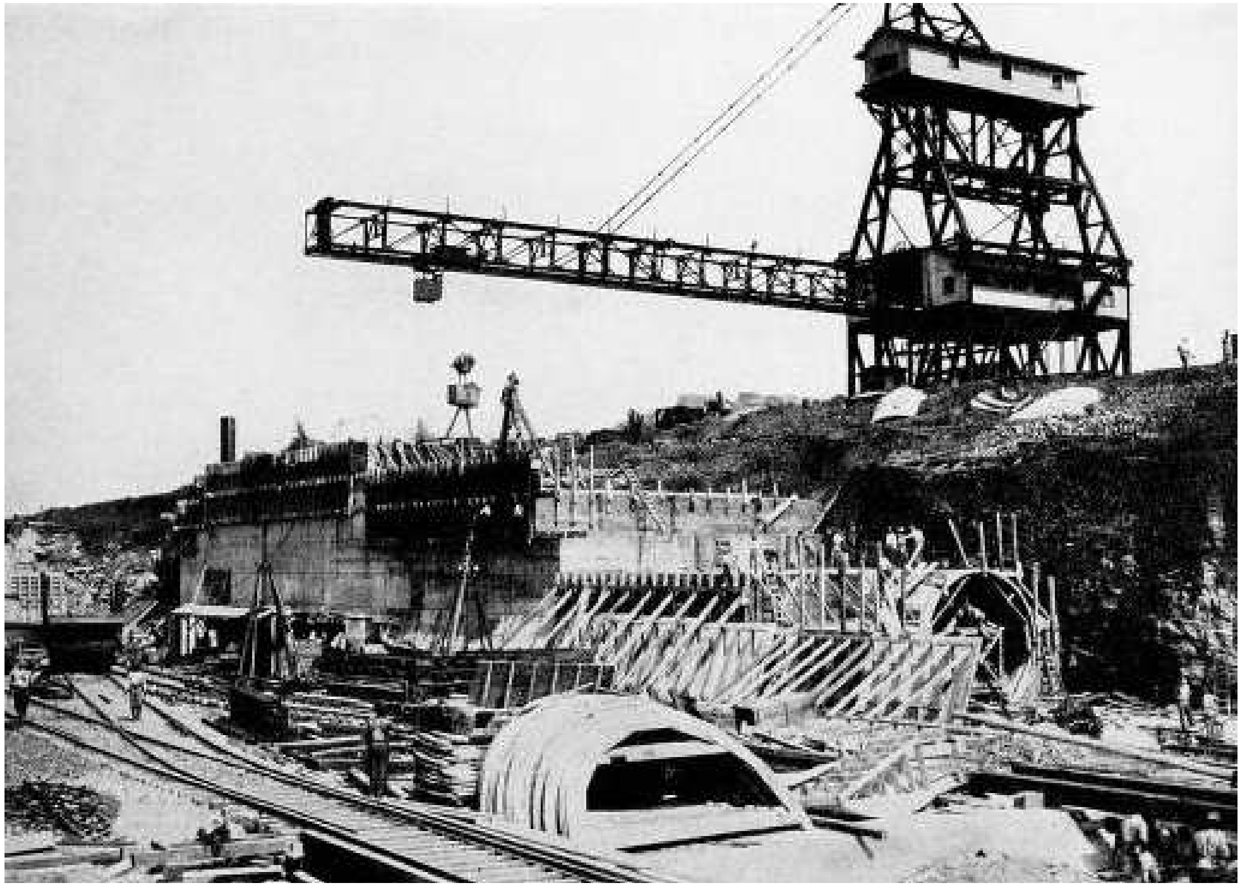


Top Left: caption: “Gatun Lock site looking North from East Bank, August 25, 1909”

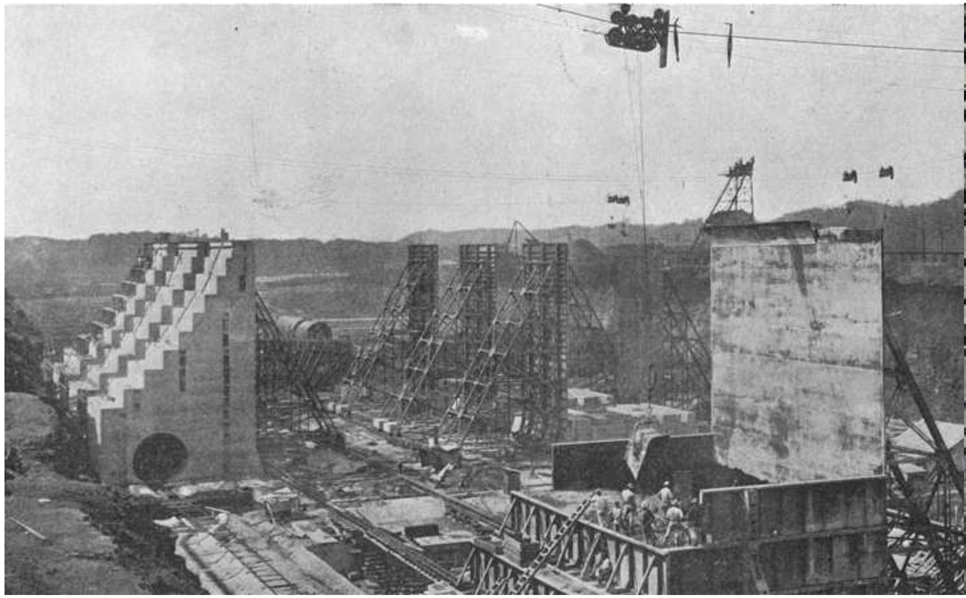
Top Right: caption: “‘Giant Cement Carriers at Work.’ Placed in pairs on either side of a piece of work requiring concrete, these frames support cables in which swing cars carrying concrete and controlled by a workman in the elevated house shown.”

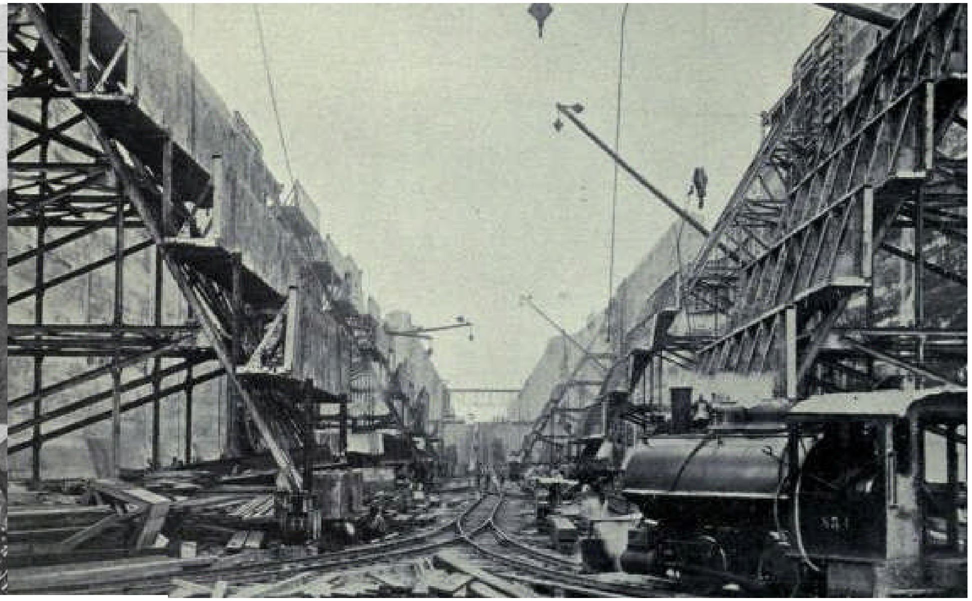
Left: caption: “First bucket of concrete, Gatun Locks”

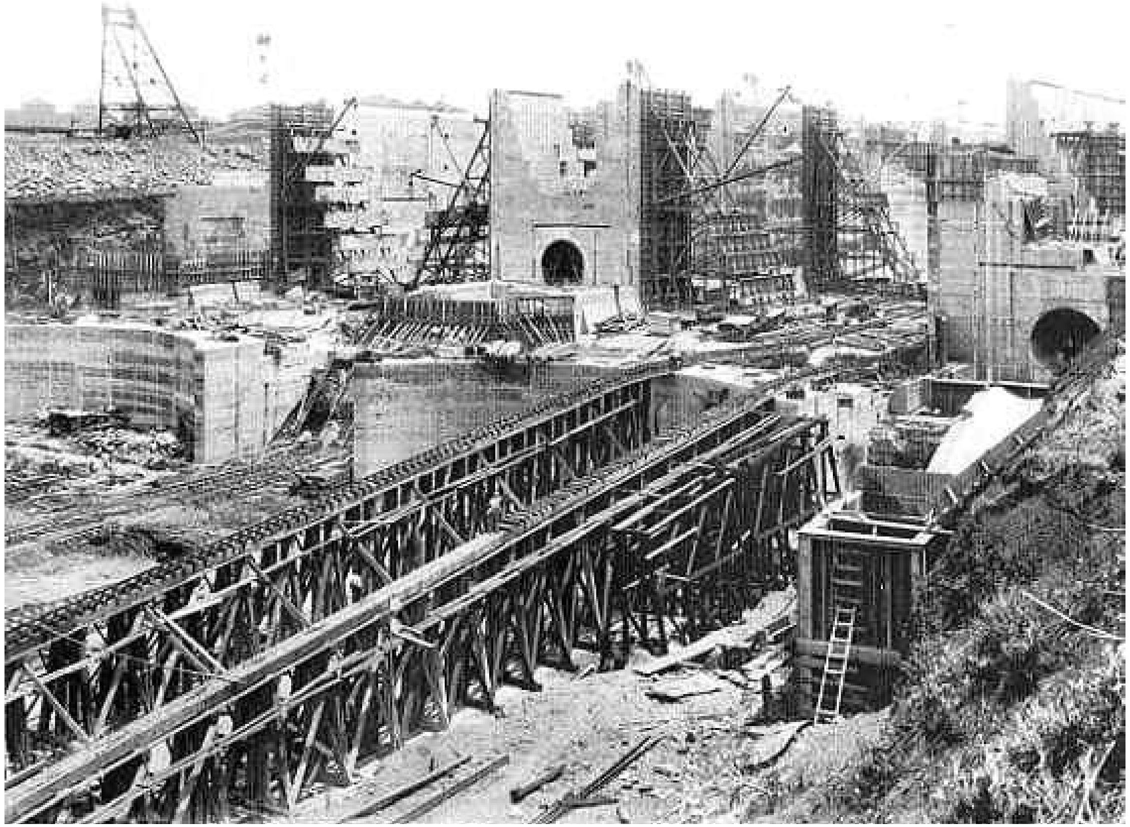




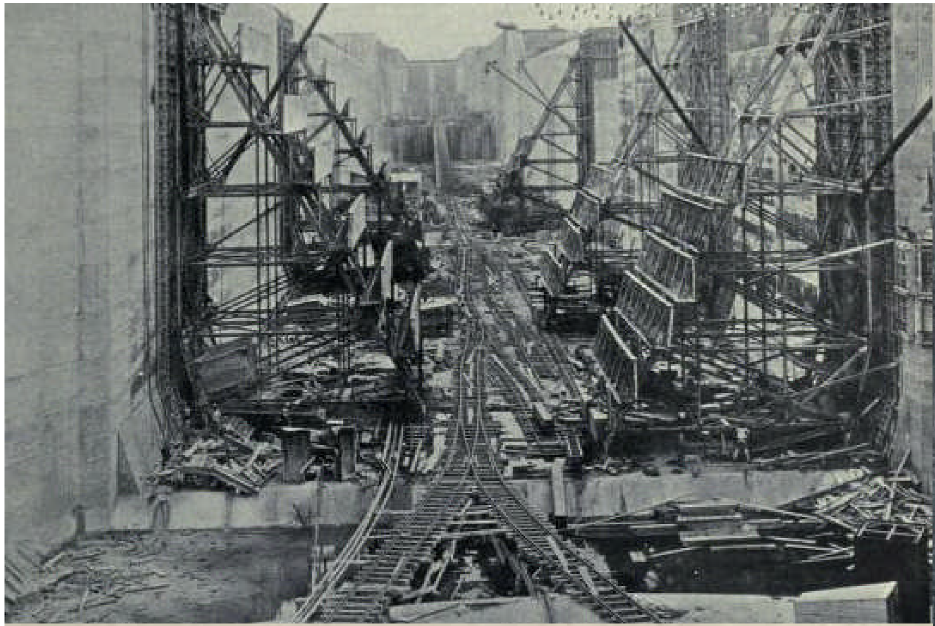
<u>Top L&R</u>: caption: "Steel Forms, Gatun Locks"
<u>Left</u>: caption: "'Traveling Crane Handling Concrete in Lock Building.' These cranes are the striking feature of the Canal landscape, handling thousands of tons of concrete daily."

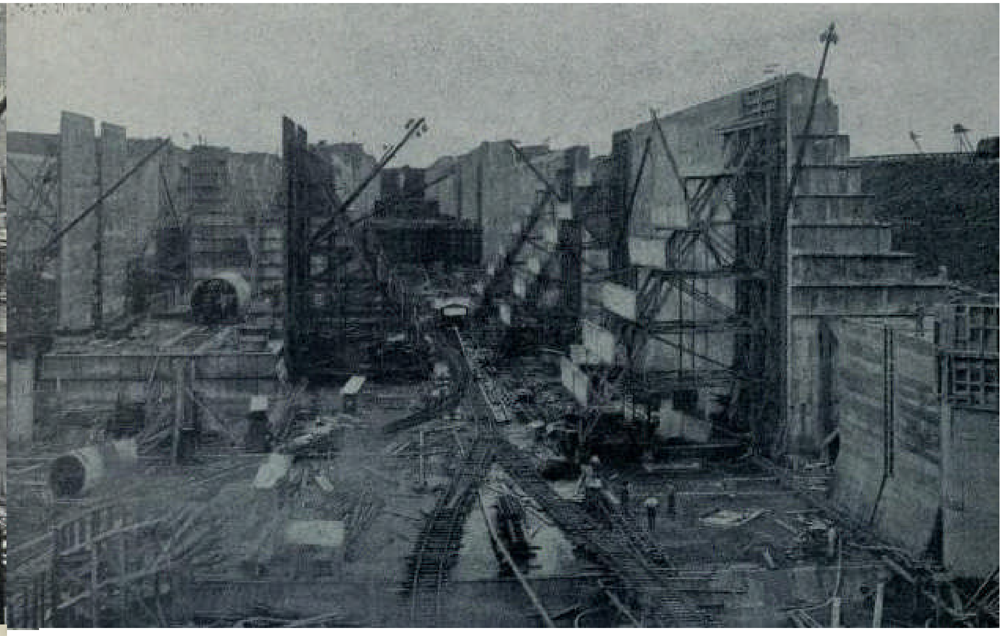


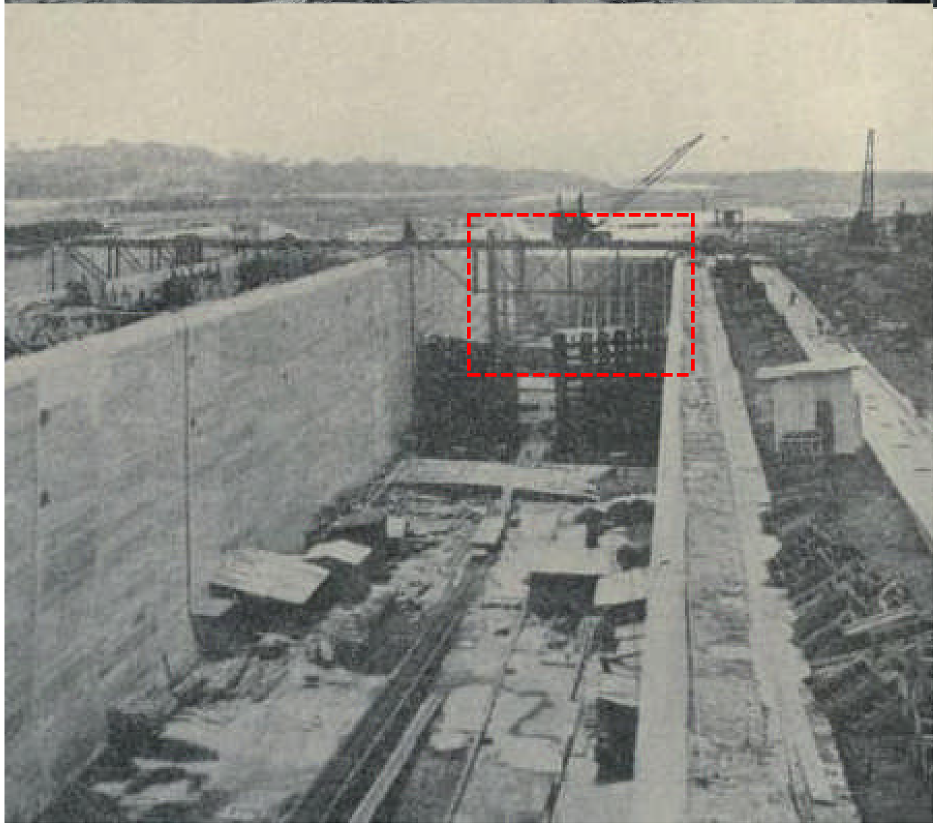




<u>Top Left</u>: caption: "Constructing sidewall monoliths of the upper lock, Gatun. The concrete was placed between steel forms, movable on tracks laid on the floor of the locks."
<u>Top Right</u>: caption: "Let us walk into the lock chamber, noticing the height of the walls, and the steel framework holding the forms into which the liquid concrete is poured"
<u>Left</u>: Gatun *Locks* construction (ca. 1910)



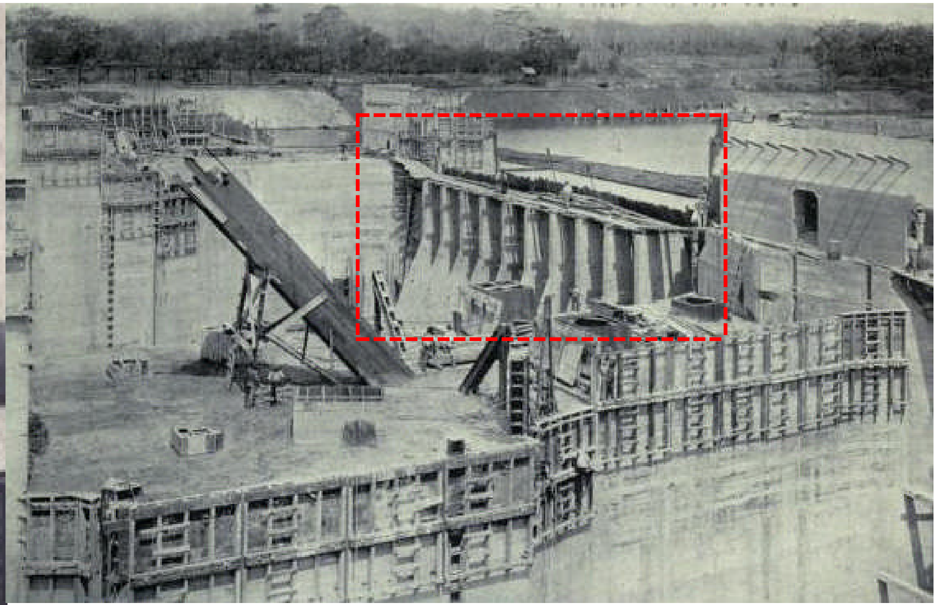


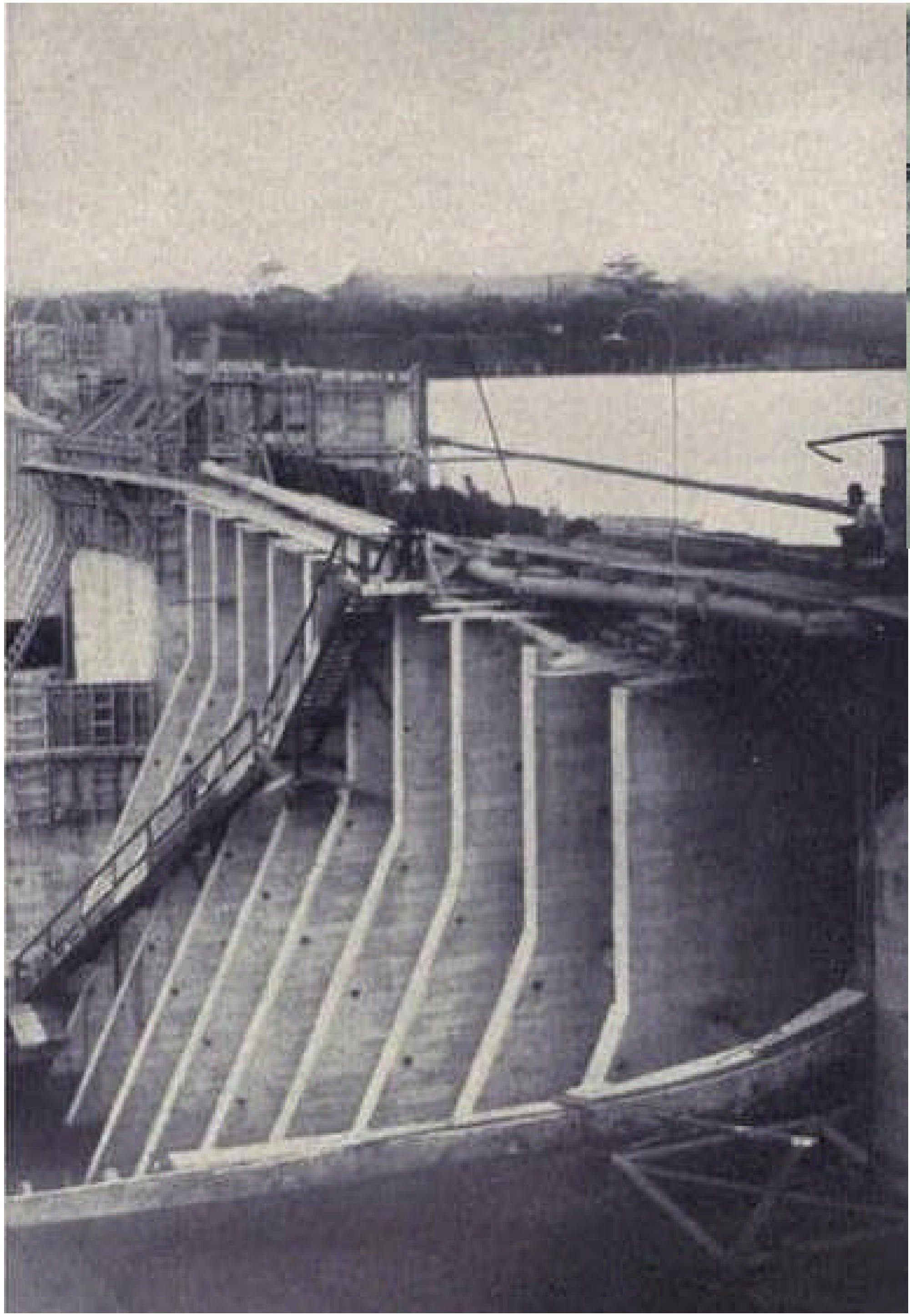


<u>Top Left</u>: caption: "Here we are at the great Gatun Locks. We are looking up from the lower end of the lowest chamber. To the far end of the third or highest chamber is more than half a mile. This is only half the lock; alongside is another set of three chambers or steps, like this."

<u>Top Right</u>: caption: "Gatun Lower Locks looking down from Cofferdam, showing West Chambers of Upper and Middle Locks. As they appeared on November 9, 1911"

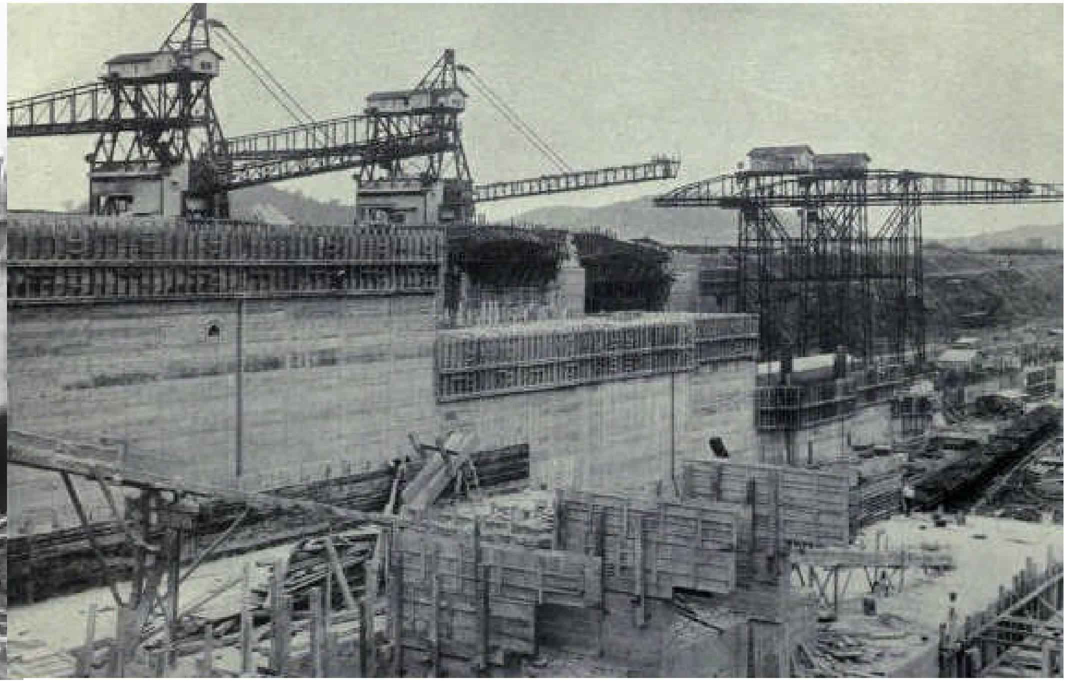
<u>Left</u>: caption: "Gatun Lower Locks, East Chamber, looking North, showing temporary Cofferdam at entrance end of Lock Chamber, June 12, 1912"

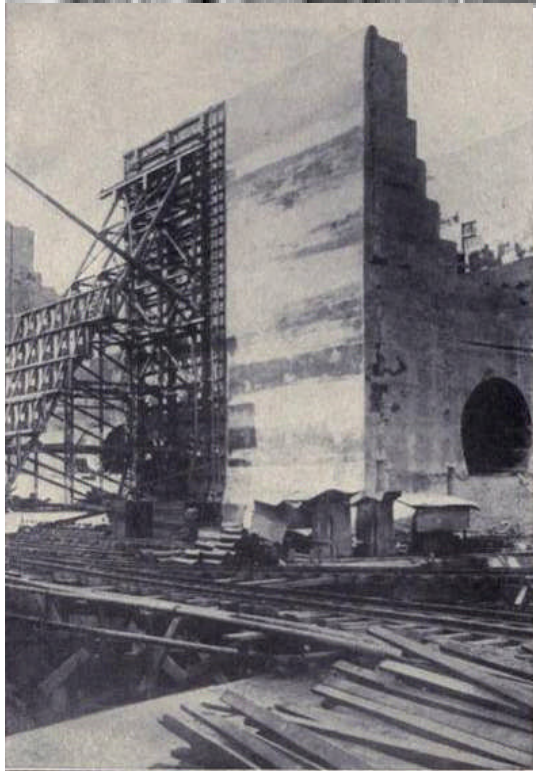




<u>Above</u>: caption: "Climbing to the top of the Lock walls, we can see how thick the concrete is, and how the water from the sea-level is kept out by a temporary dam"

<u>Left</u>: caption: "Temporary Dam at Atlantic Side of Gatun Locks"

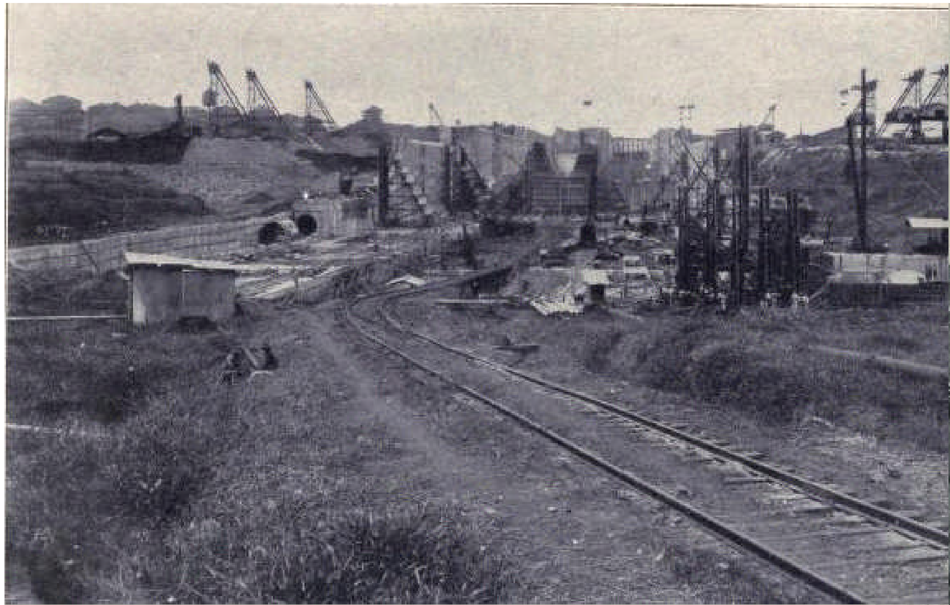


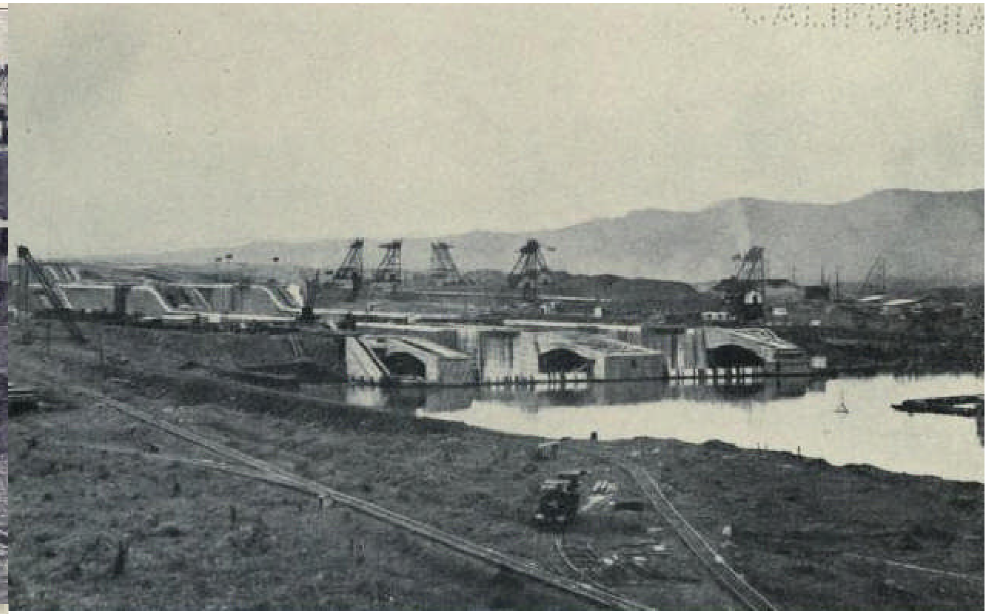


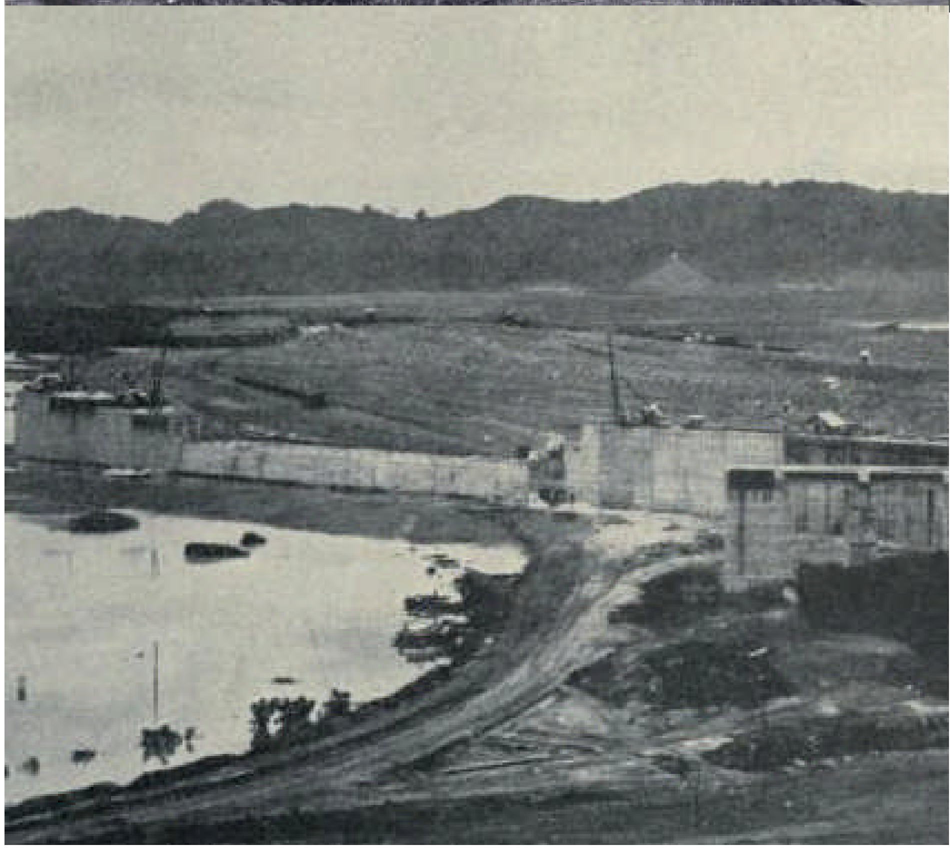
Top Left: movable (on tracks) "Berm Crane"

Top Right: caption: "These are the machines for mixing and laying the concrete of which the Locks are built. Tons of sand and mountains of cement and broken stone are used."

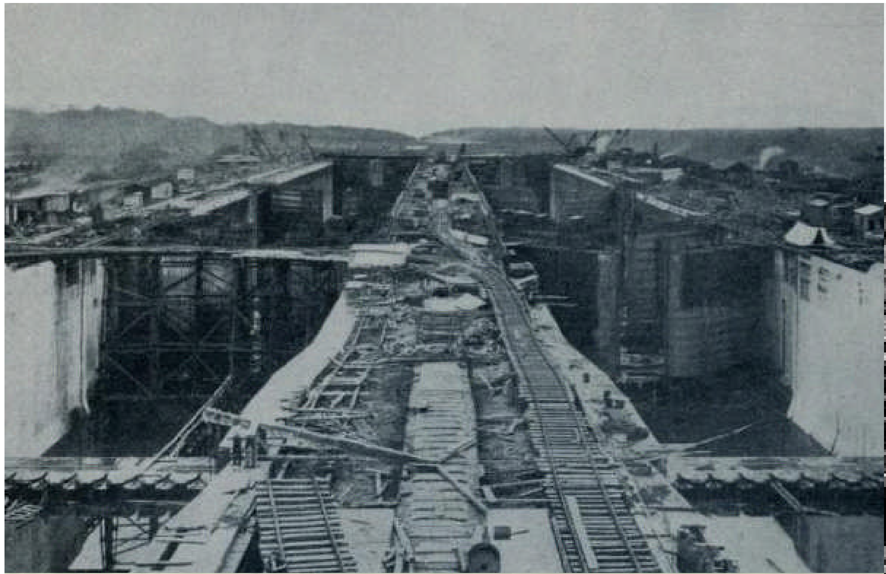
Left: caption: "Showing part of a Lock. The concrete work is 90 feet high. The metal work is the mould. The round hole on the right will be used to fill the locks with water, and is large enough for a railroad train to pass through."

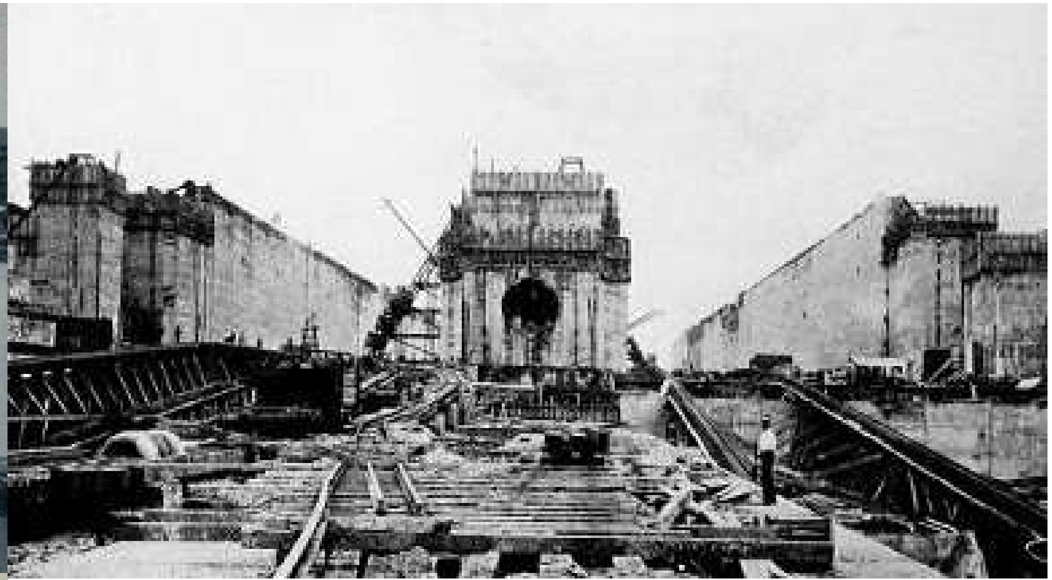


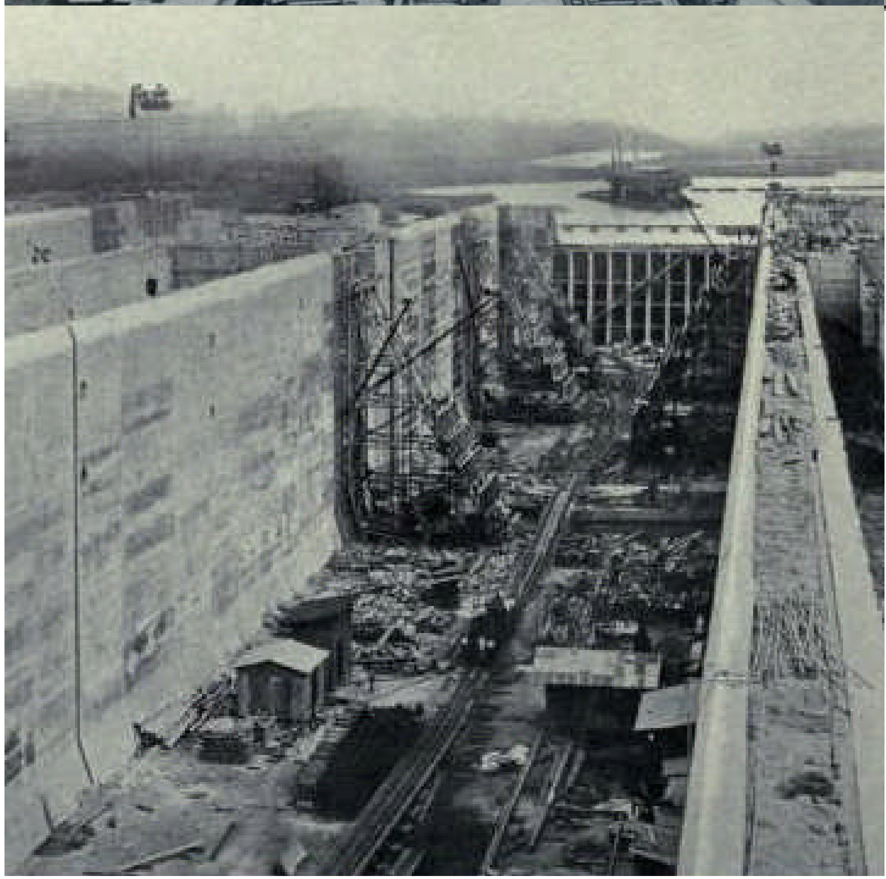




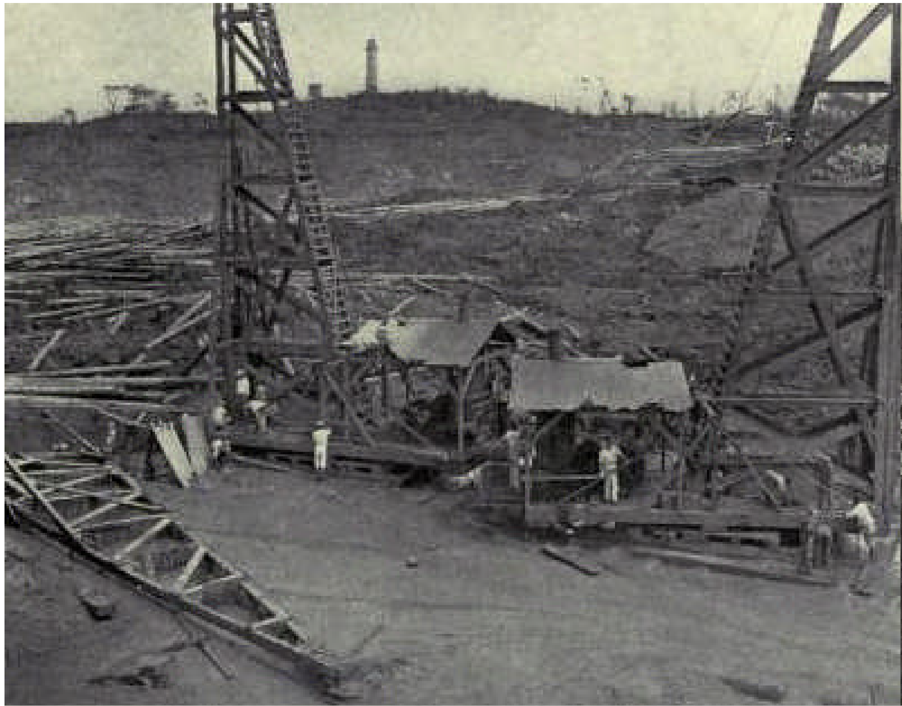
<u>Top Left</u>: caption: "Gatun Lower Locks, looking South, showing Middle and Upper Locks in the distance"
<u>Top Right</u>: caption: "Gatun Locks. General view looking Southwest, showing North End of the Locks, with temporary Cofferdam in place, July 2, 1912."
<u>Left</u>: caption: 'Gatun Locks and Dam. Looking West from Water Tower, showing South Center Approach Wall and forebay at Gatun Locks, with Dam and Spillway in the distance, June 1912."

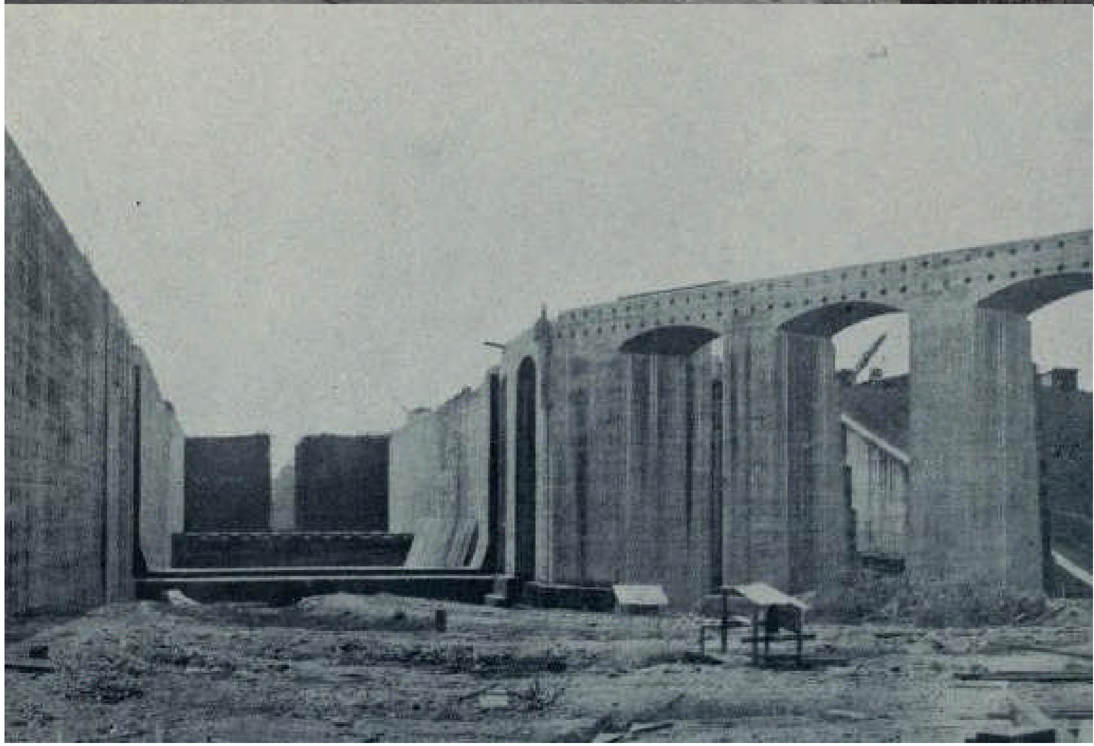






<u>Top Left</u>: caption: "Gatun Upper Locks, looking North from Lighthouse, as they appeared July 2, 1912. The three pairs of Locks at Gatun have a combined lift of 85 feet"
<u>Top Right</u>: caption: "Lock Construction Showing Conduits"
<u>Left</u>: caption: "Half way along the Locks we turn and look back. In the distance is the low country from which we have come, and through which the sea-level section of the Canal runs from the Atlantic."

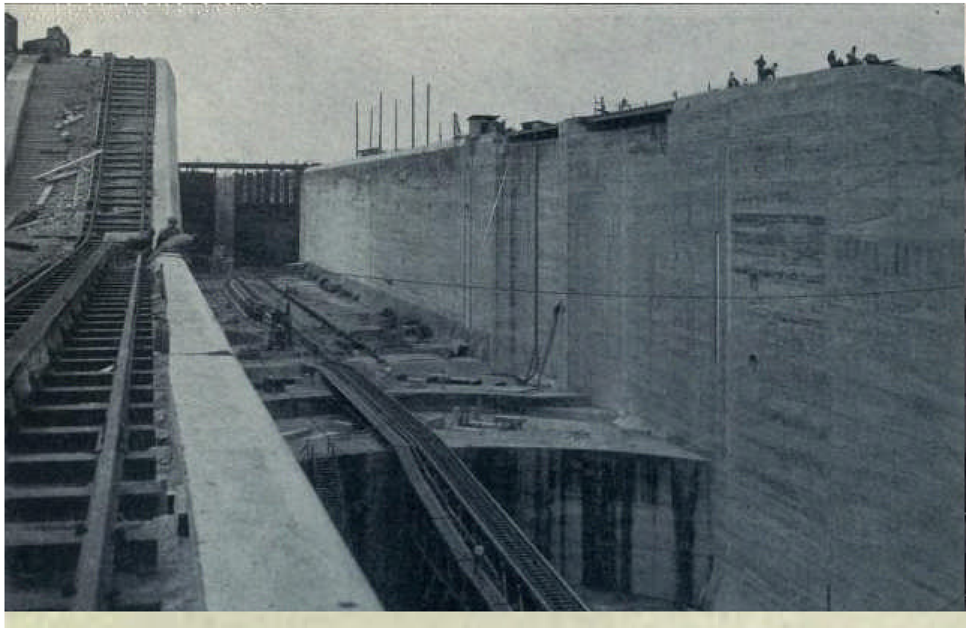


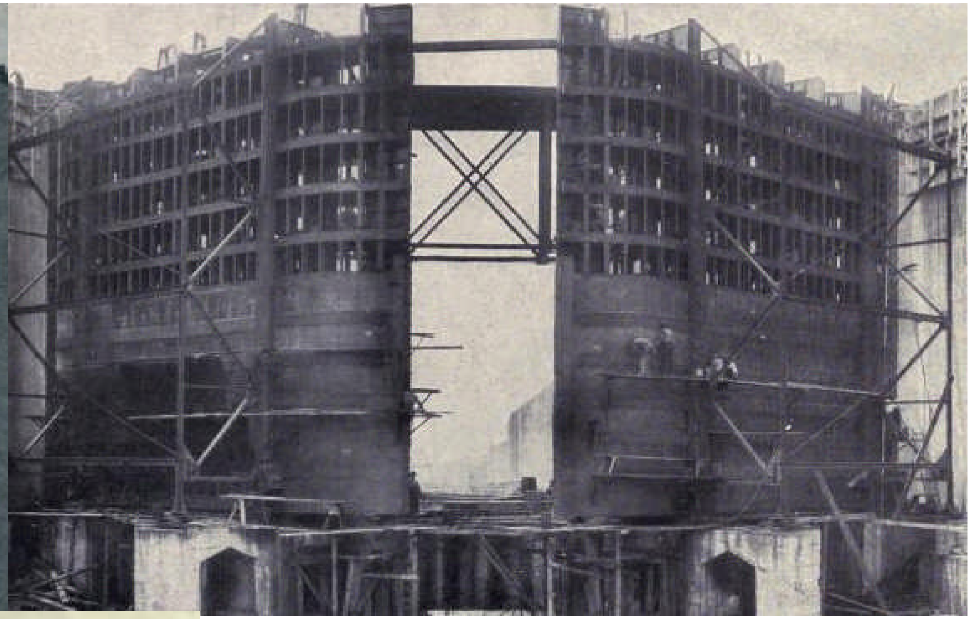


<u>Top Left</u>: caption: "Slide into space excavated for North Guide Wall, Gatun Locks"

<u>Top Right</u>: caption: "North Guide Wall, Gatun Locks"

<u>Left</u>: caption: "Gatun Locks Forebay, East side looking North, showing flaring Approach Wall, June 7, 1912"

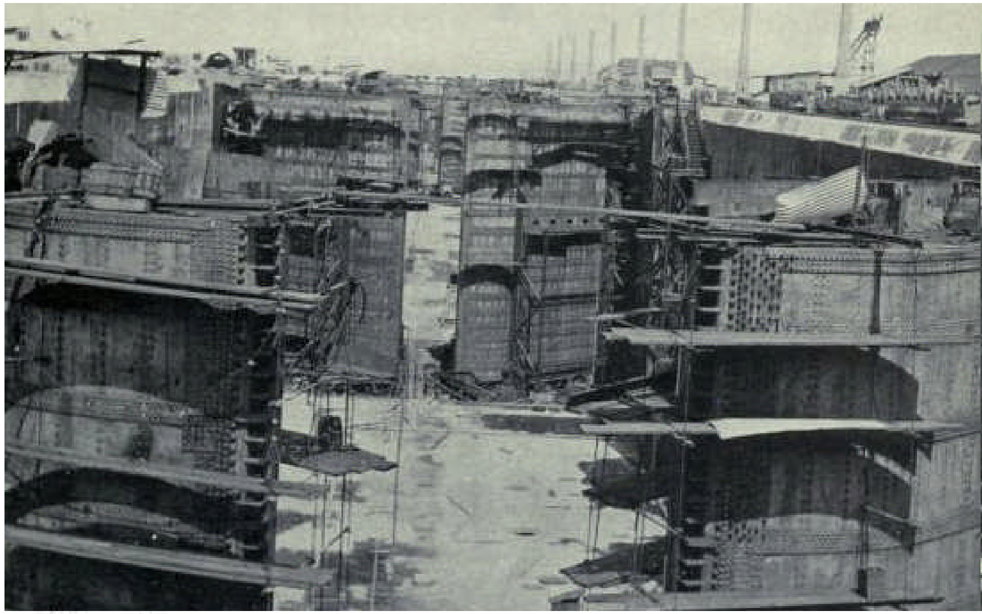


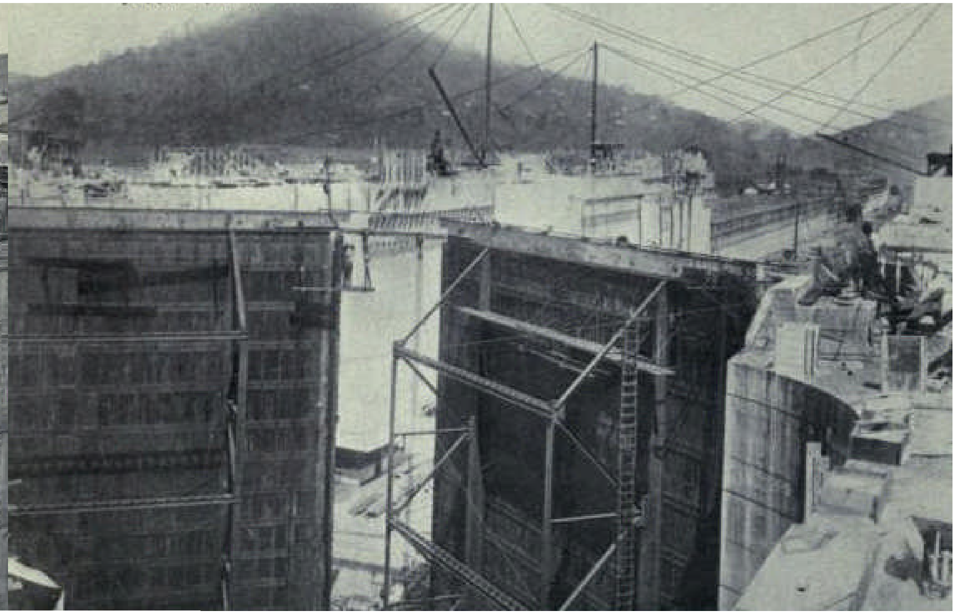


<u>Top Left</u>: caption: "View showing East Chamber, Lower and Middle Locks at Gatun, with section of Rack Track on East Wall, March 14, 1912"

<u>Top Right</u>: caption: "Gatun Upper Locks, view looking North, showing progress of construction of Upper Gates in East Chamber"

<u>Left</u>: caption: "A dredge grounded 55 feet below sea-level, Gatun Locks"

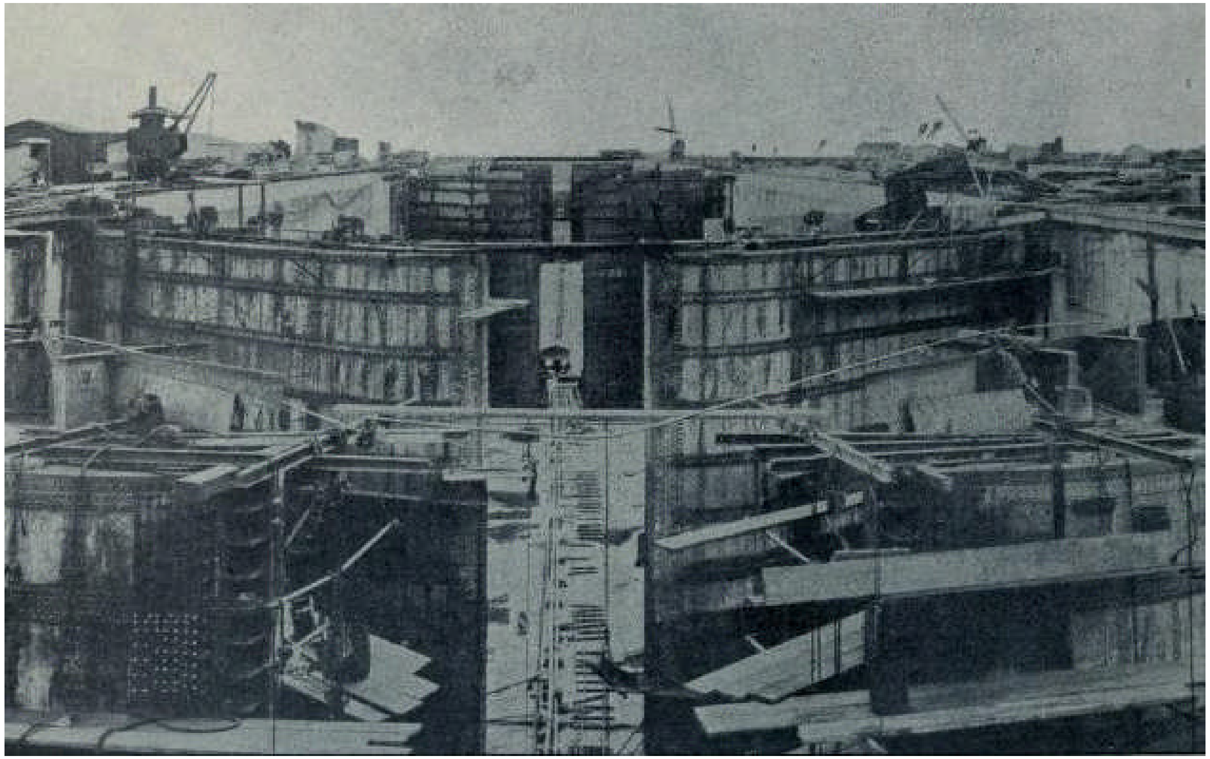




<u>Top Left</u>: caption: "Now we are at the head of the Gatun Locks, and looking back we see the series of massive gates through which the ships will pass"

<u>Top Right</u>: caption: "Here, at Gatun, are the large steel Lock Gates. By making them hollow and watertight, they partly float in the water, making them light and easy to operate."

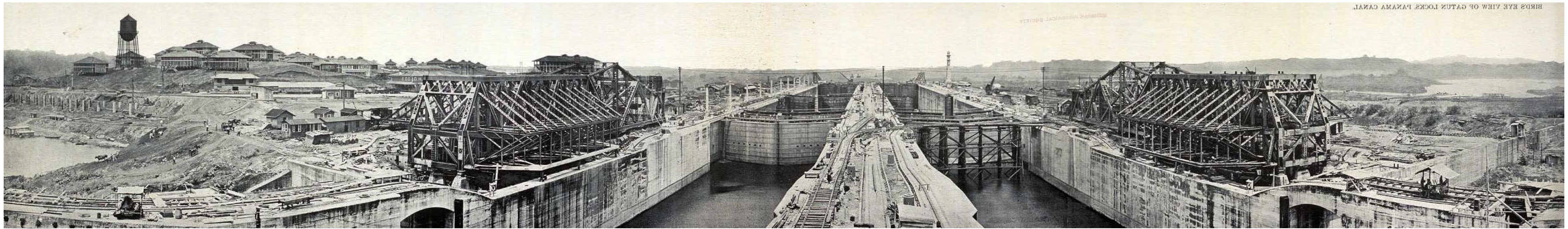
<u>Left</u>: caption: "'Gatun Locks, North Entrance, March 1913."

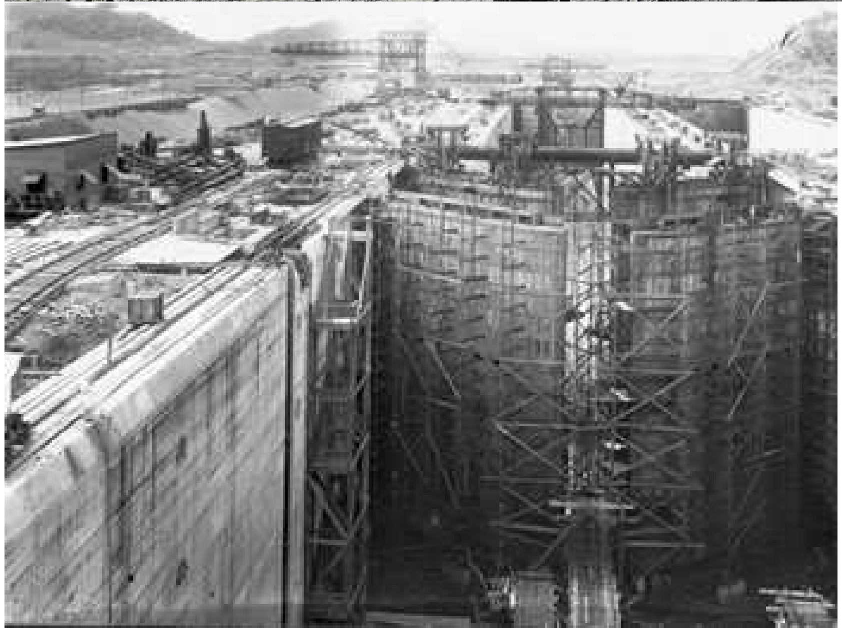


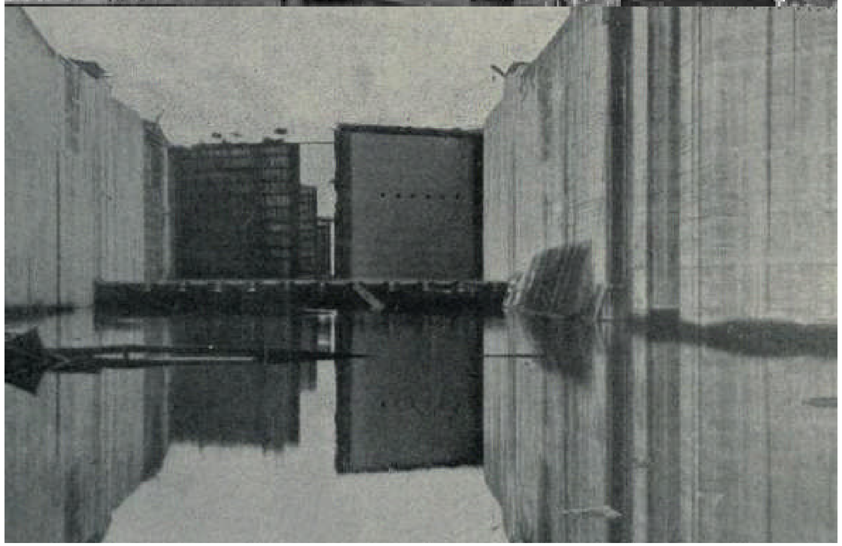
"…Since 95 percent of ocean-going ships are less than 600 feet long, and it would be a waste of water and of time to use the entire 1,000-ft. lock for short vessels, each lock is provided with intermediate gates, so that any one of five different lengths of chamber may be used…"

Popular Mechanics, **December 1913**

Above: caption: "Gatun Upper Locks, West Chamber, looking North, showing Upper Guard Gates, Operating Gates, Intermediate Gates and safety gates in process of construction, June 7, 1912"







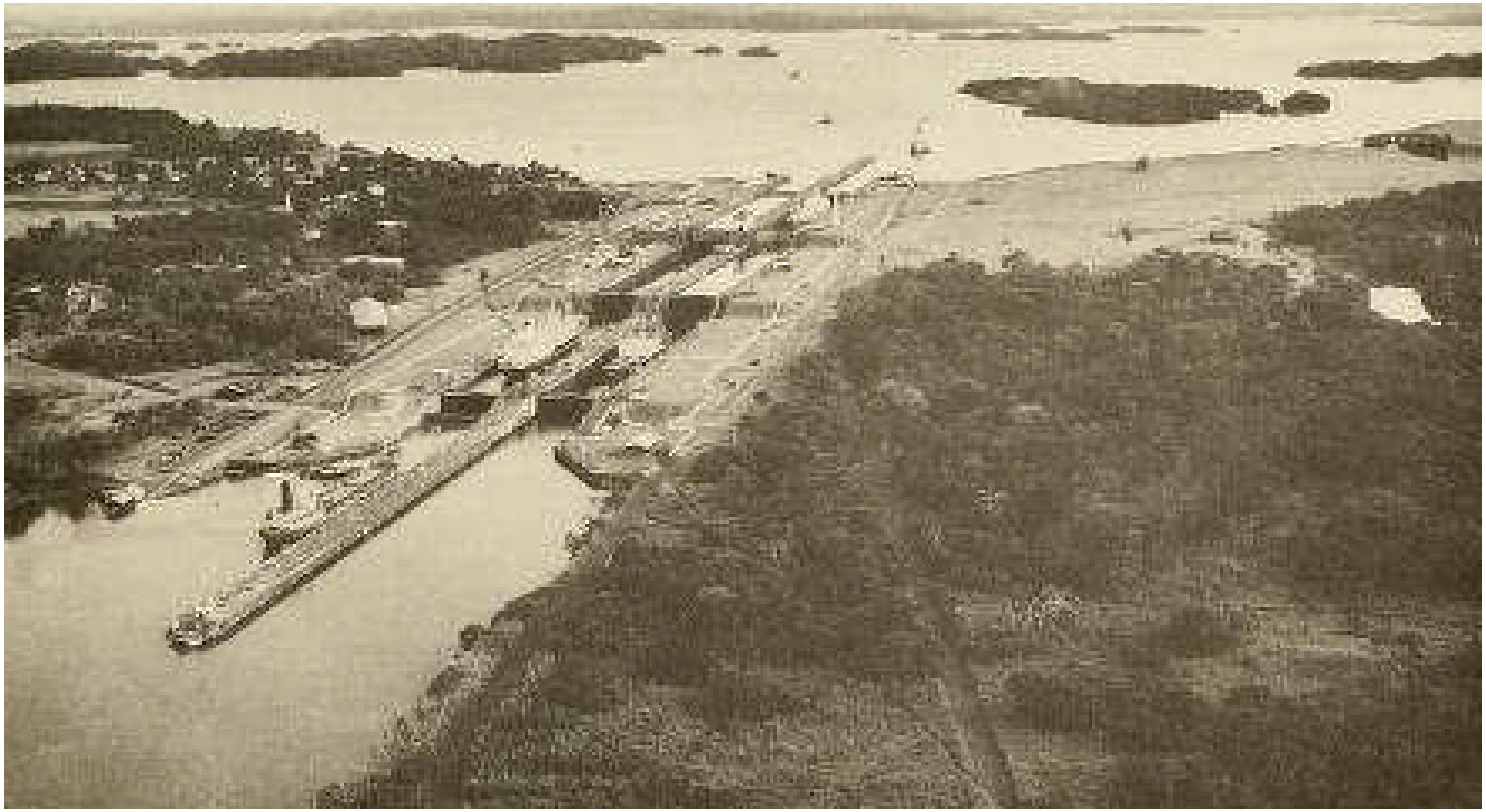
<u>Above</u>: caption: “Birds-eye view of the construction site at the Gatun Locks, 1913”

<u>Left Top</u>: Lock Gates under construction (ca. 1912)

<u>Left Bottom</u>: caption: “Gatun Upper Locks, East Chamber, looking North from Forebay, showing Upper Guard Gates and Emergency Dam Sill, July 7, 1912. The Lock Gates are steel structures 7 feet thick and weigh from 300 to 600 tons each.”

“The widening and deepening of the Kiel Canal, which connects the Baltic with the North Sea, will be completed in the spring of 1915, at an estimated cost of $56,000,000. The depth will be 45 ft., and the width will be considerably increased. Double locks, 1,082 ft. long and 147 ft. wide, thus larger than the Panama Canal locks, will be constructed at Holtenau and Brunshuttel. All bridges across the canal, except the one at Rendsburg, which will be of the swing type, and one of the largest of its kind in the world, will be elevated sufficiently to give passage to the largest vessels.”

***Popular Mechanics,* May 1913**



"…During the last three years, 6,000 vessels have passed through the canal annually. The net tonnage has been over 29,000,000, the cargo tonnage more than 29,600,000 and the tolls about $27,000,000 a year. The United States leads in traffic with more than forty-six percent and Great Britain is second. Two-thirds of the ships pass from west to east, carrying principally mineral oils, lumber, ores, nitrate and wheat from the Pacific, and iron and steel manufactures from the Atlantic coast…"

***Popular Mechanics*, July 1931**

Above: caption: "Gatun Locks at the Caribbean end of the Panama Canal"


CANAL ZONE POSTAGE
25TH ANNIVERSARY 1939
OPENING PANAMA CANAL 1914
GATUN LOCKS - AFTER
10
CENTS

Part 5

Making the Cut

The Big Ditch

In the mountain chain stretching from *Alaska* all the way to *Chile*, there was one point where the mountains had turned into low-lying hills; *Panama*. The lowest point in the saddle between *Gold Hill* (east) and *Contractors Hill* (west) was only 333.5-feet above sea-level. So it was decided that is where the cut would go. Depth of the cut was not the problem. Rather, it was the length of the cut considering the fact that the engineers would have to cut through ten miles of rock and clay; a daunting task. The American press dubbed this nearly ten mile long valley: “The Big Ditch.”

In order to connect the *Chagres River* to the *Pacific Ocean*, the canal engineers would have to cut through rock and earth at a small town known as *Culebra* (located at the *Continental Divide*). "Culebra" is Spanish for *Snake*. At first the men speculated this term referred to the zigzag path of the linked chain of hills. However, once rattlesnakes began to appear on a regular basis, there was no doubt from whence the name was derived. The engineers would have 8.75 miles of hills and rocks to deal with. Of this stretch - from *Gamboa* (on the *Chagres River*) at the north-end, to *Pedro Miguel* - on the south-end, only one mile; the stretch through the Continental Divide itself, would prove to be the most difficult and was nicknamed "Culebra Cut." However, the nearly nine mile long cut has come to be known, in general, as "Culebra Cut."

<u>Above</u>: (postcard) caption: "The Deepest Section of the Famous 9-Mile Culebra Cut"


GAMBOA
Fairway
C
U
T
PAN
AMERICAN
HIGHWAY

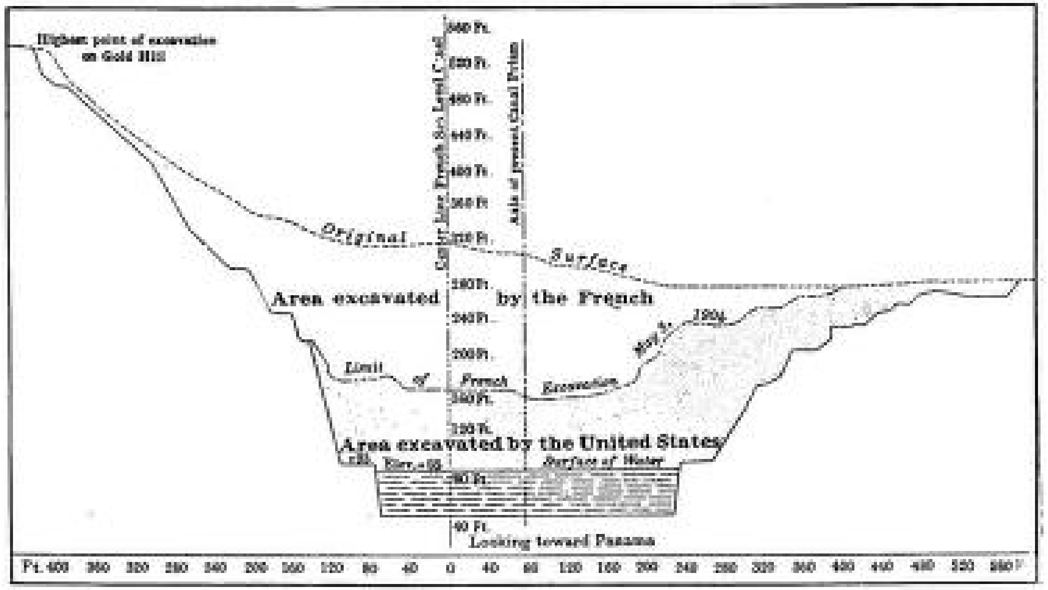
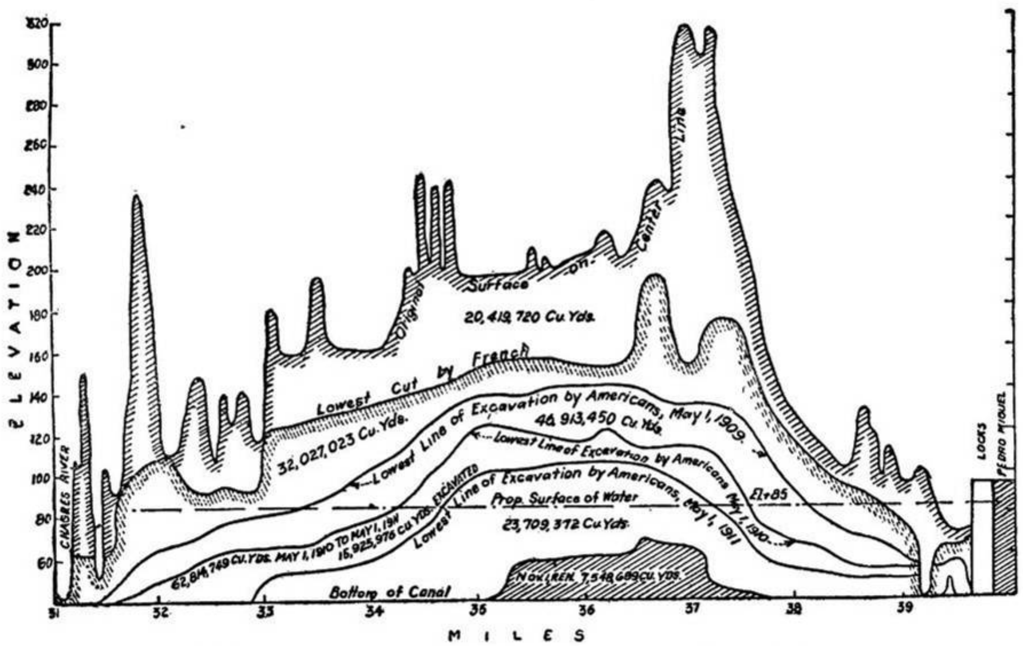


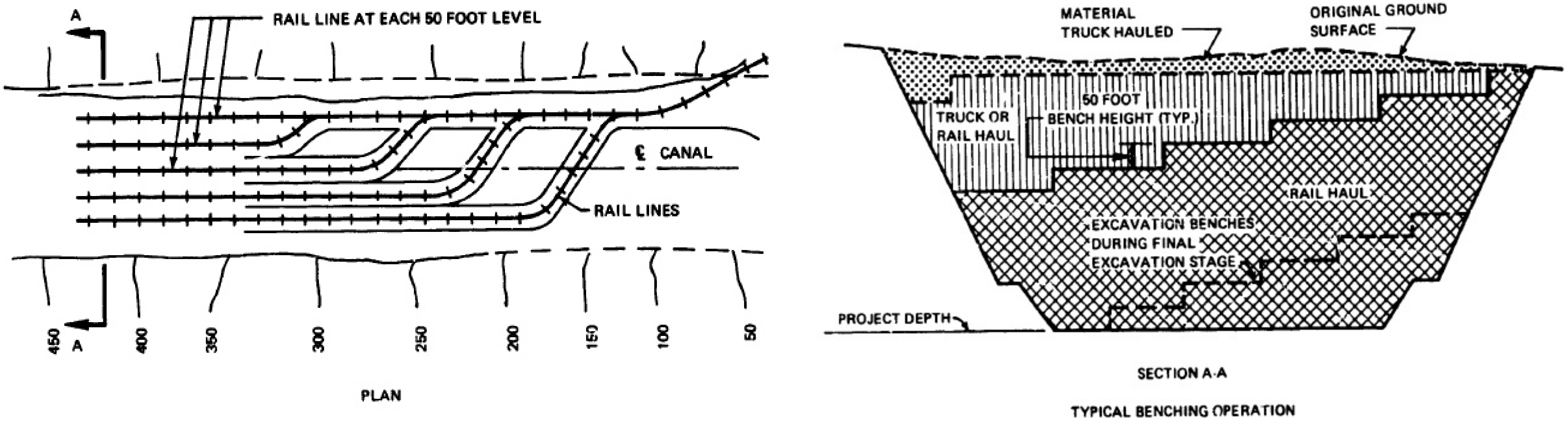
DIAGRAM OF COMPARATIVE EXCAVATIONS BY THE FRENCH AND AMERICANS IN CULEBRA CUT



PROFILE OF CULEBRA CUT FROM THE DIKE AT GOMBOA TO PEDRO MIGUEL LOCKS

"…The Culebra Cut, nine miles long, through the mountains, was the most difficult part of the canal construction. At the highest point, Gold Hill, the mountain rose nearly 580 ft. above sea-level. Here more of the work done by the French company was utilized than at any other point along the canal. They had taken out about 20,419, 720 cu. yd. of earth and rock, but there still remained, for the American forces to excavate, 89,794,493 cu. yd. to which frequent 'slides' of earth from the mountain slopes have added another 22,000,000 cu. yd…"

Popular Mechanics, **December 1913**



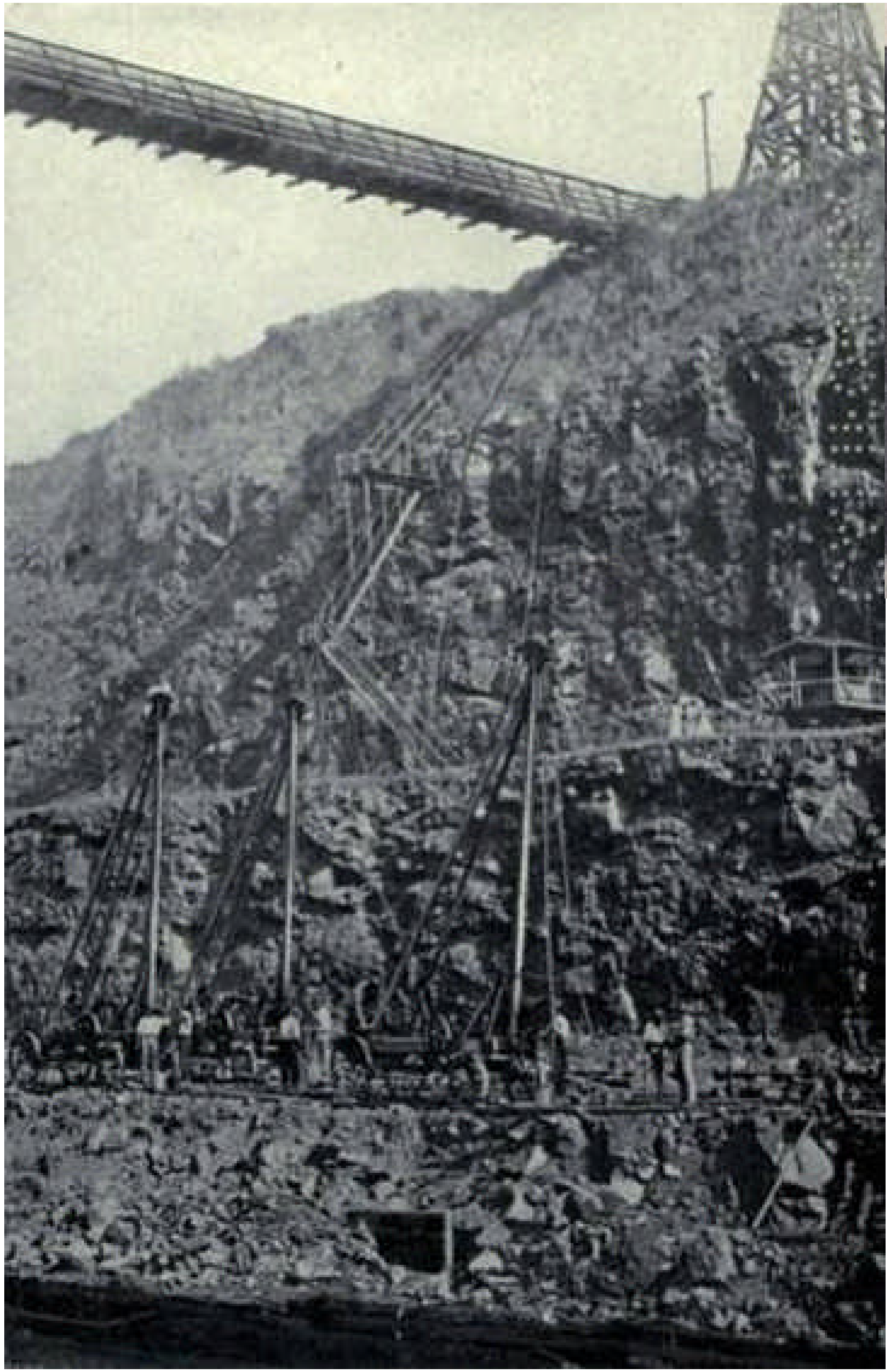
OPEN-PIT MINING/
RAIL HAUL CONCEPT

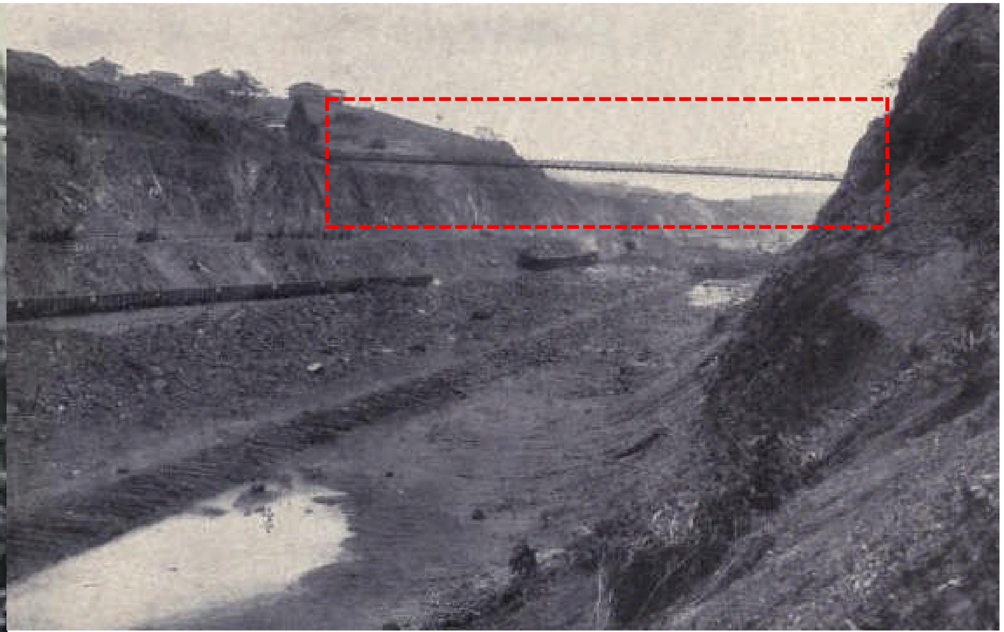
The second system, open-pit mining with rail haul, would employ 15- to 25-cubic yard shovels to fill 110-ton gondolas in 20-car trains. Rail haul would be more economical than truck haul for moving large volumes of excavated material over relatively long distances. Recent innovations in rail equipment, such as remote-control trains with small crews and fast-acting automatic rotary car unloaders, make rail haul even more attractive under such conditions. Figure 5-2 shows schematically how the open-pit mining/rail haul concept might be applied to the construction of a canal. This system would be economical where haul distances are greater than 2 miles and adverse grades for loaded gondolas do not exceed 3 percent. Large volumes would have to be moved to offset the high cost of railbed preparation and laying track. Criteria for track layout would constrain the location and configuration of spoil areas.

<u>Above</u>: excerpt from the *Interoceanic Canal Study* (1970) regarding proposed excavation method for new canal. The same method (Open-Pit Mining/Rail Haul) was employed in *Culebra*.

Left: view looking south toward the eastern bank of *Culebra Cut*, opposite *Contractor's Hill*, showing the terraced bank ca. 1890. This was the condition the *French Canal Company* left the cut in when they ceased operations. Work in the cut did not resume until 1905.

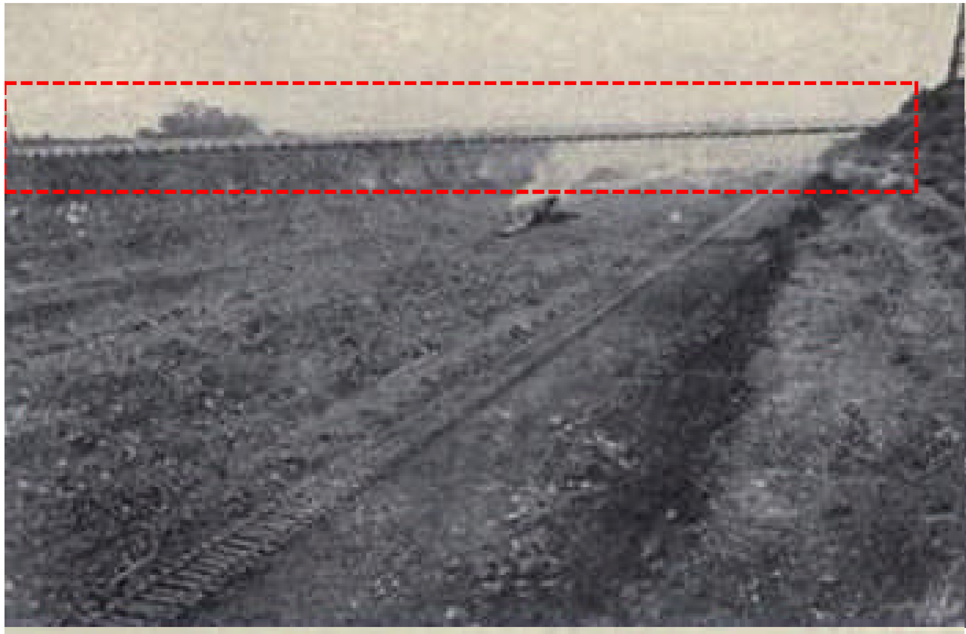
Right: caption: "Showing how much digging had to be done, notice the first excavation made by the French, at the extreme upper left hand corner of the picture"

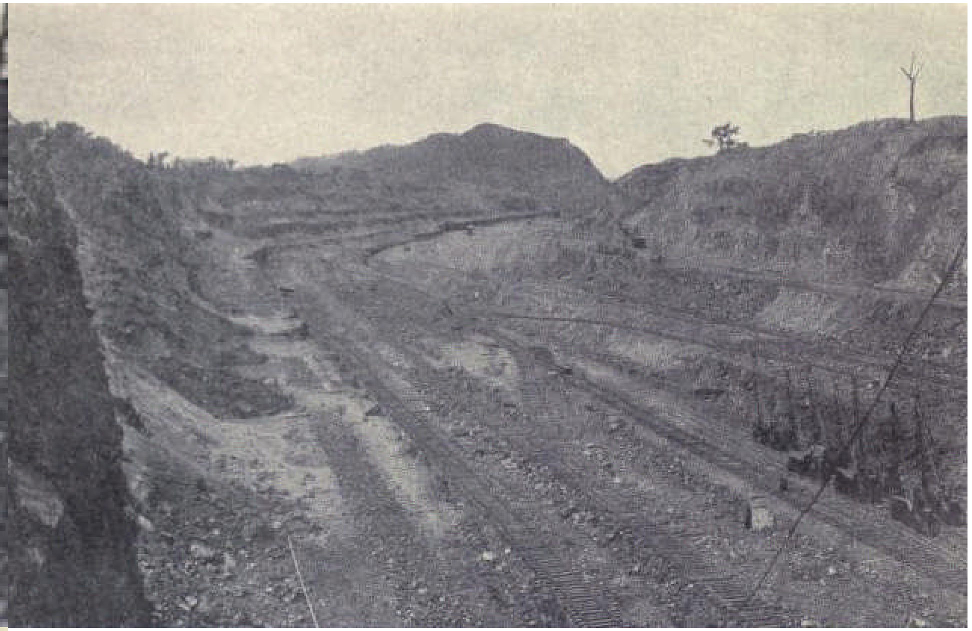




Above: caption: “Culebra Cut at Empire Suspension Bridge. Bottom of cut to be 57 feet lower than the train cars.”

Left: caption: “The only bridge across the Canal is this light foot-bridge at Empire. This is temporary, and will be removed before the Canal is opened.”





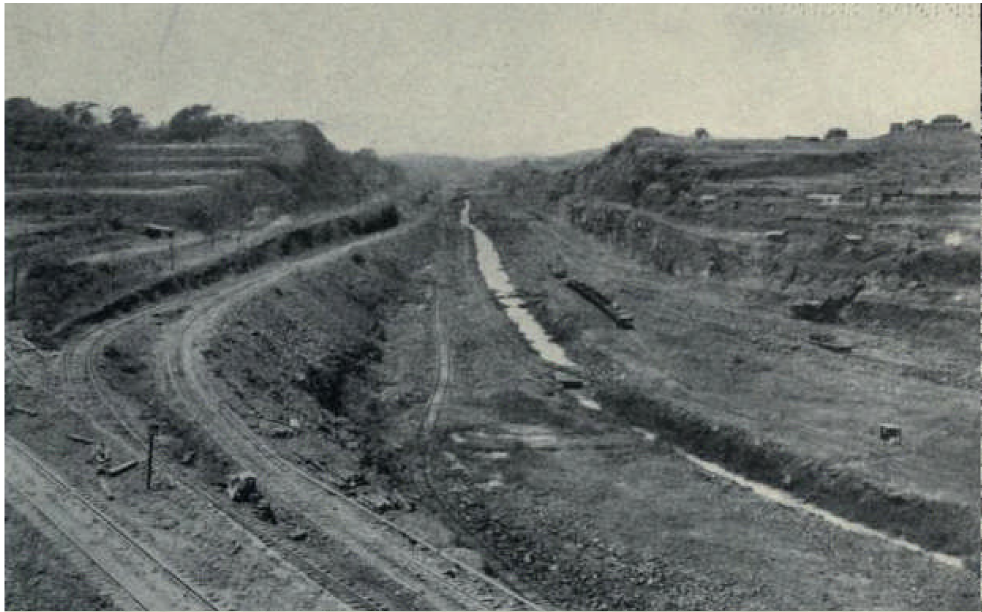
<u>Top Left</u>: caption: “Suspension Bridge across the Cut at Empire”

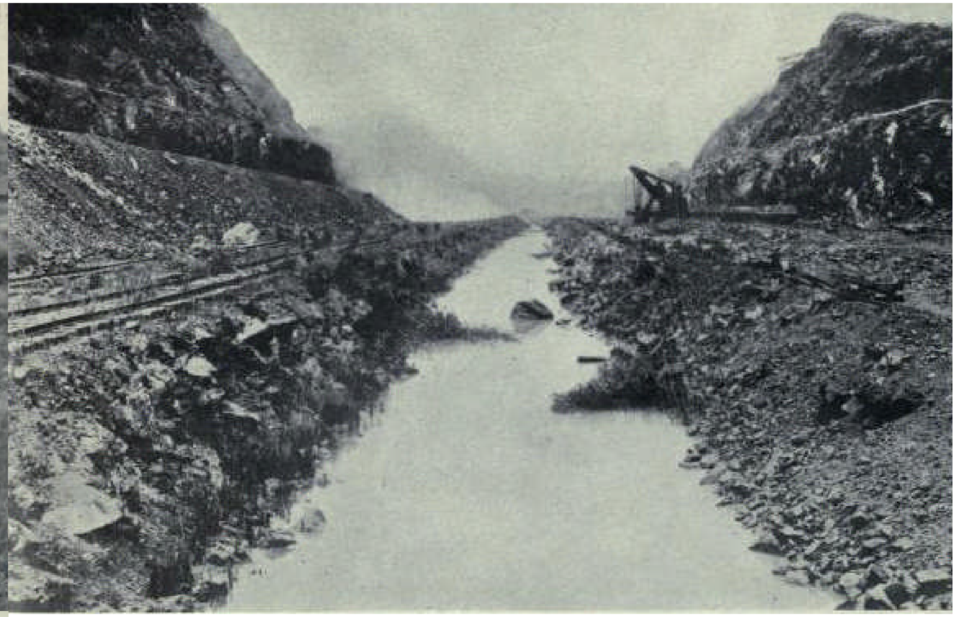
<u>Top Right</u>: caption: “Culebra Cut, looking South from Empire Suspension Bridge. The group of Well Drills in the middle of the canal is about 27 feet above the bottom, or at Elevation +67, May 1912.”

<u>Left</u>: caption: “Culebra Cut, looking North from Empire Suspension Bridge. The nearest shovel shown, in the lowest cut, is working 12 feet above the bottom or at Elevation +52, May 1912.”

“Storage chambers for coal are being dug in the bottom of the Panama Canal. In time the question of coaling United States war vessels will be a vital one and coal pockets are being prepared now while the machinery is on the ground. The bottom of the canal has been chosen for the storage chambers so that the coal will be safely hidden from any possible enemy. A further advantage lies in the fact that coal deteriorates less rapidly under water than when exposed to the air. Several drills and dredges are now at work excavating the bottom of the canal and building the storage chambers.”

Popular Mechanics, **November 1913**





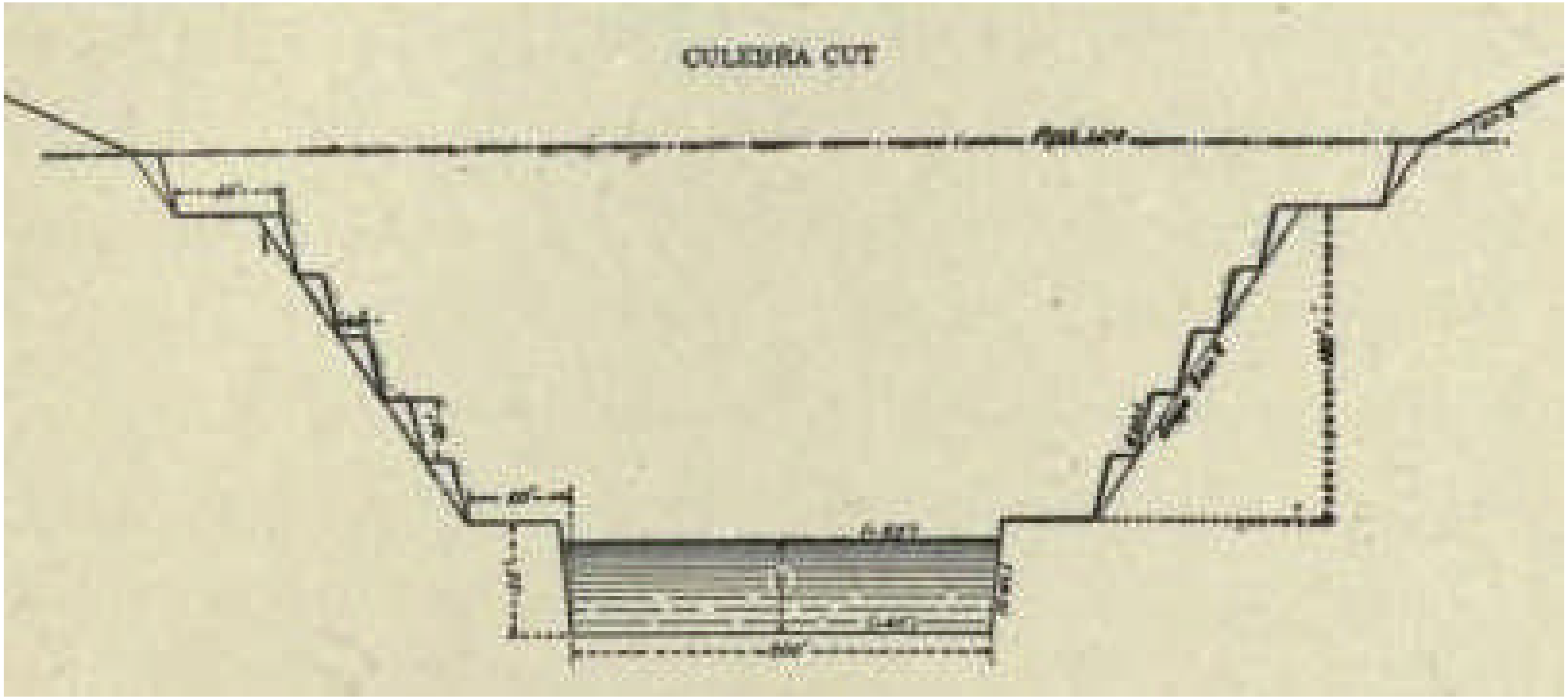
<u>Top Left</u>: caption: "Culebra Cut looking South from Bend in East Bank near Gamboa. The train and shovel are standing on the bottom of the Cut. The water in the Drainage Channel is about 10 feet below the bottom of the Canal or at Elevation +30, June 1912."

<u>Top Right</u>: caption: "View showing the Bas Obispo section practically complete. The channel in the center of the Cut carries off all rain and surface water."

<u>Left</u>: caption: "Culebra Cut nearly finished, 1912"

Gaillard's Cut

Major ***David du Bose Gaillard*** **(left),** ***U.S. Army Corps of Engineers*****, was put in charge of the Big Ditch. Gaillard brought dedication and quiet, clear-sighted leadership to a very difficult and complex task. In a sad twist of fate, Gaillard died from a brain tumor in December 1913. He never lived to see the opening of the canal a few months later, in August 1914. The** ***Culebra Cut*****, as it was originally known, was renamed (by** ***Executive Order*****) the "Gaillard Cut" in 1915 in his honor, but the original name is still widely used.**



The new plan called for a bottom width of 300-feet. This required the creation of a valley up to a third of a mile wide at the top and eight miles long. The gap would have a vertical distance from the bottom of the cut to the top of 120-feet. A vast amount of new earthmoving equipment was imported and a comprehensive system of railways was constructed for the removal of earth and rock spoil.

"…In the removal of this tremendous mass of earth and rock new standards for steam-shovel work were set by the American engineers. Much of the machinery installed by the French company has been used in the Culebra Cut, especially 104 locomotives used to haul the dirt trains to remove the 'spoil.' The excavation was a less difficult problem than the disposal of the material excavated. The plan for this part of the work was developed by John F. Stevens, the former chief engineer, and has been followed under the administration of Colonel Goethals…"

***Scientific American,* December 1913**

RE: twice a day, work stopped for blasting. Holes were drilled, filled with explosives and detonated to loosen the rock and rock-hard clay. Steam shovels then excavated the spoil, placing it on railroad cars to be hauled to dump sites. Excavation equipment, in addition to the railroad itself, included steam shovels, unloaders, spreaders and track-shifters. Of this equipment, only the steam shovel had been known to the French, and then in a much less powerful form.

<u>Top Left</u>: caption: “A Marion steam shovel excavating the Panama Canal in 1908”
<u>Top Right</u>: caption: “Every Bite Recorded at Headquarters”
<u>Left</u>: caption: “A steam shovel in operation”

"A great iron scoop, swaying ponderously on the end of a long steel and wooden beam, dips, with lightning speed and a rattle of chains and gears, into an excavation. The monster behind it snorts and pants, the scoop slides into earth and rock, and with a defiant rat-a-tat-tat of escaping steam, lifts its giant burden high in the air, swings around and dumps the mass into a waiting car. That is the hand of the modern giant at work. Picture a thousand laborers toiling with pick and shovel and wheelbarrow, a regiment of men toiling all day long at back-breaking work. Beside them place a massive steam engine, the biggest built. The two are equal…A rare novelty only fifty years ago…has dug the Panama canal, moved hills from the path of railroads, excavated the foundations of all the great buildings of America, prepared the roadways used by 17,000,000 motor cars, helped build irrigation dams and canals where land was too dry, and opened the drainage sluices where swamps were too wet…"

***Popular Mechanics,* June 1926**

To the Second and Fraction of a Foot

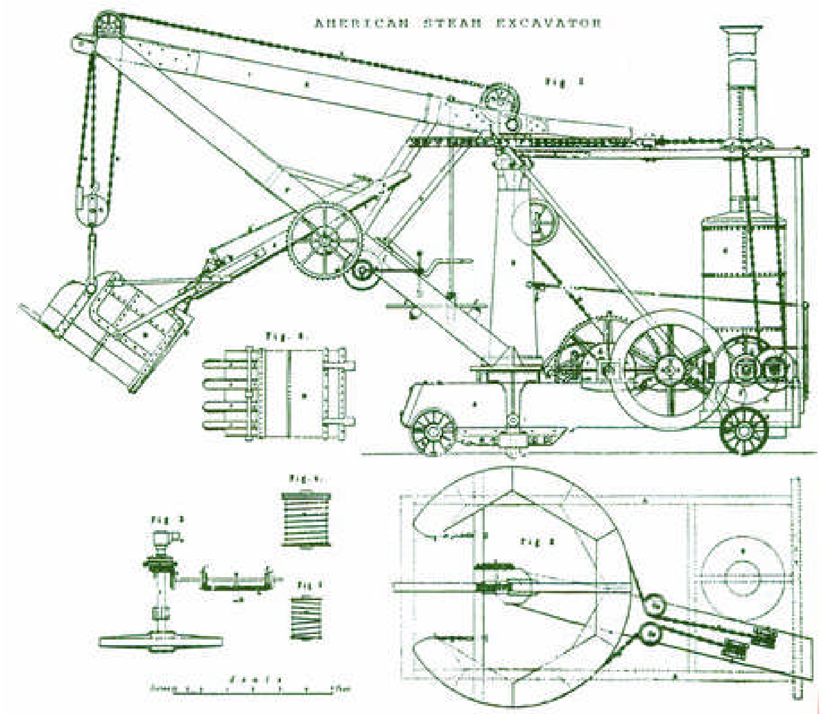
"…The shovel operator has to do many things at once, and time each to the second and the fraction of a foot. The shovel may be swinging around on its revolving base, the radial arm lowering, the scoop arm drawing back, and the hinged bottom of the bucket closing, to lock automatically – all at one time. The operator so times the process that when the revolving radial arm comes over the work, it has been lowered the right distance and the shovel drawn back the correct amount to be pushed into the earth. The power of the shovel is divided into three parts, one for hoisting, one for revolving and one for pushing the shovel into the ground. Hoisting takes the most, sixty percent, and the other two require twenty percent each…"

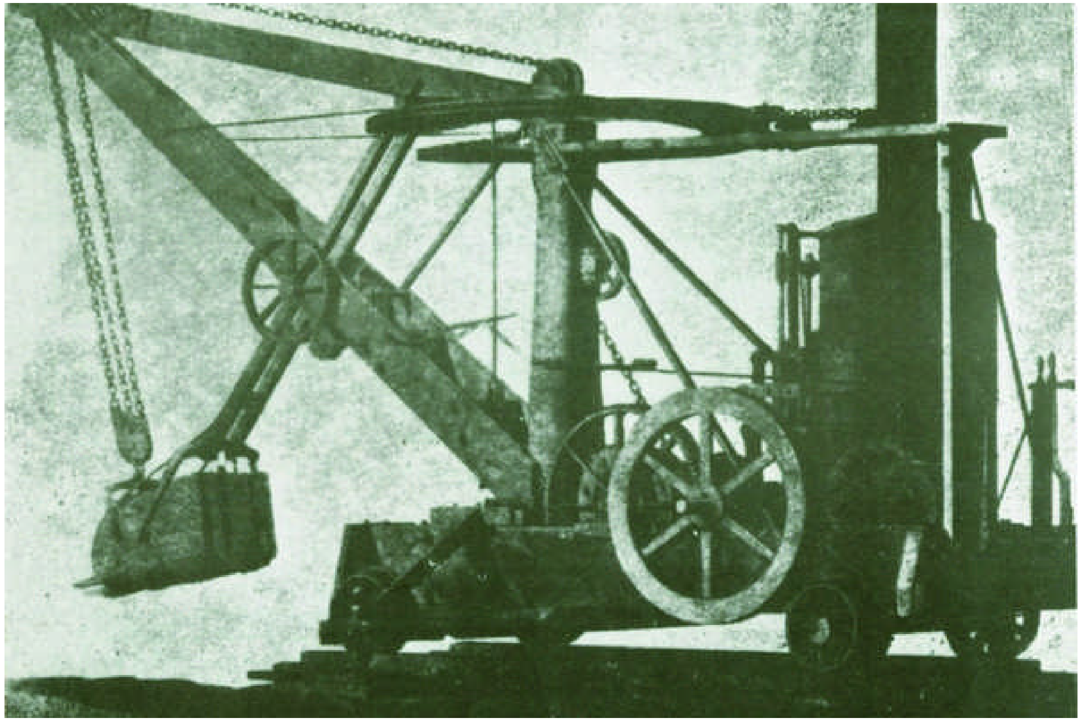
***Popular Mechanics*, June 1926**

An American Invention

"…The steam shovel is an American invention, dating back almost as far as the railroad, but it came before its time. Hand labor was still too cheap to leave any demand for mechanical power, so William Otis, of Boston, who built the machine in 1839, failed to realize on his creation. His original shovel, however, embraced practically every feature of modern machines, and even the name, which has stuck, in this country at least. Nobody else produced a steam shovel until 1875, when an English firm brought out the first one of steel construction, and one of their machines, built in the following year, is still excavating clay at a brick plant at Newcastle…"

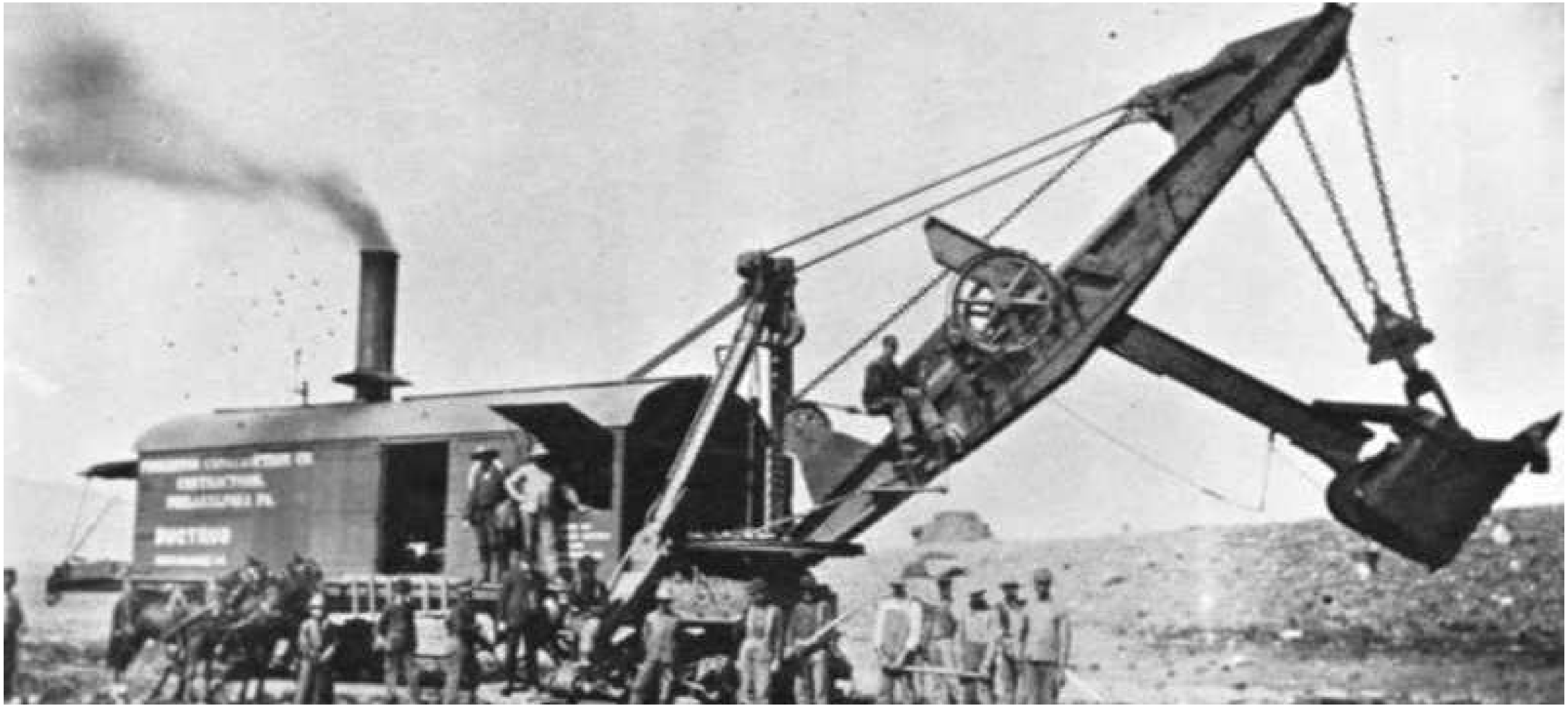
***Popular Mechanics,* June 1926**





In the early *19th Century*, large-scale excavation for canals and railroads required thousands of men digging by hand and handling teams of horses to move the "spoil." The growth of railroads, in particular, required something better. The firm of *Carmichael, Fairbanks & Otis* was constructing a segment of railroad near *Canton, MA* in 1835 when *William S. Otis*, a partner in the firm, had an idea. With the assistance of a friend; *Charles Howe French*, Otis developed a steam-powered "Crane Excavator." This machine had a fixed mast and swinging boom like that of a quarry derrick; with a bucket attached to the end of a dipper stick that was mounted to the boom. The boom was lowered to enable the bucket to dig in an arc through the cut face, then raised and swung to one side or the other to dump. The swinging and dumping were accomplished manually; a man on each side of the shovel hauled to on a rope to swing the boom back and forth and the man on the dumping side tripped the bucket. The shovel was powered by a vertical boiler that drove a double-drum chain hoist and the machine traveled on four railroad wheels. Otis patented an improved version of this shovel in 1839. While the improved machine was working in *Massachusetts* on its first project, Otis died of *Typhus* at the age of 26. The Otis shovel was the earliest known steam-powered, single-bucket excavator and remained in production until 1910.

The City that Built the Panama Canal



The *Marion Steam Shovel Company* was founded in 1884 in *Marion, Ohio*. The company built steam shovels. Business boomed during the late nineteenth century as railroad construction occurred in the American and Canadian West. With the United States' acquisition of the *Panama Canal Zone* in 1903, the federal government turned to the Marion Steam Shovel Company to provide the steam shovels necessary for the canal's construction. Marion became known as: "The city that built the Panama Canal." The Marion Steam Shovel Company continued to prosper during the 1920s and the 1930s. During the 1920s, the company manufactured the largest shovel known to exist up to that point in time. However, as steam power became less popular, the Marion Steam Shovel Company changed its name to the *Marion Power Shovel Company*.


OHIO
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MARION STEAM SHOVEL
The Marion Steam Shovel Company built the primary tools for America's civil engineering for more than 100 years. Founded in 1884 by Henry M. Barnhart, George W. King, and Edward Huber, the company's patent steam shovels helped revolutionize railway and road construction, and were used in the building of the Panama Canal, Hoover Dam, and the Holland Tunnel. "The Shovel" also built ditchers, log loaders, dredges, and draglines, including some of the largest land vehicles ever built. The first electric machine was built in 1915, but it was not until 1946 that the name was changed to Marion Power Shovel. In the mid-twentieth century, "The Shovel" employed 2,500 workers. In the 1960s, the National Aeronautics and Space Administration selected Marion to build the crawlers that transport spacecraft to their launch pads. Hundred-year rival Bucyrus International acquired and closed the company in 1997.
THE OHIO BICENTENNIAL COMMISSION
THE INTERNATIONAL PAPER COMPANY FOUNDATION
THE OHIO HISTORICAL SOCIETY
2003
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"…An average of 75 dirt trains, each running continuously to and from the cut, has been in use night and day since the canal work got under way. Each train consists of 20 or 21 cars of capacity from 10 to 19 cu. yd., the material excavated in the Culebra Cut averaging about 3,600 lb. to the cu. yd. Much of the excavated material was used in building the Gatan Dam…"

RE: the one-year record high for construction-era excavation was set in 1908, with more than 37million cubic yards of spoil taken from the cut

Top Left: caption: "Culebra Cut, looking North – December 1904"

Top Right: caption: "At this point we reach the deepest part of the Culebra Cut, between Gold Hill and Contractor's Hill. 494 vertical feet of earth and rock will have to be removed when the work is complete."

"Ores containing gold, silver and copper have been found in the Culebra Cut of the Panama Canal."
***Popular Mechanics,* May 1908**

"…The speed with which the work was pushed is indicated by the fact that the average time for unloading a train of flat cars was from 7 to 15 minutes…"

***Popular Mechanics,* December 1913**

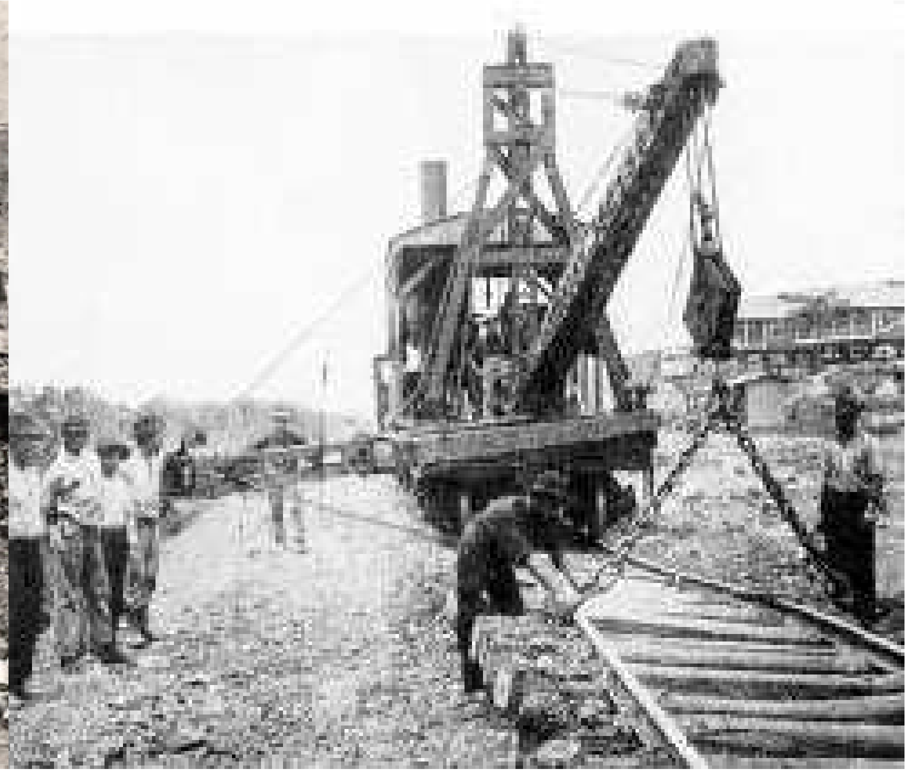
RE: the *Lidgerwood Unloader*, manufactured by the *Lidgerwood Manufacturing Company* of *New York City*, was another indispensable piece of equipment. Wooden flatcars with a rated capacity of nineteen cubic yards hauled most of the spoil, pulled in long trains by full-sized, American-built locomotives. Built with only one side, they had steel aprons bridging the spaces between cars. Dirt was piled high against one side. At the dump site, the unloader; a three-ton plow, was hitched to the last car by a long cable to a huge winch-like device mounted on a flatcar at the head of the train. Taking its power from the locomotive, the winch pulled the plow rapidly forward, unloading the whole twenty-car train in a single, ten-minute sweep. One of these machines once set an eight-hour record by unloading eighteen trains, about 3.5 miles of cars containing about 7,560 cubic yards of material. Engineers estimated that twenty of these unloaders operated by 120 laborers did the work of 5,666 men unloading by hand.

Seventeen-cubic yard capacity, four-sided *Western & Oliver* dump cars (above) made up a train consisting of twenty-seven cars and were widely used. Since it was difficult to unload the dirt from these cars (the heavy clay would stick to the steel sides), they were used almost exclusively for hauling rock from *Culebra Cut* to *Gatun Dam*. Their four-sided design made them impossible for use with the unloader.

Down on the Panama Canal

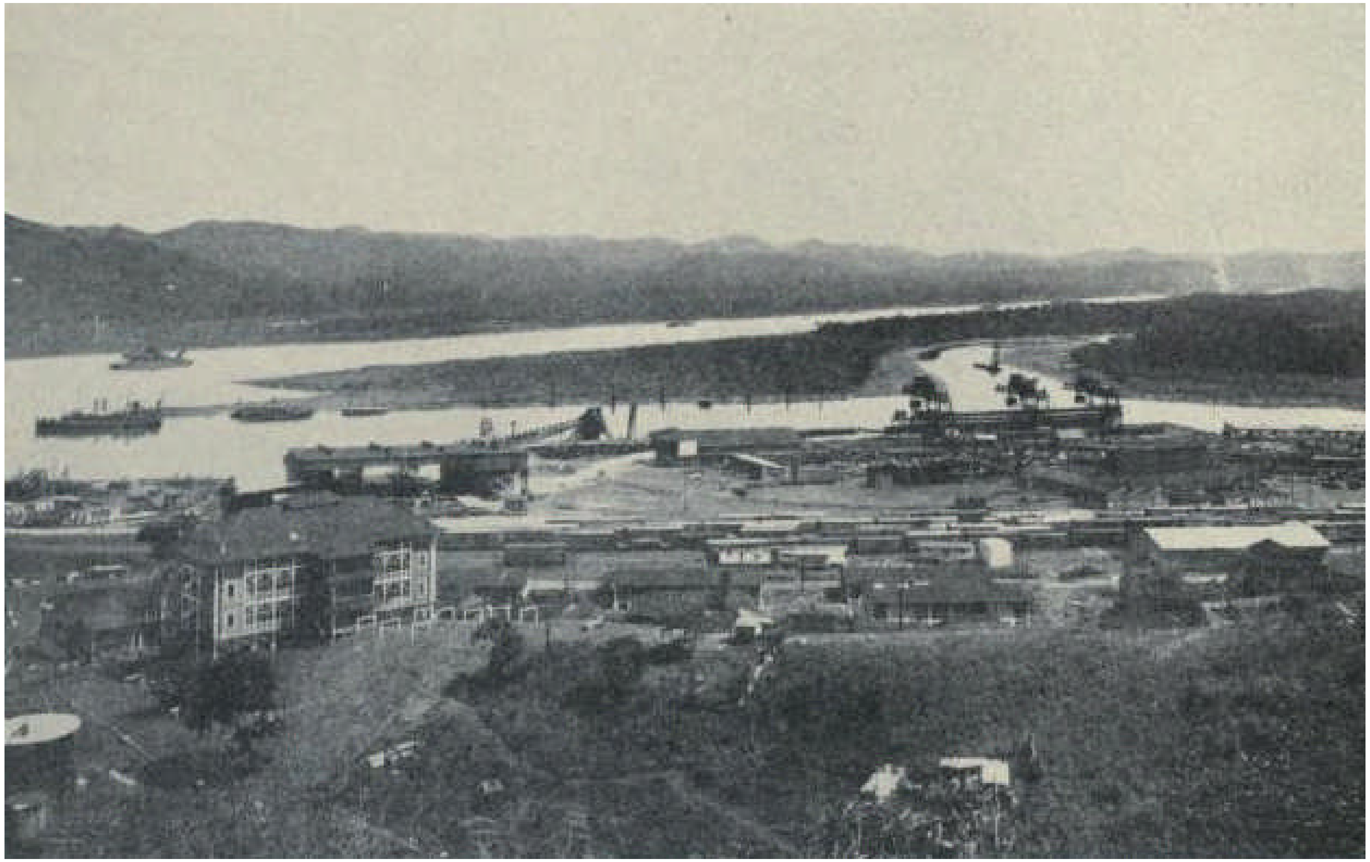
"Down on the Panama Canal machinery must be made to relieve hand labor to the utmost, and if no machine is at hand to do the work required, the engineers have had to rig up something even though the device is not described in the books. Such a machine is the patented invention of General Manager Beird, of the Panama railroad. He had occasion to move many miles of track several feet to one side. To do this he rigged up a machine which operates very much like a steam shovel with hooks instead of the shovel. Two lifts are made of each section, one rail length long, with a crew consisting of a foreman, engineer, fireman, and four laborers. In 8 hours they move 6,000 ft. of track a distance of 4 ft. sideways at a cost of half a cent a foot."

***Popular Mechanics,* September 1907**

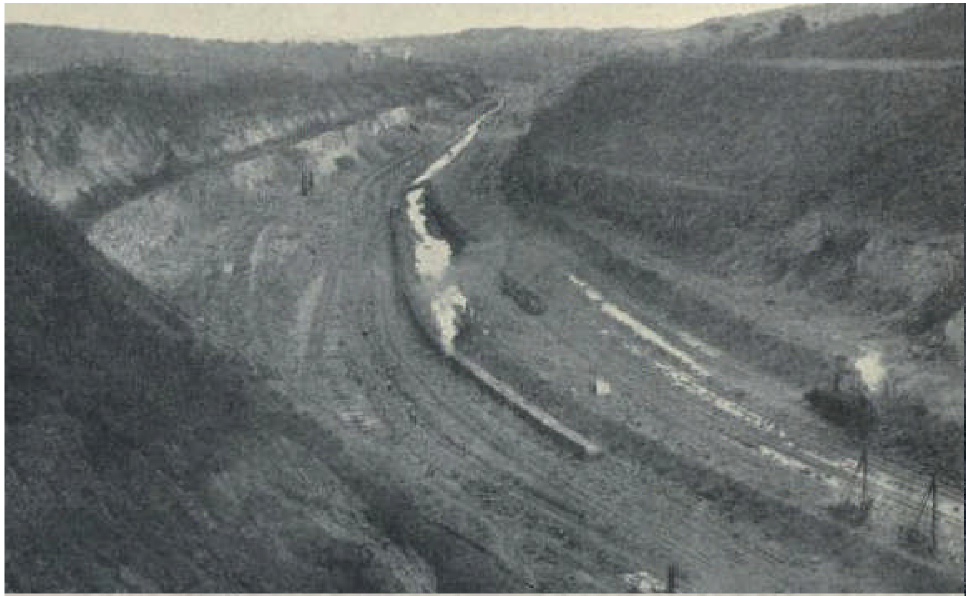
<u>Above</u>: the *Track-Shifter* was invented by *William G. Bierd*, general manager of the *Panama Railroad* from September 1905 to October 1907. The huge crane-like machine would hoist a whole section of track – rails and ties – and swing it in either direction, to relocate it as much as nine-feet at a time. With the tracks at the dumps needing constant shifting to keep pace with the arriving loads of spoil, the track-shifter was extremely useful. It took less than a dozen men operating the shifter one day to move a mile of track; a task otherwise requiring +600 men.

<u>Above</u>: the *Dirt-Spreader* was another American innovation. A car operated by compressed air, it had steel "wings" on each side that could be raised and/or lowered. When lowered, they sloped 11.5-feet backward from the rails. Moving forward, the dirt-spreader spread and leveled the material left along the track by the unloader. Like the unloader, the spreader did the work of some 5K to 6K men working by hand.



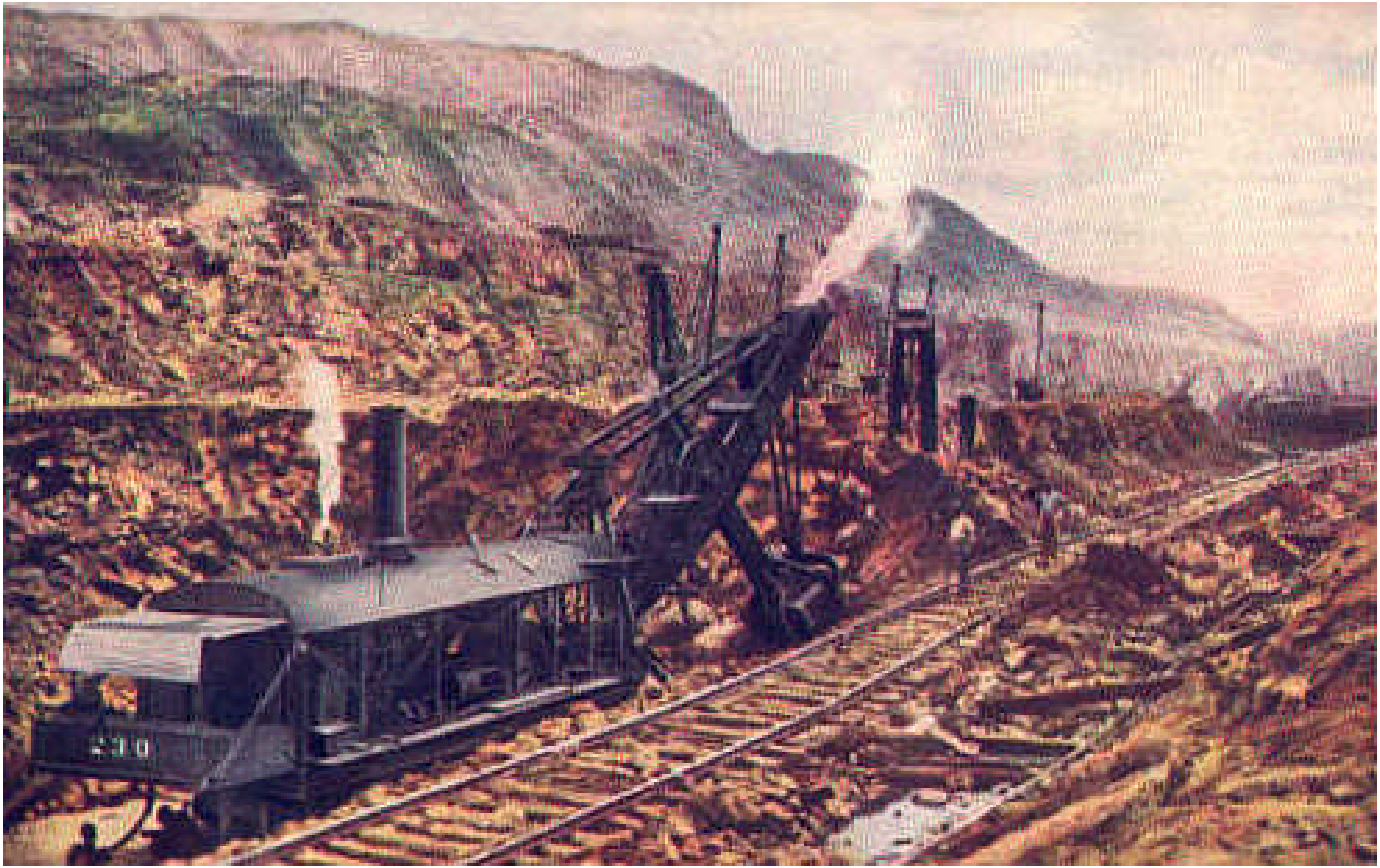
Spoil was also used to claim nearly five-hundred acres of *Pacific Ocean* to create the *Balboa* townsite and the *Fort Amador* military reservation. Millions of cubic yards of material also had to be hauled out to big waste dumps in the jungle. In the largest of these; *Tabernilla*, 17 million cubic yards of material were deposited. Balboa was the biggest dumpsite. Other big dumps were *Gatun Dam*, and *Miraflores*.

<u>Above</u>: caption: 'General view of Balboa Terminal site, looking North, June 1912"



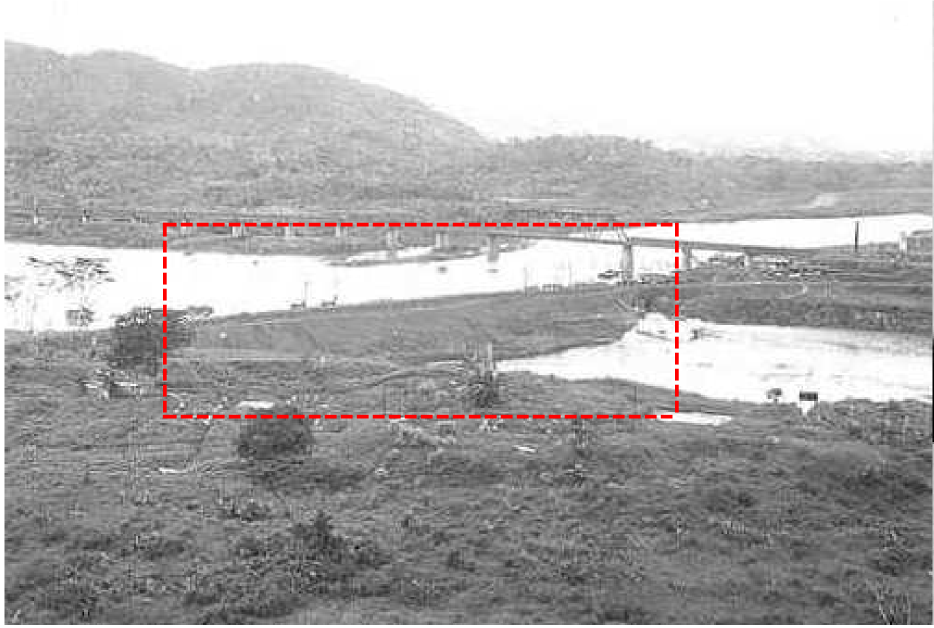
<u>Top Left</u>: caption: “Culebra Cut, looking North from Cunette. The two shovels shown in the foreground are working on the bottom, Elevation +40. The water standing in the center drainage channel is about 6 feet below the bottom, Elevation +34, June 1912”
<u>Top Right</u>: caption: “Culebra Cut, South End, looking South. Showing the partly completed Anchorage Basin North of Pedro Miguel Lock. Train is on completed bottom of Canal, Elevation +40, June 1912.”
<u>Left</u>: caption: “Culebra Cut, looking North, between Contractor’s Hill and Gold Hill”

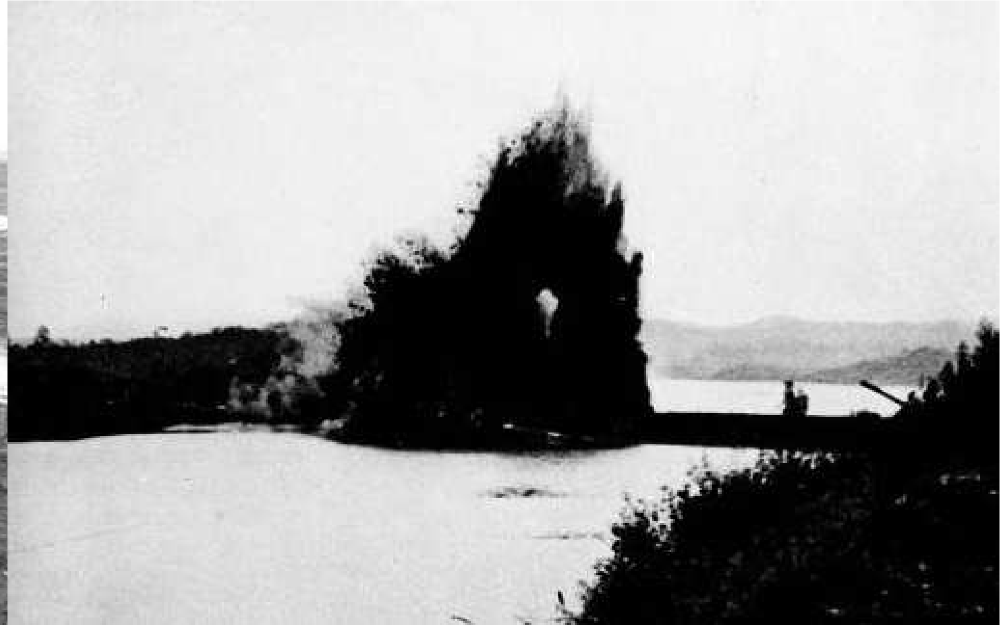
On May 20th 1913, shovels No. 222 and No. 230, which had been slowly narrowing the gap in *Culebra Cut*, met "on the bottom of the Canal." At forty feet above sea-level, the cut had reached its full construction-era depth. When a January 1913 slide at *Cucaracha* spilled two million cubic yards of earth into the cut, it was decided to flood Culebra Cut and finish the clearing by dredge. The last steam-shovel lifted the last rock in the cut on the morning of September 10th 1913, to be hauled out on the last dirt train by locomotive No. 260. Six big pipes in the earthen dike at Gamboa flooded Culebra Cut that same week. Then, on October 10th 1913, President *Woodrow Wilson* pressed a button in *Washington* and, relayed by telegraph (from Washington to *New York* to *Galveston* to *Panama*) the signal that blew the center of the dike to complete the flooding of the cut and join it to *Gatun Lake* forever.



<u>Above</u>: caption: “Steam Shovels Meeting at Culebra”

Gamboa’s Busted!





"…To keep the rising waters of Gatun Lake out of the unfinished Culebra Cut, the Gamboa dike was located across the northern end of the cut. On Oct. 1, 1913, the first water was let into the cut through 24-in. pipes, and on October 10 the dike was exploded by the pressing of a button at Washington. There still remains about 6,000,000 cu. yd. of material to be taken from the cut before the channel is finished, but this will be done by dredges while the canal is in use by ships. When finished, the passage of the canal will take about 10 hours…"

***Popular Mechanics,* December 1913**

RE: "Gamboa's Busted!" That was the gleeful cry of POTUS *Woodrow Wilson* as he pressed a telegraph key that remotely detonated 40-tons of dynamite set in *Gamboa Dike* blowing it apart on October 10th 1913, thus joining the two great oceans of the world forever.

Left: caption: "Gamboa Dyke. Chagres River and Bridge, showing the flooding of Culebra Cut by destroying the Dyke, October 1, 1913"

Right: caption: "'The Continent's Backbone Broken.' The Blast that destroyed Gamboa Dyke completed water connection between the Atlantic and Pacific."

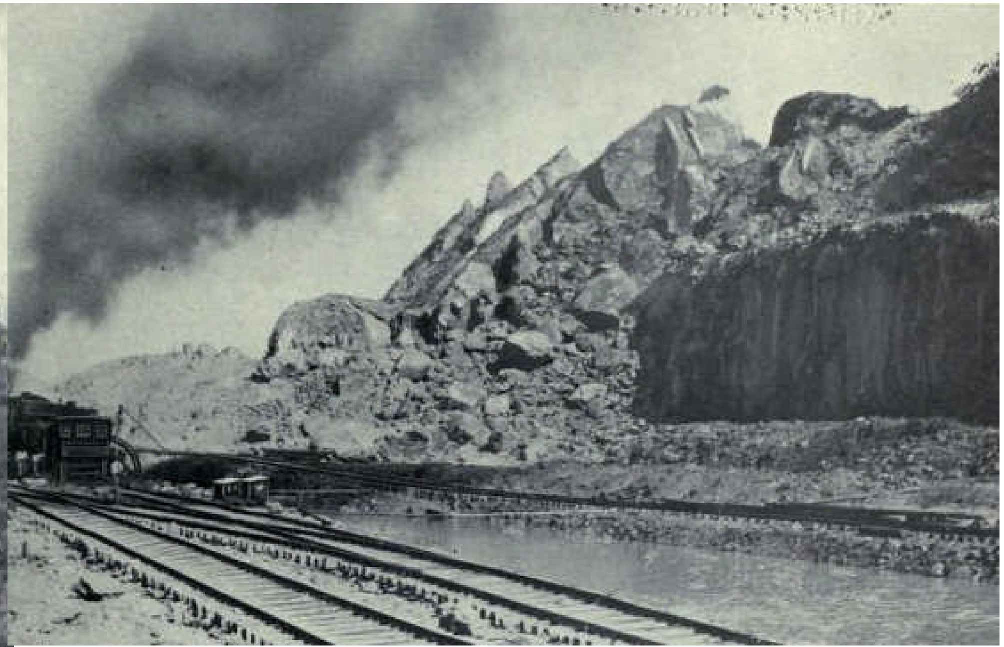

CANAL ZONE POSTAGE
25TH ANNIVERSARY 1939
OPENING PANAMA CANAL 1914
15
CENTS
GAMBOA - AFTER

Tropical Glaciers

"…Another difficulty, equally important and less dubious, has been encountered in the Culebra cut, where a channel nearly 50 feet deep is being hewn out of the rock. If the cut were entirely in solid rock, the duration and cost of the work could be accurately computed, but the rock is covered, and in places traversed, by sand and clay, which continually slide and often carry the rock with them. In 1885, when DeLesseps was endeavoring to construct the canal, the German engineer Pescheck declared that the practicability of the project depended on the frequency with which these sliding masses of clay, which had already been met with, should be encountered. As a matter of fact, they appear to occur very often. They contributed largely to the failure of the DeLesseps enterprise and they have sorely troubled the American engineers, who have been only partially successful in preventing sliding by steadily diminishing the steepness of the sides of the cut and correspondingly increasing the cost and duration of the work. Moreover, the heavy sliding masses often displace and distort the bed of the canal by their pressure. In one night, in 1887, 100,000 cubic yards of rock were thus precipitated upon the canal bed…"

Scientific American Supplement, **September 23rd 1911**

RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries"



<u>Left</u>: caption: “One of the ‘slides’ from the opposite side of the Canal. The engineer in charge of this division was nearly carried down with the earth.”

<u>Above</u>: caption: “A nearer view of the same slide. The mass of material blocked railway tracks, wrecked cars, and by breaking a water conduit flooded this section of the Cut.”

“An underground system of reinforced-concrete posts and tie rods has been proposed as a possible means to prevent land slides in the Culebra Cut of the Panama Canal. The plan involves setting a row of underground posts in a line parallel with the banks of the canal and bracing them with other posts set an angle against them. To set the underground posts, it is proposed to drill holes from the surface of the loose strata to the firm rock below the level of the canal bottom. After the bottom of the holes had been ‘sprung’ with dynamite to form large cavities in the firm strata for anchorages, steel rods would be placed in the holes for reinforcement. The cement grouting would be forced into the holes under a pressure of 750 to 1,000 lb. per square inch, so that the concrete would penetrate all the fissures in the rock and form a secure anchorage. The vertical piles would form a secure foundation for a retaining wall and the inclined posts would act as the diagonals of a strong dam of triangular cross section. Combined with this, adequate drainage and sub-division of the slope and an underground dam to protect the edge of the slope from wave action are also suggested as a means of preventing trouble in the future.”

Popular Mechanics, **November 1911**

Sufficient Impetus

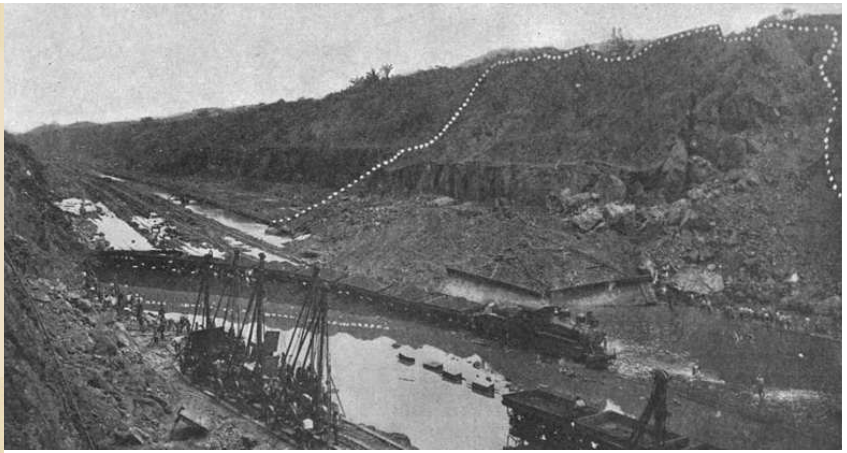
“One of the worst slides the Panama Canal engineers have had to contend with occurred in February, when 500,000 cu. yd. of earth slid into the cut just opposite the town of Culebra. It has always been held that the slides were caused by heavy rainfalls, which make the soil soggy and the sloping rock underneath slippery. Under this condition it is believed that when the weight overcame adhesion and when the concussion of dynamite blasts gave sufficient impetus, the slides took place. It is said that no such explanation is possible for this slide, because there had been no heavy rains in the section for six weeks and no blasting in the vicinity.”

***Popular Mechanics,* April 1911**

"…Along most of the nine miles of the Culebra Cut the banks have found their 'angle of repose' at which there is no danger of further slides…"

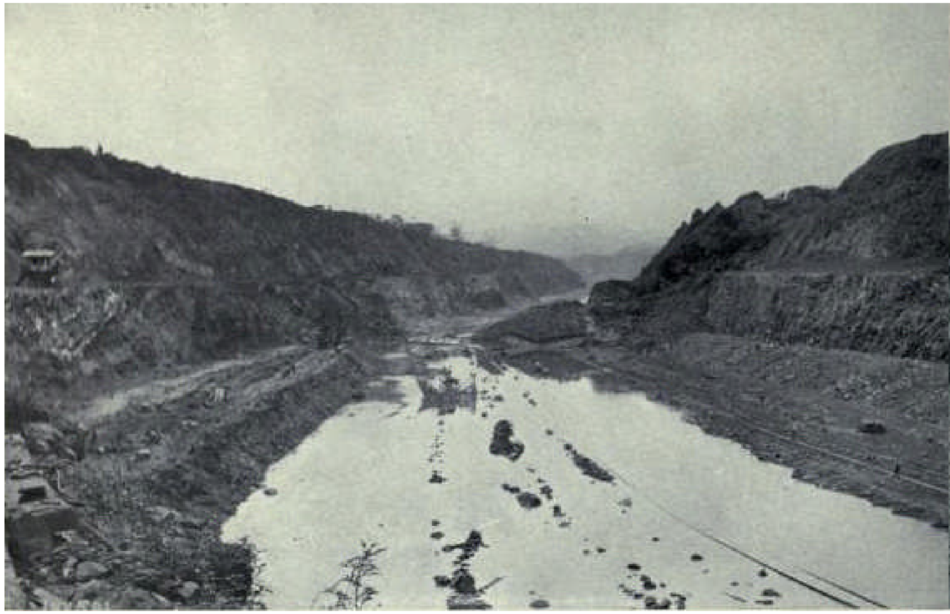
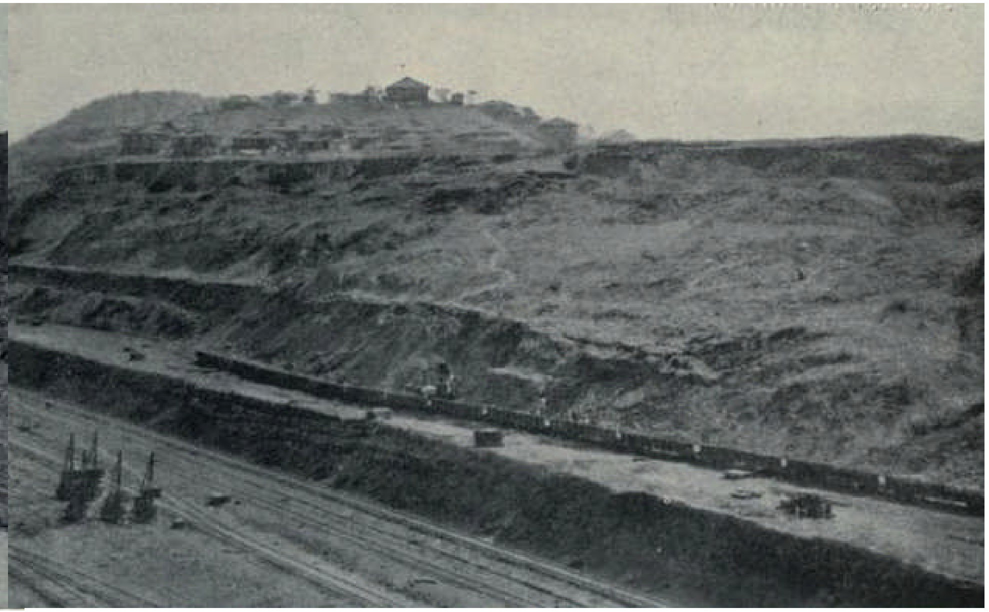
***Popular Mechanics,* December 1913**

RE: earth slides in *Culebra Cut* were a constant concern for construction engineers. The first under the American effort occurred at *Cucaracha* on October 4th 1907 when some 500K cubic yards of material moved into the cut following several days of unusually heavy rain. For ten days the slide moved an average of fourteen-feet every twenty-four hours. Another very destructive slide occurred in nearly the same place in 1912. Seventy-five acres of dirt near the town of *Culebra* broke away. It moved slowly, foot by foot, into the canal carrying buildings with it down into the valley. It took nearly six months to repair the damage. Cucaracha remains today a slide surveillance area. However Gaillard was undeterred. The slides were a setback, but not a catastrophe that could not be overcome. He described the slides as "Tropical Glaciers."



<u>Above</u>: on August 20th 1912, 400K cubic yards of dirt and rock slipped down into the bottom of the valley, destroying railways, engines, digging machinery, and generally making a huge mess. The dotted white line shows the outline where the side of the hill slipped down.

<u>Left</u>: caption: "Slide Areas Along the Panama Canal"

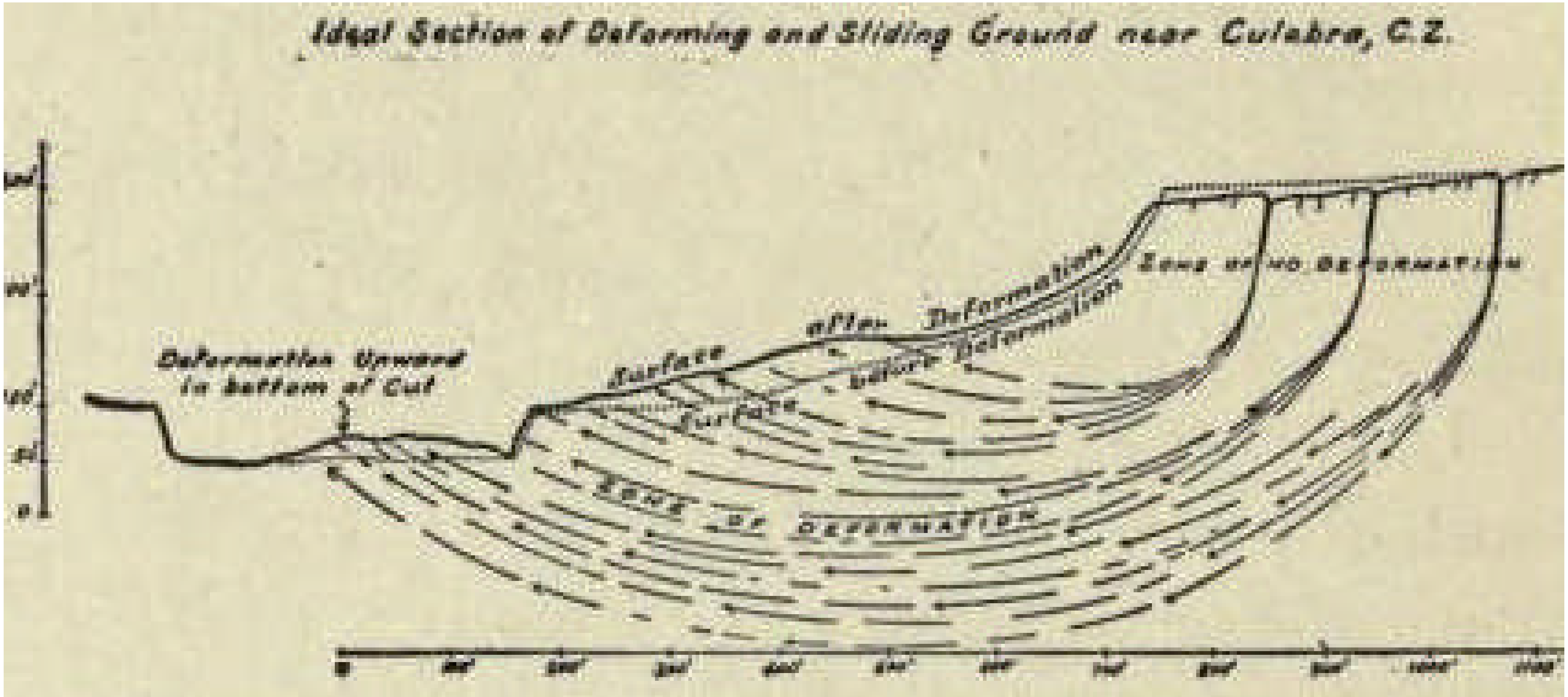
 

"…It is also stated that the reason for the trouble encountered with slides has been chiefly due to structural breaks caused by oversteep slopes at points where the slopes were high and the rocks weak. The remedy has been to remove the unbalanced pressure and lessen the slope. It is interesting to note that these slides have made it necessary to excavate some 30,000,000 cu. yd. more earth than was first estimated as necessary at Gaillard cut, formerly known as Culebra."

***Popular Mechanics,* May 1916**

<u>Top Left</u>: caption: "One of the 'slides' which have been so annoying a feature of the excavation work. About 100,000 cubic yards of earth and rock slid into the Canal at this point."

<u>Top Right</u>: caption: "Slide of stratified rock, West Bank of Canal, Culebra-on-the-Dump, looking toward Culebra. Slide involves about 1,000,000 cubic yards and moved about 3 feet per day on a slope of 1 vertical to 7 horizontal. The train is standing at Elevation +95, February 1912



A "normal" or "gravity" slide like *Cucaracha* - the largest of its kind at the Canal, occurs where a layer of porous material rests upon a sloping surface of harder material such as rock. Rainwater saturating the overlying porous material forms a slippery zone against the harder material below, causing the entire top layer, which can vary in thickness from ten and forty feet, to slide.

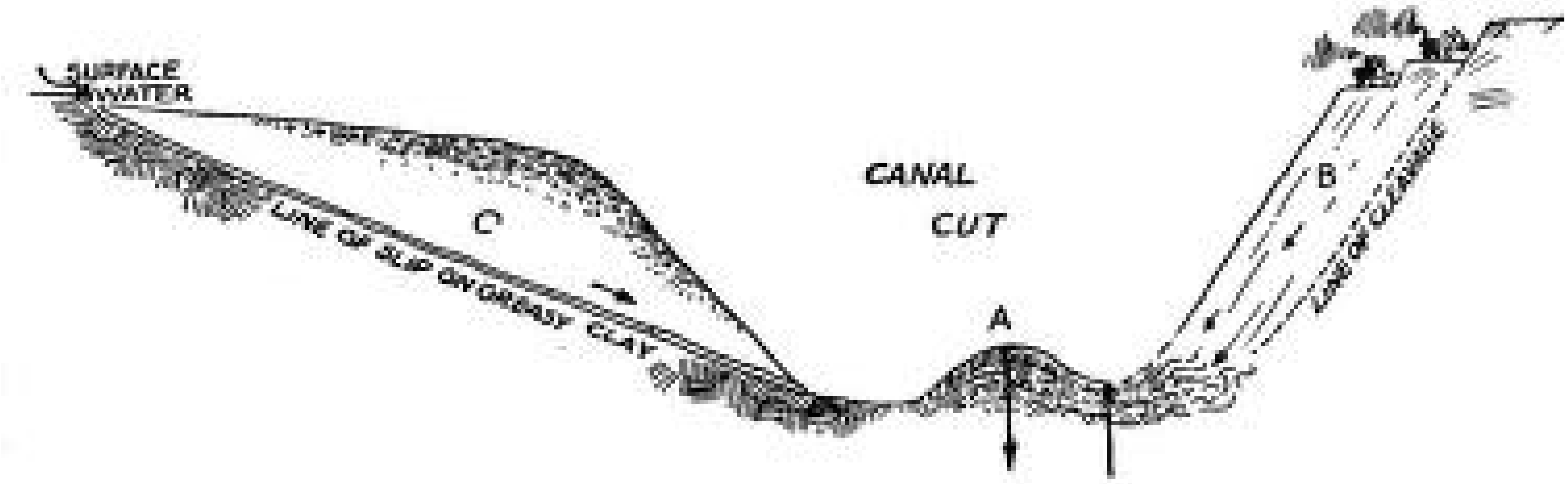
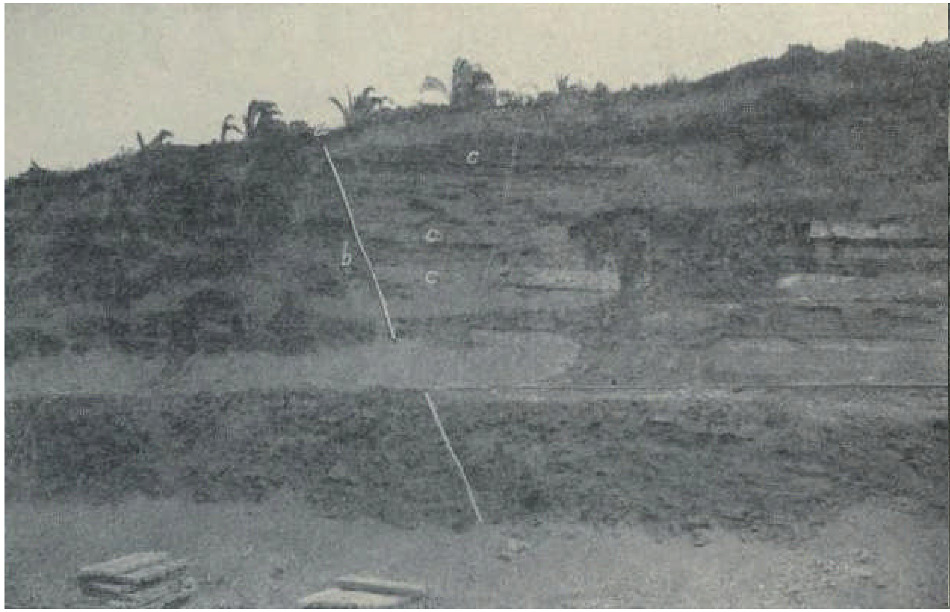


DIAGRAM OF CULEBRA CUT SLIDES

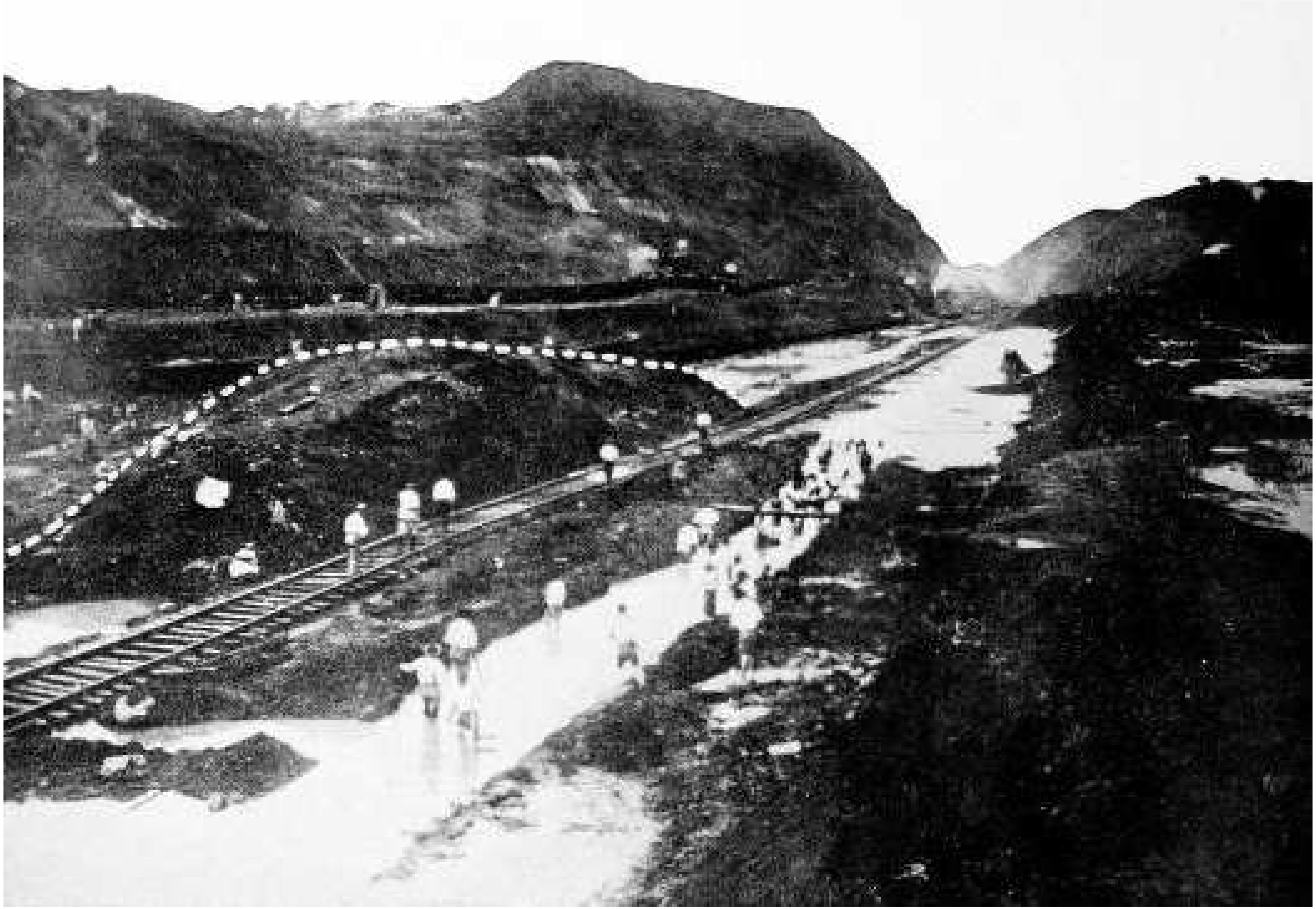
C. is a slide moving over a slippery surface; the mass B breaks on a line of cleavage and crushes the underlying material, forcing it up at A. The steam shovels are working to reduce pressure on B

Geologists classify another type of slide as "structural break" or "deformation" slides. In these, factors such as unstable geological rock formations, slope steepness and height and the effects of blasting combine to form a slide. At the Canal, excavation removed lateral support from the high banks created in the deepest portions of *Culebra Cut*. Unable to sustain the weight above it, the slopes sheared and settled forcing the underlying layer of poor quality rock and soft material to be crushed and forced laterally into the prism of the canal, heaving up the canal bottom. The most formidable slides of this character occurred during the dry season and were in no way due to ground saturation by rainfall.

Left: caption: "'A' Fault Plane. 'B' Crushed and Sheared Zone of Rock. 'C' Stronger Rocks, Beds of Limy Sandstone. This fault was the chief cause of the big slide on the West (opposite) side of the Canal near Lirio."

Right: caption: "Columnar structure in hardened flows of mud lava. This joining afforded passages for seepage water which tended largely to promote a large slide just North of La Pita."



<u>Above</u>: caption: "'An Eruption of the Canal Bed.' The pressure of the adjoining hills has forced up the soil at its weakest point, namely the bed of the Canal, to a height of 18 feet, as shown by the dotted line."

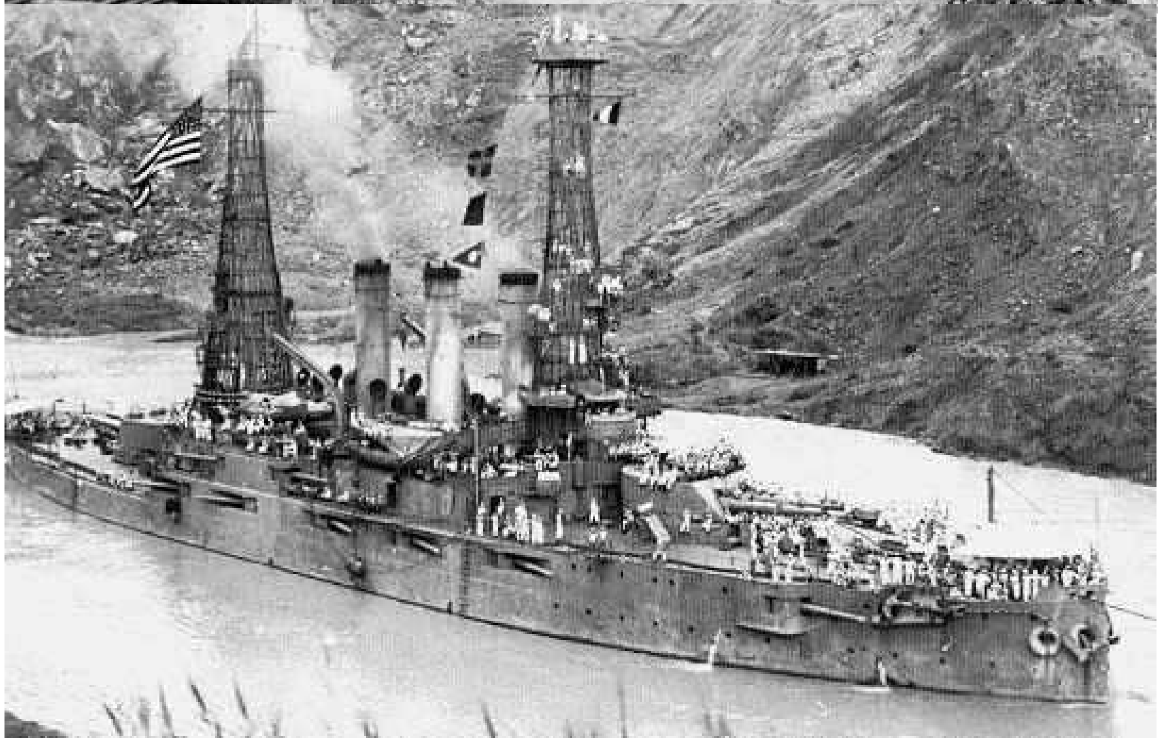
 

The two most serious structural break slides during the American construction period occurred on the east bank north of *Gold Hill* and on the West Bank in front of *Culebra* village. The West Bank slide covered a 75-acre area requiring the removal of some 10 million cubic yards of material, and a number of village buildings had to be removed or demolished. The 50-acre Gold Hill slide on the east bank required removal of some 7 million cubic yards of material.

Left: caption: "Slide in East Bank of Canal near Cucaracha, June 1912. This illustrates one of the difficulties with which the Engineers and Construction Department have had to contend."

Right: caption: "Culebra Cut, Culebra. Break in East Bank of Canal. Amount of material involved; 320,000 cubic yards. The train shown in foreground is about 35 feet above the bottom, or at Elevation +75. February 11, 1912."

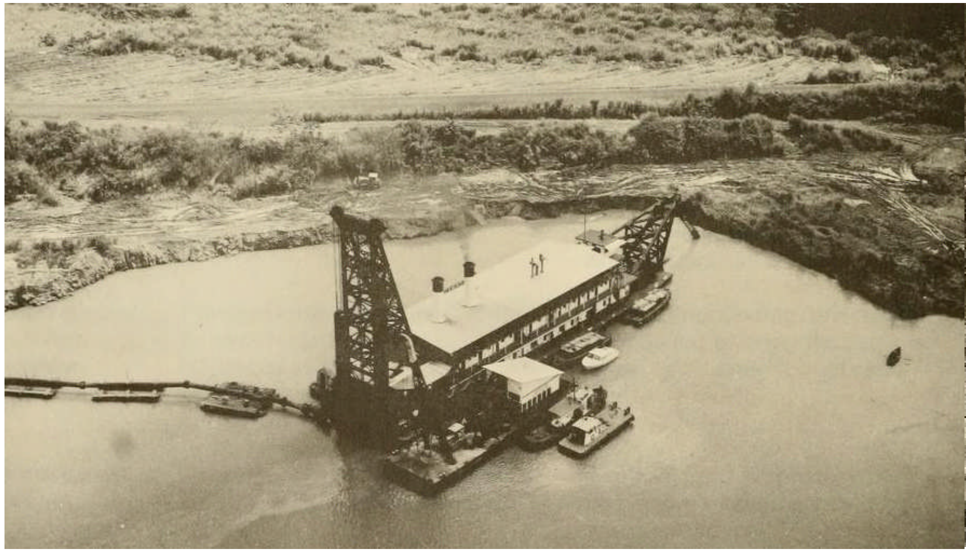
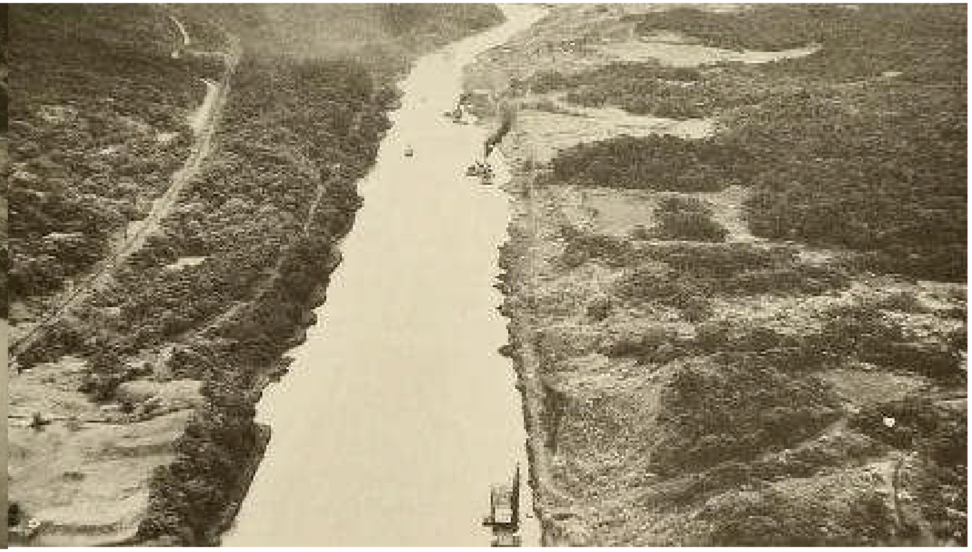
Left: caption: "Culebra Cut – Cucharacha Slide. Looking North, showing laborers digging a ditch through the toe of the slide, October 11,1913."



<u>Top Left</u>: caption: "Steam shovel 218 buried under fall of rock, West side of Canal, near Las Cascadas. The shovel was working on the bottom of the Canal when destroyed, May 31, 1912."

<u>Top Right</u>: slide into *Culebra Cut*, 1913

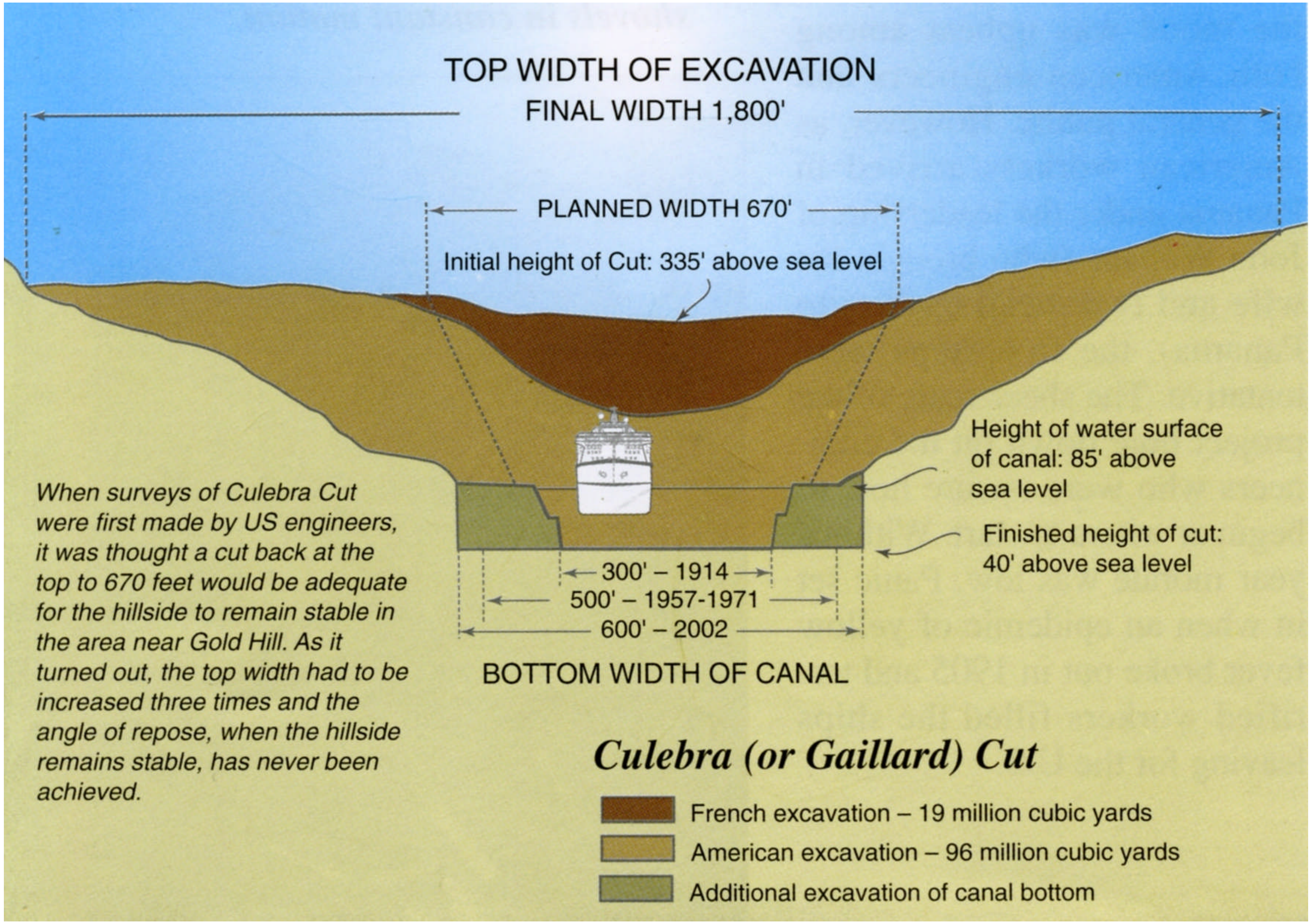
<u>Left</u>: the battleship *U.S.S. Ohio* steams through the Culebra Cut past the *Cucharacha* slide, July 1914

Canal engineers were completely unprepared for and confounded by this unexpected slide activity. In 1906, the minority report of the *International Board of Consulting Engineers* placed total *Culebra Cut* excavation for a lock canal at 53,800,000 cubic yards; the minority report estimated the amount necessary for a forty-foot deep sea-level canal at 110 million cubic yards. In 1908 the canal commission revised the cut excavation estimate to about 78 million cubic yards; in 1910 to 84 million; in 1911 to 89 million; in 1912 to nearly 94 million; and in 1913 to about 100 million. The increased cut excavation required was due partially to an increased bottom width from 200 to 300-feet; an increase of about 13K cubic yards, but the slides were the main reason.

Left: caption: "The Gaillard being widened using a large pipeline dredge"

Right: caption: "Widening the Panama Canal channel from 300 feet to 500-feet was completed in 1970"


TOP WIDTH OF EXCAVATION
FINAL WIDTH 1,800'
PLANNED WIDTH 670'
Initial height of Cut: 335' above sea level
Height of water surface of canal: 85' above sea level
Finished height of cut: 40' above sea level
300' – 1914
500' – 1957-1971
600' – 2002
BOTTOM WIDTH OF CANAL
When surveys of Culebra Cut were first made by US engineers, it was thought a cut back at the top to 670 feet would be adequate for the hillside to remain stable in the area near Gold Hill. As it turned out, the top width had to be increased three times and the angle of repose, when the hillside remains stable, has never been achieved.
Culebra (or Gaillard) Cut
French excavation – 19 million cubic yards
American excavation – 96 million cubic yards
Additional excavation of canal bottom

Slide Management

The huge amounts of clay were a difficult problem since it was too soft to be excavated by the steam-shovels. Eventually, Gaillard’s engineers discovered that the clay could be removed by sluicing it with water from a high level. The slides still continued to cause minor problems after this, but the trick of liquefying the clay was the breakthrough in excavating *Culebra Cut*. Nevertheless, the delays caused by the various slides was estimated at two and a half years. Despite the delays, the work on the *Big Ditch* was completed two years ahead of schedule. Much of the credit was given to Gaillard's leadership.

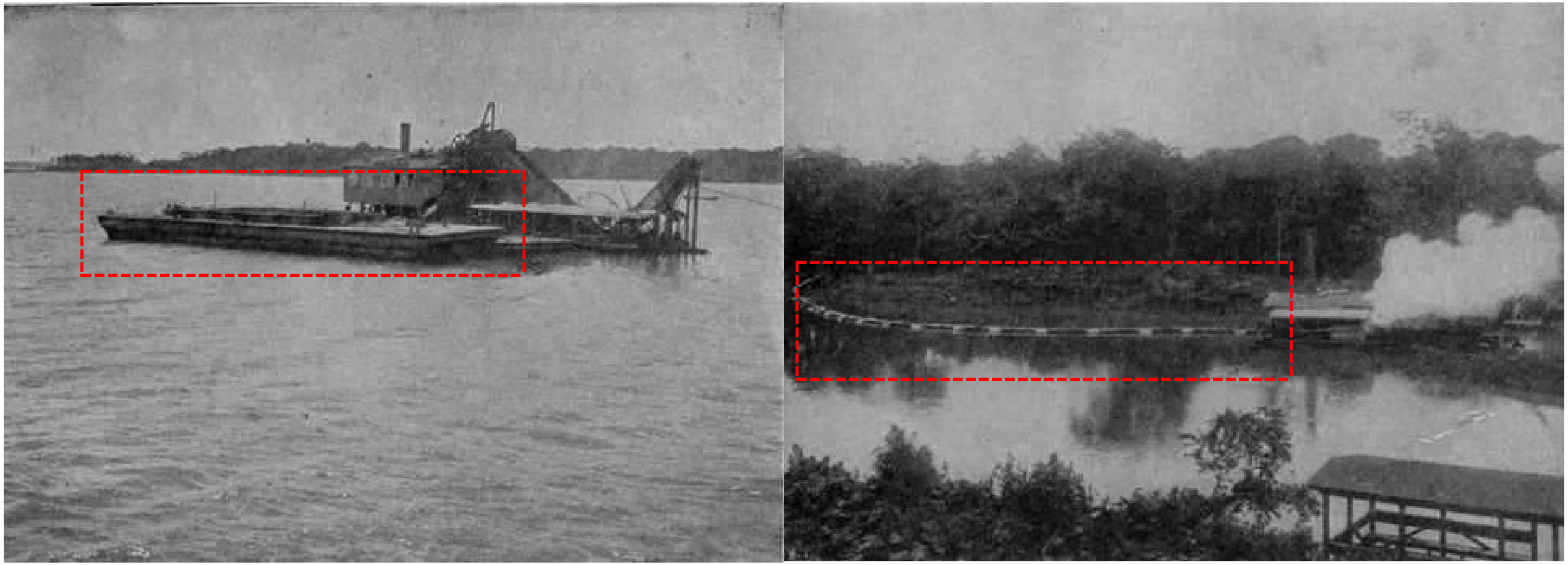
Above: caption: “Stripping Cocoli Hill adjacent to Canal Prism and showing the method of hydraulic excavation, March 21, 1912”

The Hydraulic Giant

“Washing the dirt and boulders out of the way with a jet of water thrown at high velocity from a hydraulic giant is now recognized as one of the most efficient methods for stripping the earth from mineral deposits as well s for many other kinds of heavy excavation. The hydraulic giant consists simply of a tapering metal tube, or nozzle, usually from six to eight feet long, to which water is supplied under heavy pressure. It is so mounted that it can be swung both horizontally and vertically, a feature that makes it possible to direct the jet at any point in a big area. The work done by the hydraulic giant depends on the impact of the water, and for this reason the force exerted is a factor both of the jet and the pressure under which the water is supplied. When a jet of water is thrown at high velocity from one of these machines it has many of the qualities of a hard, rigid bar…In actual practice the head may vary from a hundred feet to several thousand feet…a 5 in. stream works under a pressure of 200 psi, equivalent to a head of 460 ft…”

***Popular Mechanics,* October 1915**

Above: caption: “Excavating with a Monitor as Californians Dig Gold”

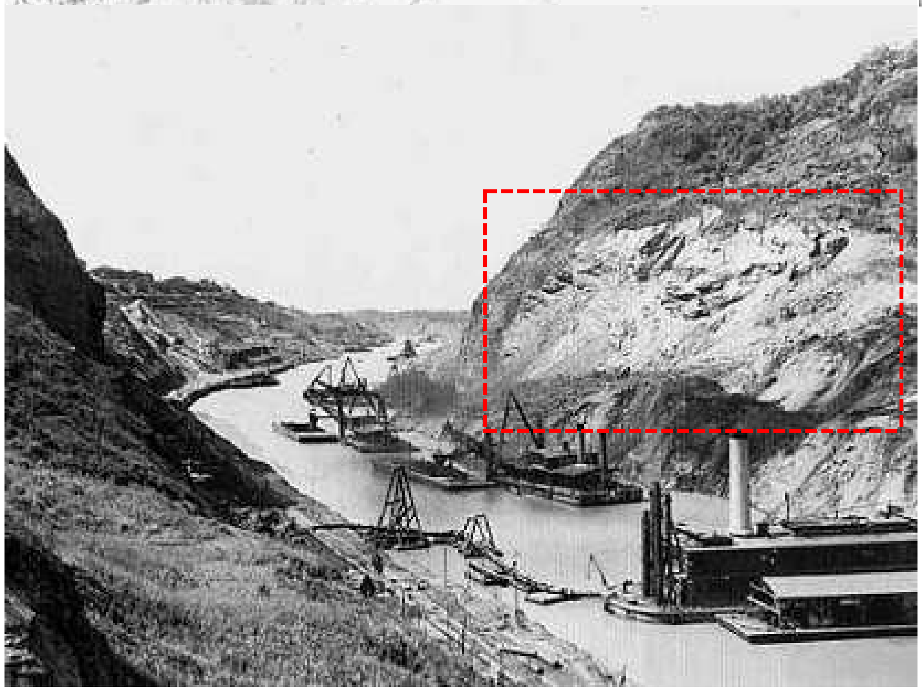


The photograph at left shows a ladder dredge, which operates by means of buckets on a continuous chain, dipping the contents of the buckets into the scow which lies alongside (outlined). The photograph at right shows a suction dredge, which operates on soft mud or sands, pumping the discharge through the pipe seen at the left of the illustration (outlined). The pipe may be carried to any desired point and used for filling.

"…At the great Culebra Cut through the divide, had it not been for the great number and size of the slides which had developed during the work of construction, the excavation would have been finished on January 1st of the present year. As it is, some seven to eight million yards have yet to be removed, about one half of this material consisting of slides which are already in motion or are likely to develop. The engineers have no apprehension that further development of slides will hinder the opening of the canal, for when the water has been allowed to rise in Gatun Lake to the full height of eighty-five feet above sea-level, any further material that may slide into this canal, will be taken out by suction dredges, loaded in barges, and towed out to sea; this method will not interfere with traffic and will cost less than the present system of using steam shovel and dirt train…"

***Scientific American Supplement,* November 23rd 1912**

RE: dredges, tugs, barges and crane boats that had been laboring in the sea-level approaches of the canal and in the two terminal bays, much of which had been left behind by the French, was now brought in to clear the cut. Barges dumped the spoil in designated areas of *Gatun Lake*, all in the manner that *Philippe Bunau-Varilla* had long ago said it should be done. Floodlights installed in the cut allowed around-the-clock work. The old French ladder dredge *Marmot* made the "pioneer cut" through the *Cucaracha* slide on December 10th 1913, to open the channel for the first time.



<u>Top L&R</u>: dredges at work in the Culebra Cut (ca. 1913)
<u>Left</u>: in the photograph (ca. 1913), the white area on the side of the hill (outlined) was the location of a large mud slide into the cut (prior to the flooding of the cut)

An Accomplished Fact

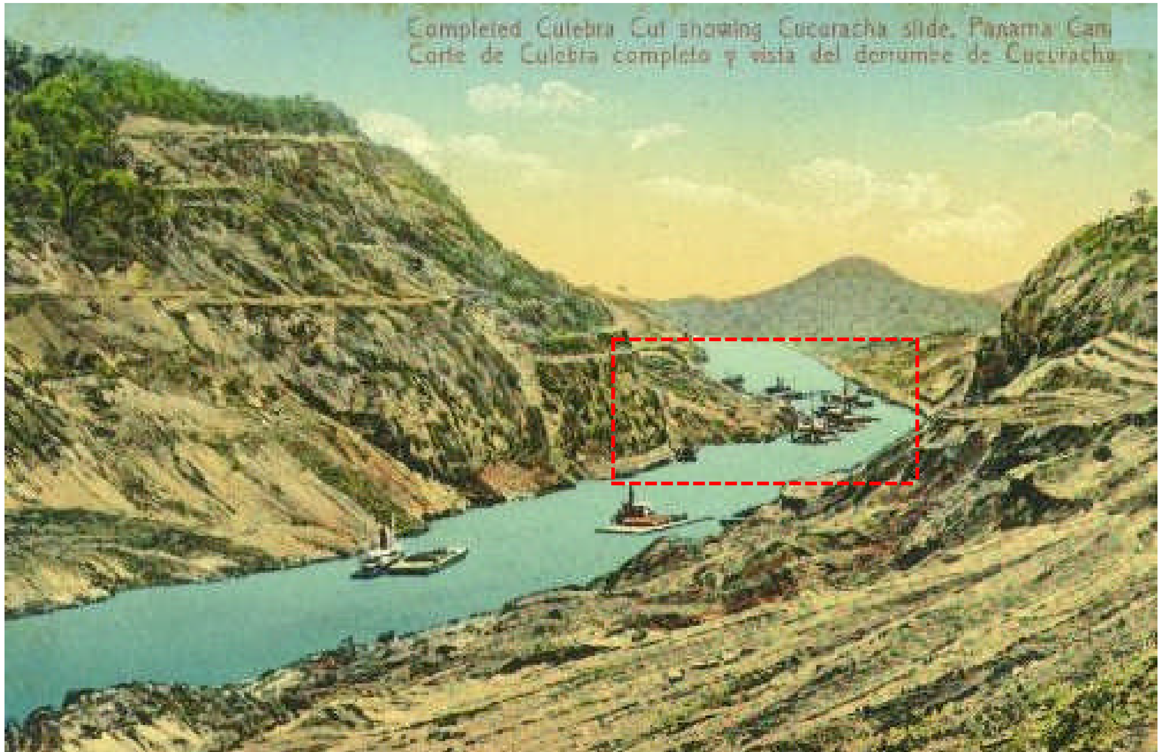
"The official announcement by the Secretary of War that the Panama Canal would be opened from the Atlantic to the Pacific on August 15, 1914, for commercial vessels not drawing more than 30 ft. of water marked the completion of the canal, although the formal opening will not occur until March, 1915. It is expected that in the future the canal will be operated without interruption, and announcements will be made from time to time as it is made ready for vessels of greater draft."

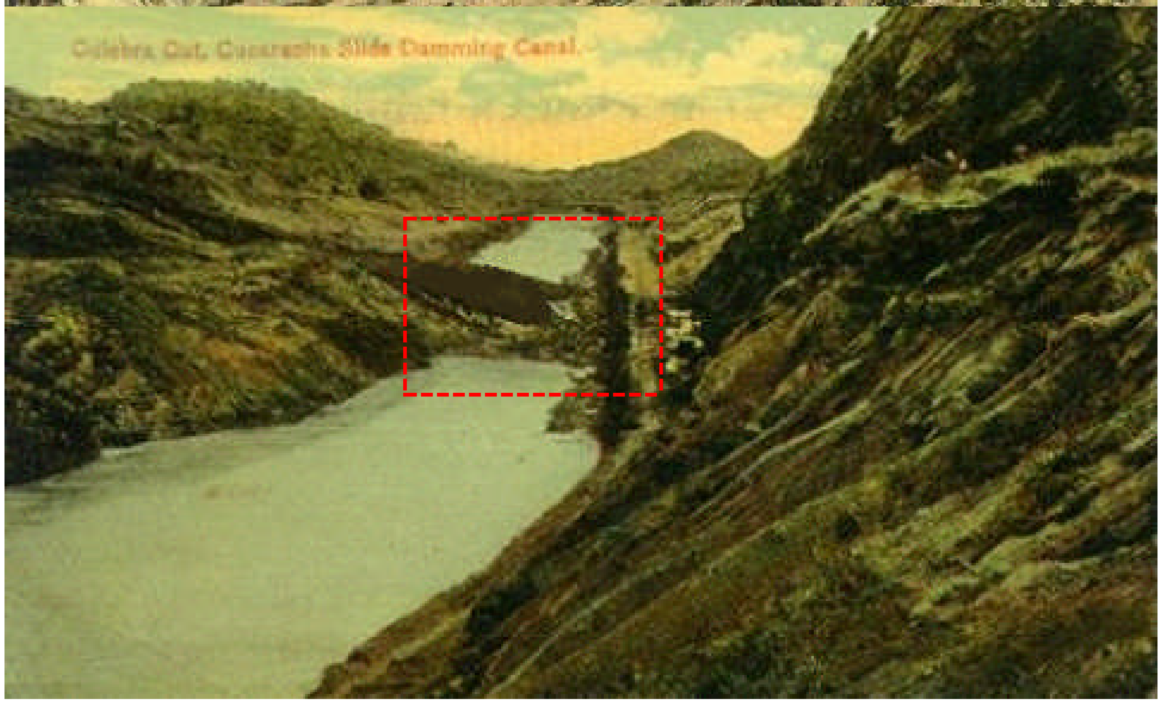
***Popular Mechanics,* October 1914**

"The first vessel to go through the Panama Canal from one end to the other under its own steam was the crane boat 'Alexander La Valley,' regularly employed in construction work on the Isthmus. Eighty months from the day work was begun under Major G.W. Goethals as chief engineer, navigation through the canal was an accomplished fact."
Popular Mechanics, **March 1914**

<u>Above</u>: crane-boat "La Valley" in canal lock. The first complete *Panama Canal* passage by a self-propelled, ocean-going vessel occurred on January 7th 1914 when the *Alexandre La Valley*, an old French crane-boat that had previously been brought from the *Atlantic*-side, emerged from the *Pacific* locks.

Pessimistic Forebodings





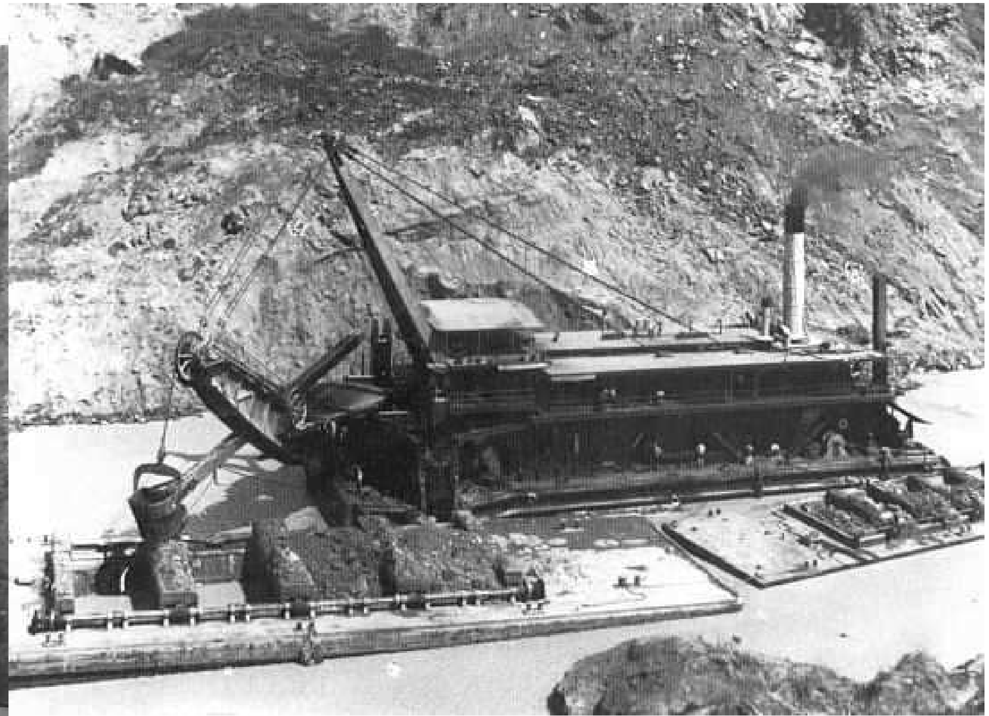
"…Similar accidents may be expected to occur after the canal is finished and in this way the depth of the water in places may be greatly diminished without detection, and vessels may be grounded and seriously injured. These avalanches are greatly promoted by the exceedingly violent rainstorms, or 'cloud-bursts,' which are of frequent occurence and, although Pescheck's prediction that they would prevent the building of the canal is probably exaggerated, they afford good ground for pessimistic forebodings…"

Scientific American Supplement, **September 23rd 1911**

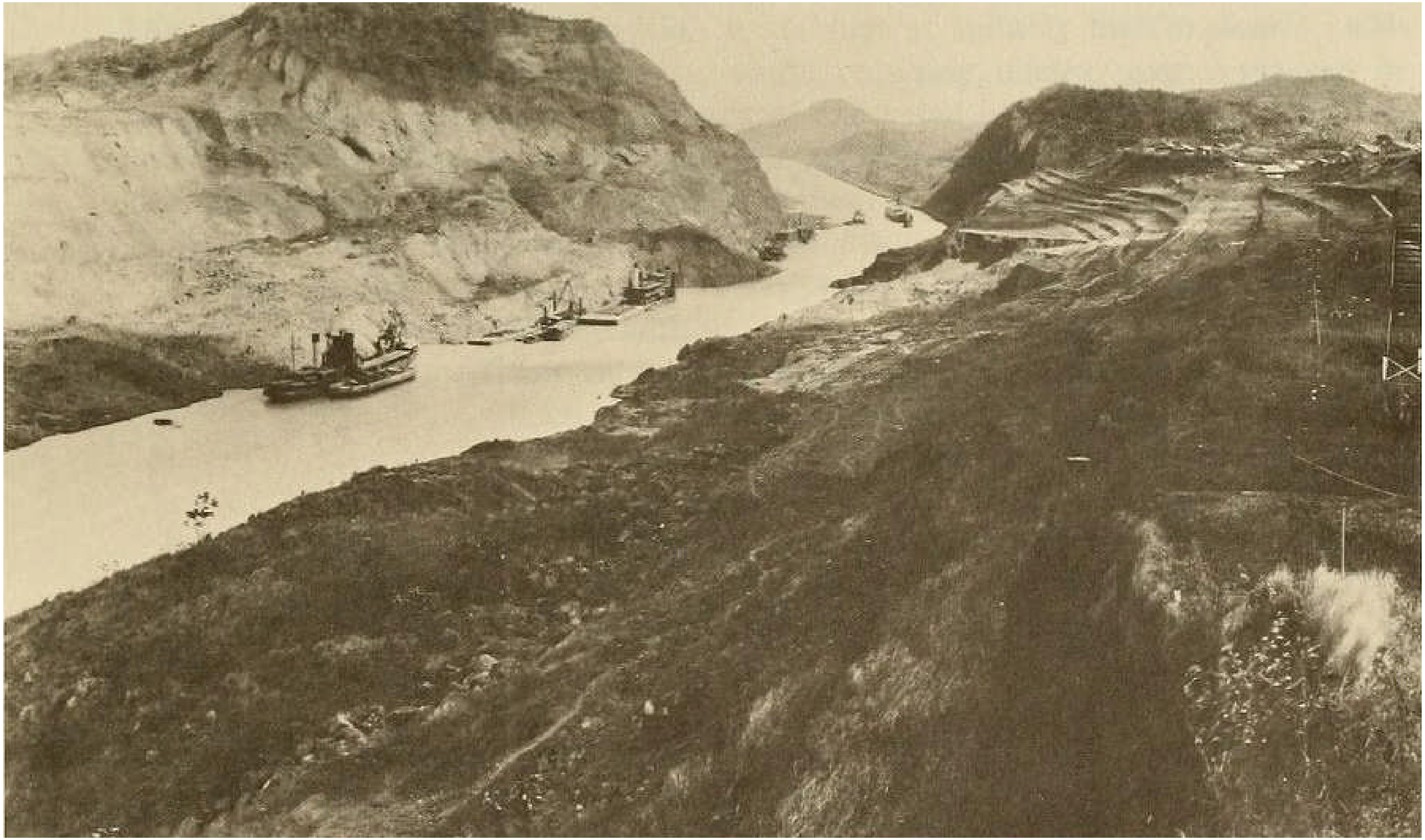
RE: excerpt from an article entitled: "A German View of Our Panama Canal Worries"

"…As the result of a succession of slides in the Gold Hill section of Gaillard Cut, that began on September 18, 1915, the Panama Canal is blocked to all traffic and, according to present estimates, will probably remain so until the end of the year. This is by far the most serious incident that has occurred since the opening of the canal more than a year ago, the slides have practically obliterated a 1,300-ft. section of the channel. According to latest reports, about 200 feet of this section has a width of only 25 ft. and a depth of from 3 to 15 feet. At one point an island has formed in the middle of the canal, leaving a channel on each side in which the maximum depth does not exceed 15 ft. The normal width of the canal through Gaillard Cut is 300 ft., and its normal depth 45 ft. The most serious feature of the situation is that at last reports the earth was slipping into the canal as fast as the dredges were taking it out. Something like 175 acres of land is involved in the slide, and it is estimated that 10,000,000 cu. yd. of earth is in motion. The present rate of excavation is about 1,000,000 cubic yards a month. Before a permanent channel can be opened, all this, and probably more, must be dug out, although the canal can be opened to traffic as soon as a channel 100 ft. wide and 30 ft. deep has been made. The time required to do this is uncertain, since it depends entirely on the future action of the moving earth above the canal prism. One of the measures taken to diminish the cause of the slides is that of blasting away the tops of the hills, thus taking away some of the weight on the affected section and bringing down immediately as much as possible of the loose earth that might cause trouble in the future…"

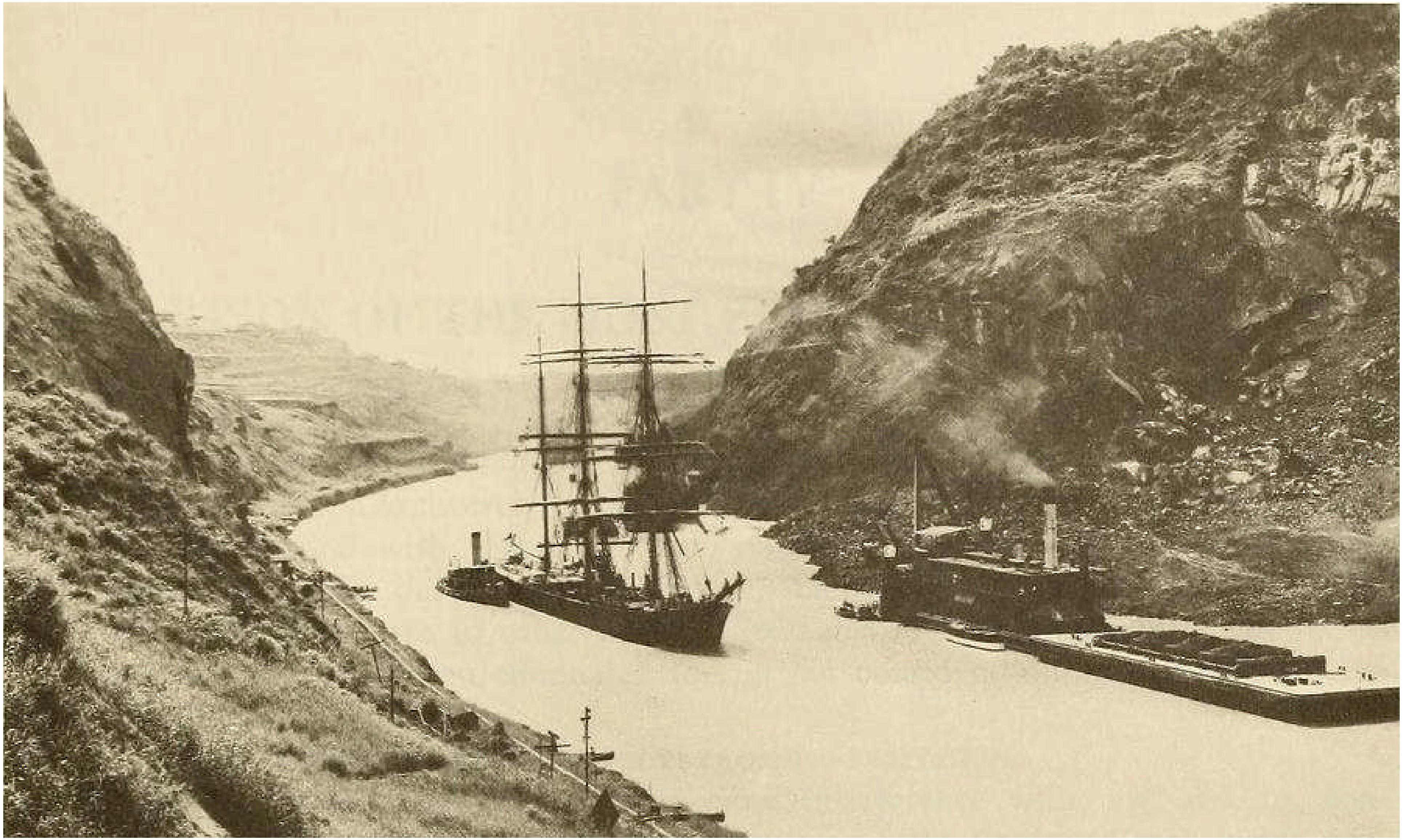
***Popular Mechanics,* December 1915**



<u>Top Left</u>: caption: "Culebra Cut, looking North from Contractor's Hill. S.S. Baron Dreisem (Russian) passing Gold Hill slide, January 16, 1915."
<u>Top Right</u>: caption: "Culebra Cut. Dredge at the Cucaracha Slide, 1915"
<u>Left</u>: Dredges at work as a large container ship passes through *Culebra Cut*



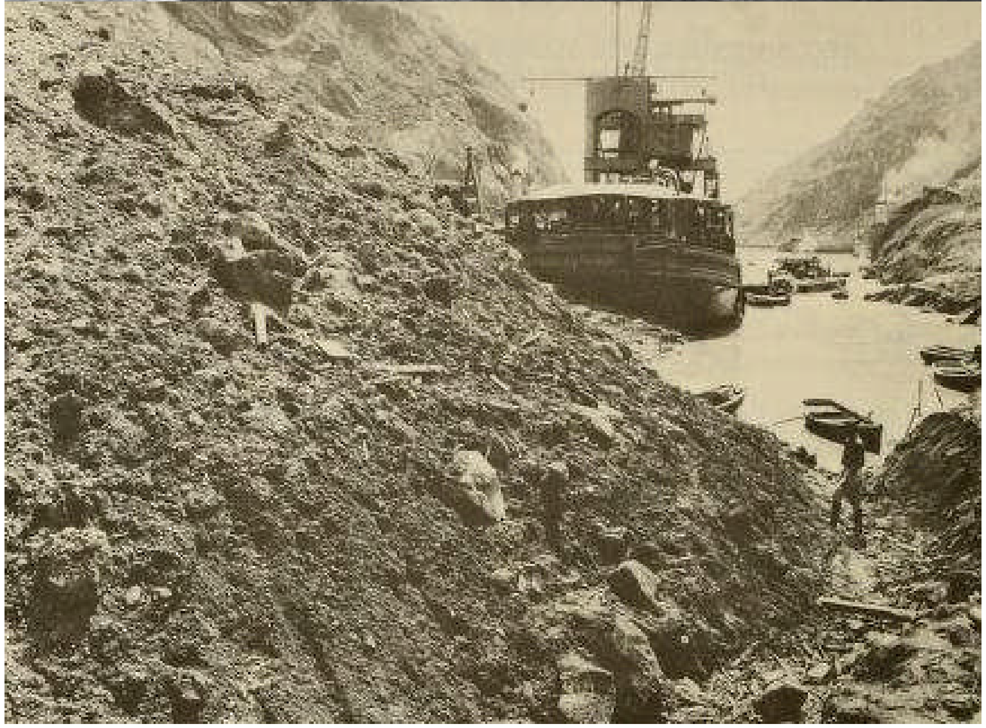
<u>Above</u>: caption: "Culebra Cut looking south from the west bank near station 1760, showing condition of both banks, February 25, 1915"



<u>Above</u>: caption: "The sailing ship "Lord Templeton" passing between Gold Hill and Contractor's Hill, June 12, 1915" 621

"Drills and dredges and numbers of workmen have been kept busy ever since the Panama Canal was opened to commercial navigation ten years ago, in removing tons of earth that occasionally slip into the passage in the steep cuts, and in widening the channel in places. To loosen the cliffs and break up the fallen material so that it can be handled easily, charges of dynamite are exploded and powerful machinery speeds the removal of debris, so that shipping will be tied up a short a time as possible. In one slide not long ago, nearly 500,000 cubic yards of earth fell into the canal, and shortly after its completion, the passage was closed to traffic for several months until it could be safely cleared again. Dredges are kept ready for instant service, whenever the slides occur, and, while steamers ply through the channel, workers are still engaged in digging operations such as were employed in original excavations, to make the canal wider at various turns and sharp points."

***Popular Mechanics,* April 1924**



"Only south-bound ships were compelled to tie up recently after a minor slide in the Gaillard cut of the Panama Canal. Soundings showed that the other side of the passage was navigable, so north-bound boats proceeded as usual while the other steamers were tied up close to shore to make room for dredges sent to excavate the channel. These small cave-ins happen occasionally as the earth settles in the steep cuts, but since the period, September, 1915, to April, 1916, when the canal was practically blocked, traffic has not been impaired seriously from this cause."

Popular Mechanics, **February 1924**


CANAL ZONE
13c
DREDGE CASCADAS

What the Panama Canal Means to You

"Although the longest way may not be the quickest, it has often proved the cheapest since the building of the Panama Canal. Recently a vessel sailed 5,770 via the canal to deliver a shipment from one city in South America to another only 650 miles away by air line. Despite the length of the voyage, the charges were less than they would have been if the merchandise had been transported directly overland, because of the almost impassable jungles separating the two points. In another instance it was found less costly to ship lumber more than 8,000 miles by steamer through the canal than to send it to the same destination 2,500 miles away by railway. The trip from the west coast, through the canal, up the east coast, and to a middle-western city by rivers and lakes, took more than two months. It even has been found cheaper to send products 1,000 miles by rail to the east and thence by boat through the canal to the west coast, a total distance of approximately 7,000 miles, than to ship them 2,500 miles overland."

***Popular Mechanics,* October 1923**

"With the celebration of the tenth anniversary of the opening of the Panama canal just a few weeks ago, it was announced that more than 25,000 vessels had passed through the waterway. Over one-fifth of that number made the trip between the Atlantic and Pacific in the single year ended June 30, last. Despite all handicaps, such as landslides, the traffic has increased so rapidly that tolls during the last fiscal year reached $24,290,963.54, as compared with $4,367,550.19 in 1915, and the vessels which have utilized the canal saved 196,825,000 miles by not having to go around South America, a distance equivalent to 7,873 voyages around the entire earth. Operating expenses last year were only one-third of the gross revenue. Due to the stupendous growth in traffic, plans have been completed for additional locks, bigger than any now in use and capable of lifting the 'Leviathan' or 'Majestic,' more storage reservoirs and an auxiliary steam-electric plant to curtail the waste of water in generating hydroelectric power…Other changes which experts advise include a new storage dam on the Alhajuela river to control and husband the flood water emptying into the Chagres river; another reservoir near the locks on the Pacific side, and also an additional set of longer locks to handle vessels of greater size…"

Popular Mechanics, **November 1924**

RE: excerpt from article entitled: "What the Panama Canal Means to You"


CANAL ZONE POSTAGE
25TH ANNIVERSARY 1939
OPENING PANAMA CANAL 1914
GAILLARD CUT-AFTER
5
CENTS

Part 6

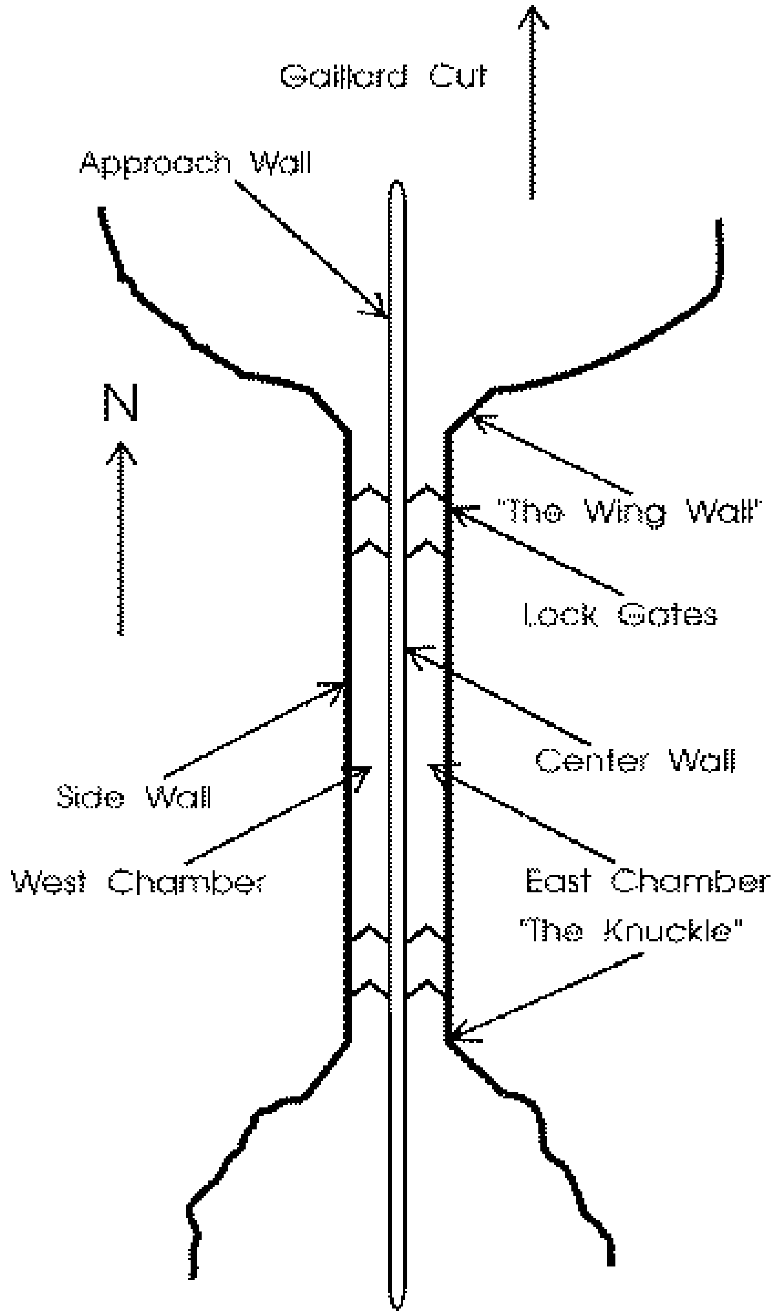
On to the Pacific

"…At the southern end of the Culebra Cut is the Pedro Miguel Lock, with a lift of 30 ft. 4 in. A ship passing through this must proceed two miles farther to Miraflores, through another fresh-water lake, about two square miles in area, with a surface 55 ft. above mean sea-level. At the lower end of this lake are the Miraflores Locks, similar in every respect to those at Gatun except they are of but two steps instead of three. Dropping down through these a distance of 54 ft. 8 in., the ship finds itself again in salt water and at the level of the Pacific Ocean. Here a channel 500 ft. wide and 8 miles long leads to deep water and the open sea…"

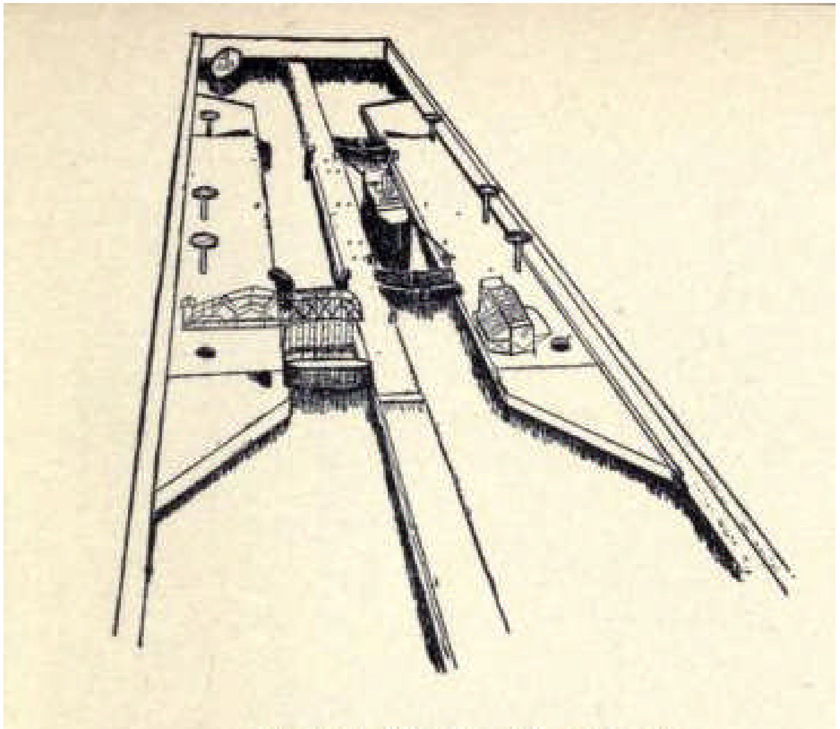
Popular Mechanics, **December 1913**

RE: the *Pacific*-side locks; *Pedro Miguel* and *Miraflores,* were finished before the *Atlantic*-side (*Gatun*) locks in May of 1913

Pedro Miguel Lock

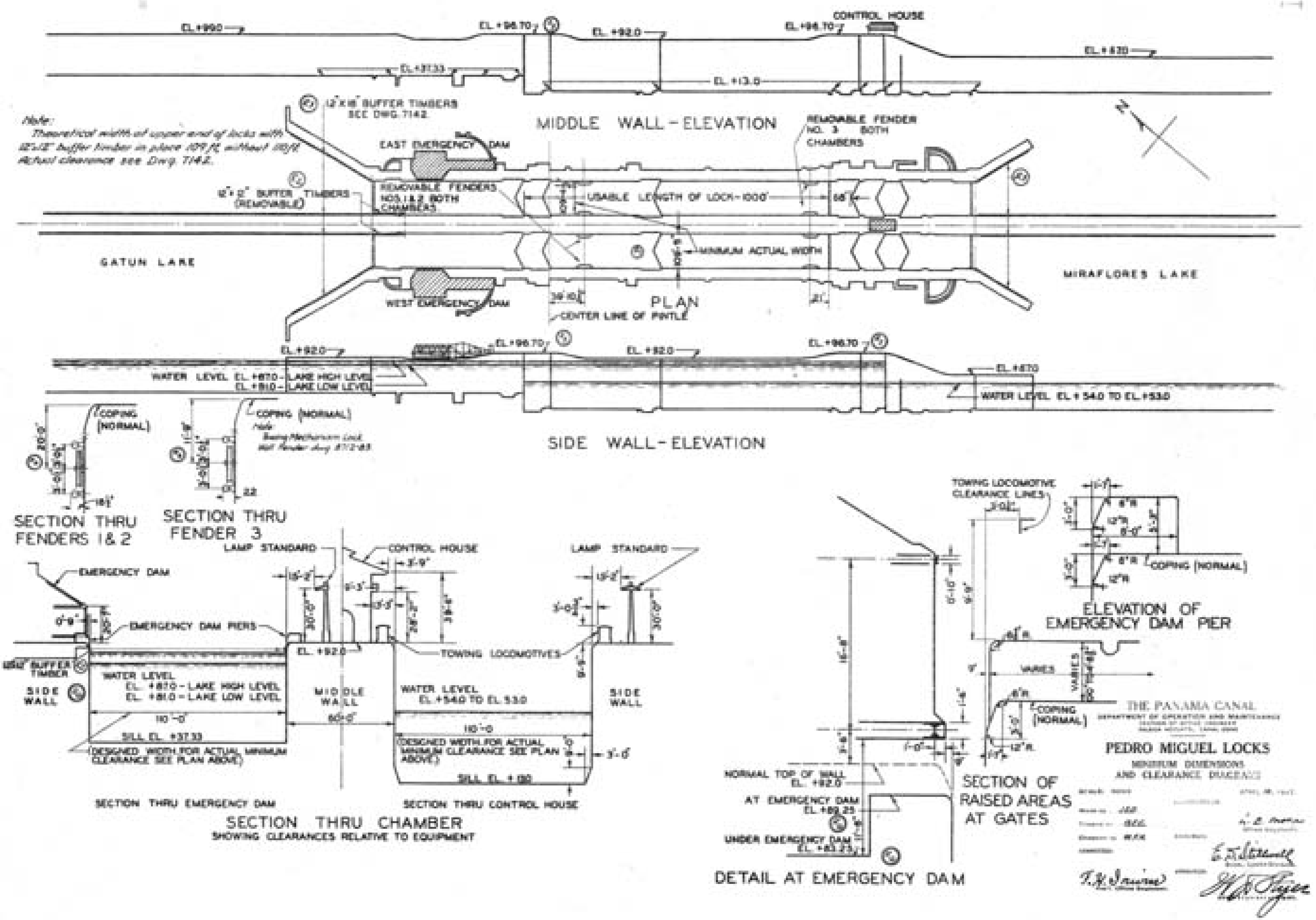


Pedro Miguel Locks

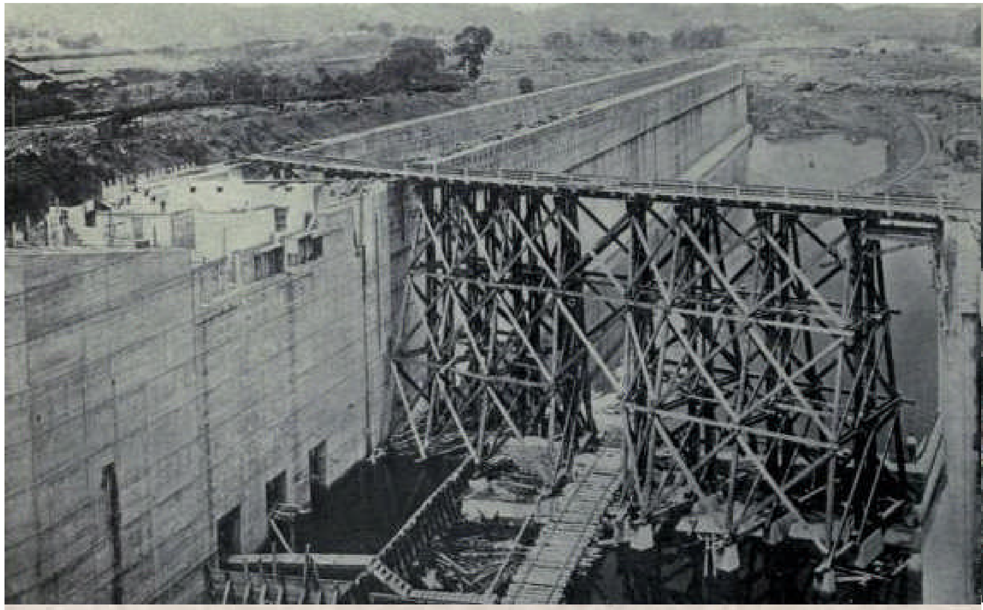


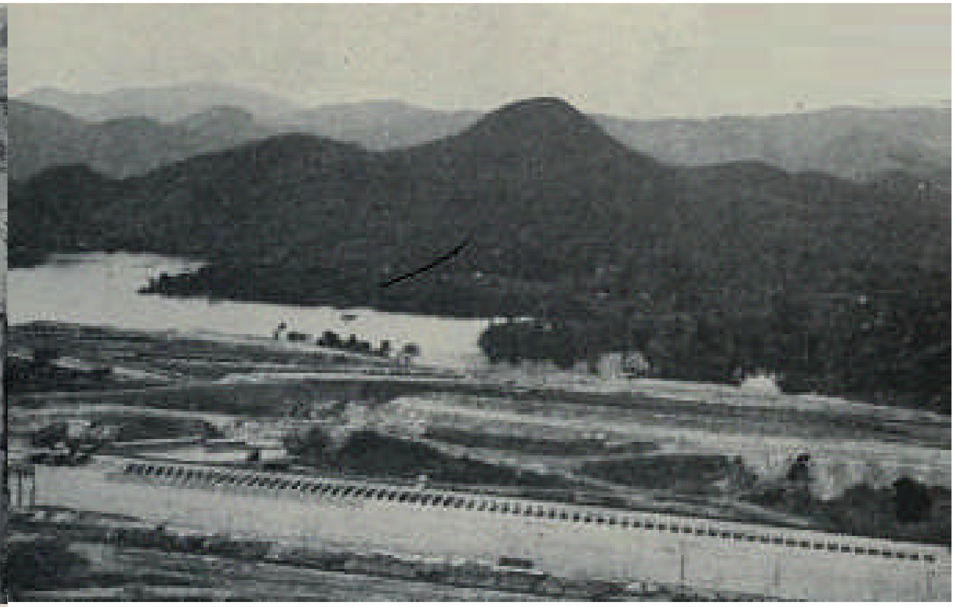
Model of Pedro Miguel Locks

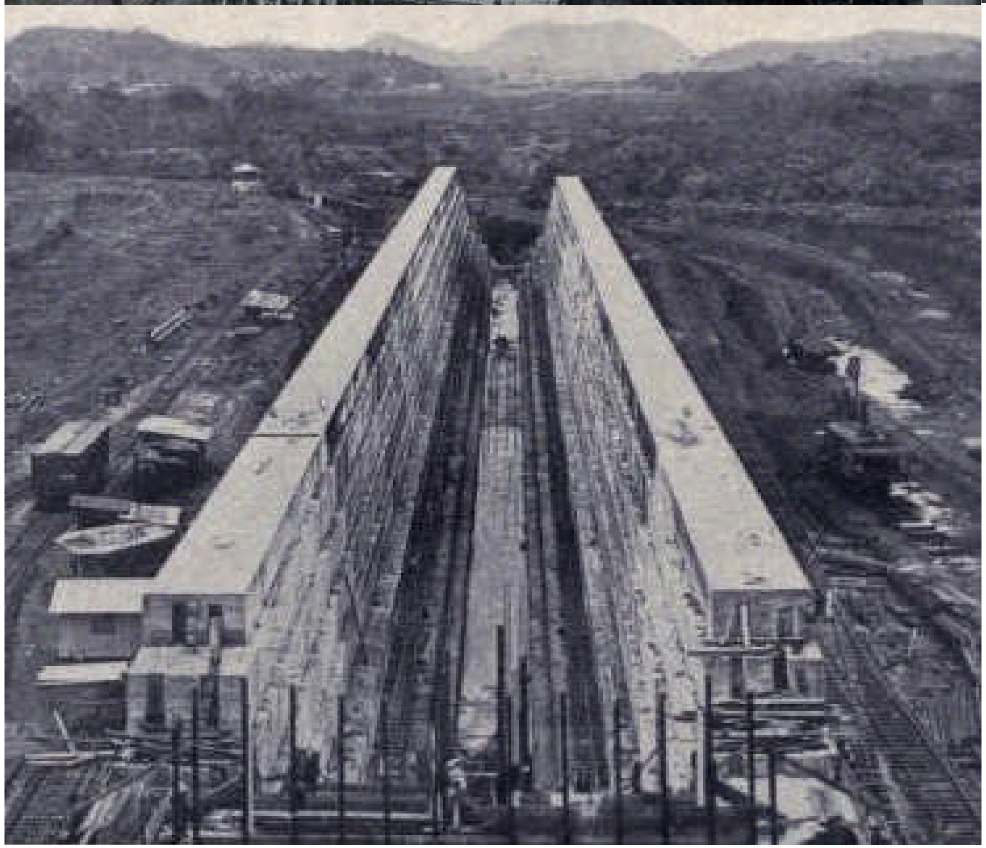
"…here the channel narrows to its smallest width of 300 ft., which it holds for nine miles through the Culebra Cut, or until the lock at Pedro Miguel is reached. Here we drop from elevation 85 to 55…"
Scientific American Supplement,
November 23rd 1912



<u>Above</u>: ***Pedro Miguel*** **Lock Plan, Elevations & Sections**



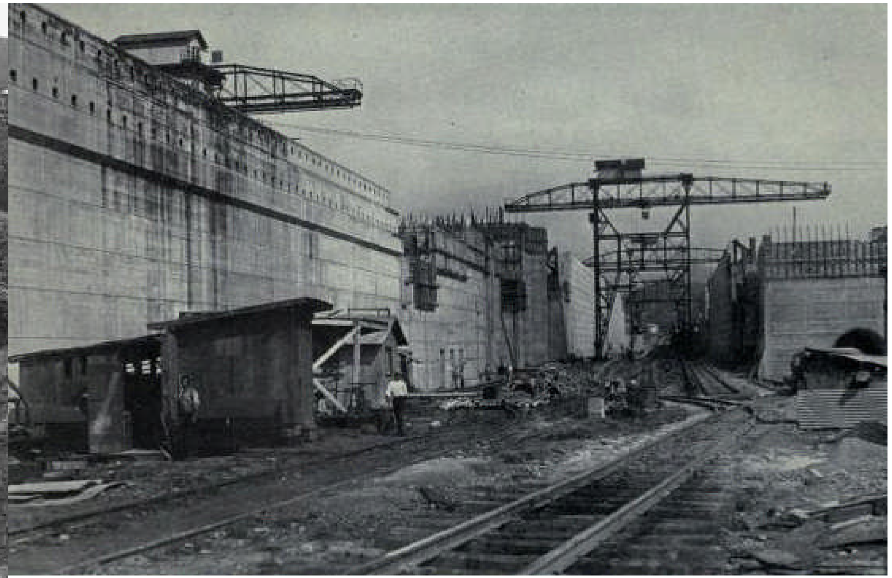


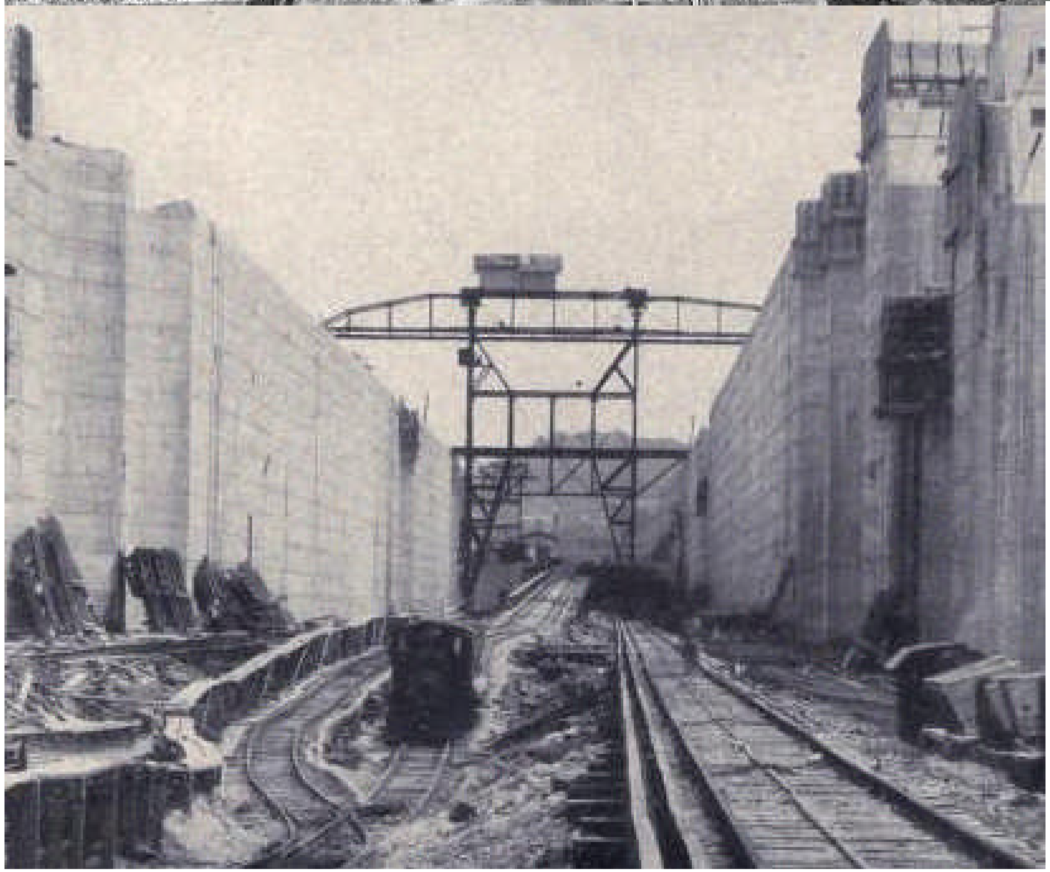


<u>Top Left</u>: caption: "At Pedro Miguel (which the Americans call 'Peter Migill') is the first step downward from the level of Gatun Lake toward the Pacific"

<u>Top Right</u>: caption: "Pedro Miguel Locks. Bird's-eye view of North Approach Wall from hill at East End, as it appeared July 1912"

<u>Left</u>: caption: "Bird's-eye view of Pedro Miguel Locks looking to the South"

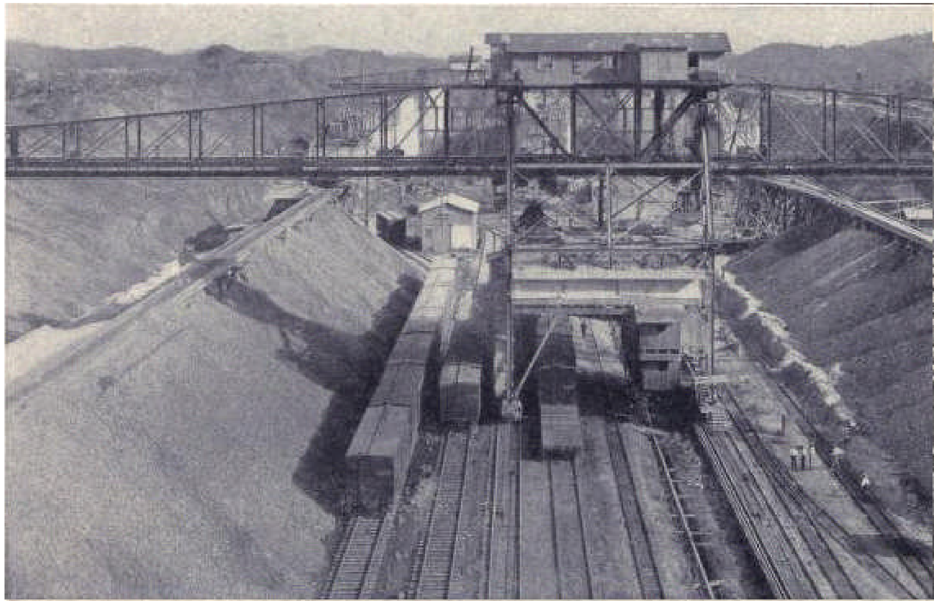


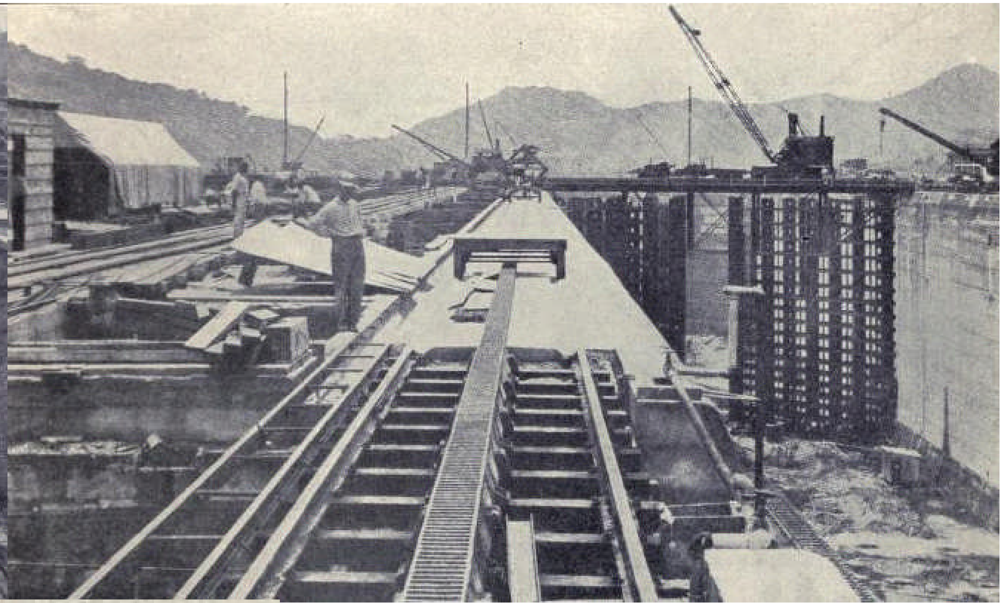


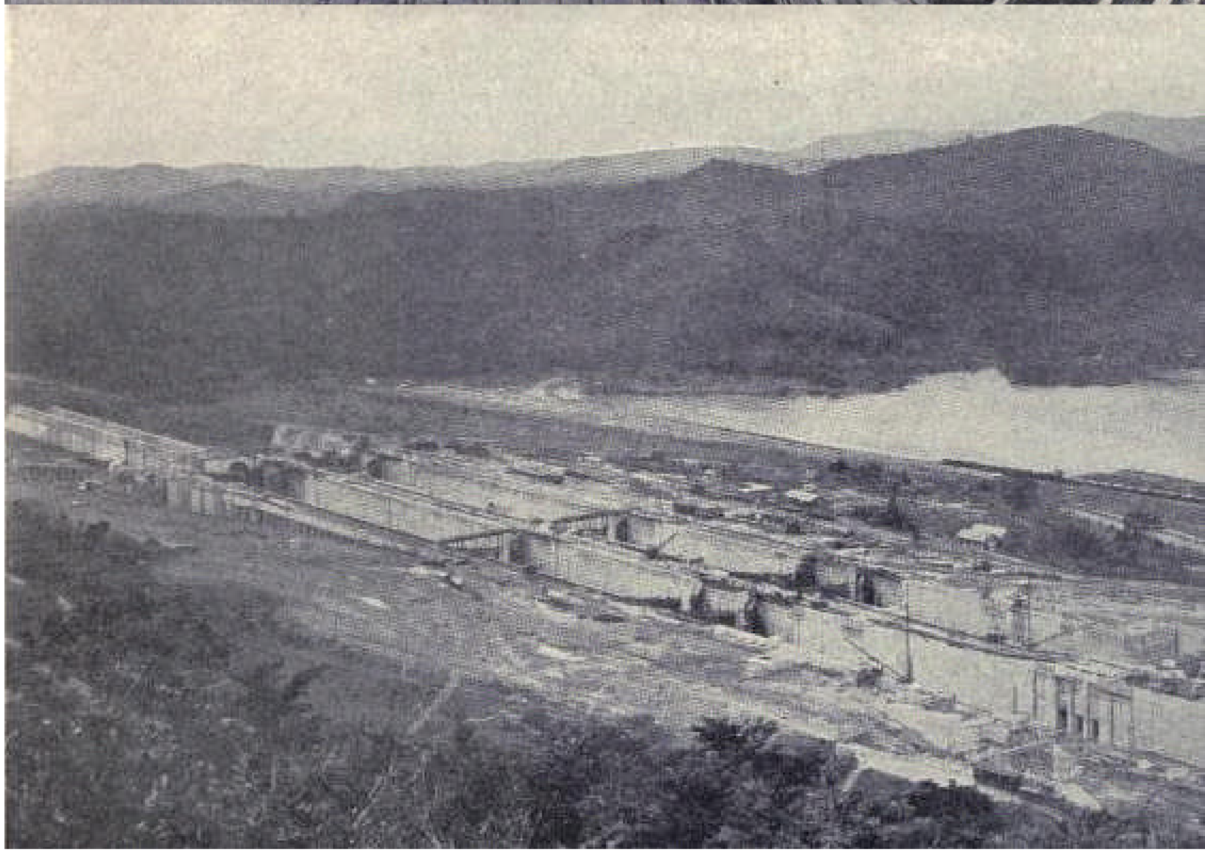
Top Left: caption: "Pedro Miguel Locks. General view looking South from Forebay."

Top Right: caption: "Looking back at Pedro Miguel, we get a good view of the lock chamber. Notwithstanding its great length, it is only one-third as long as the Gatun Lock."

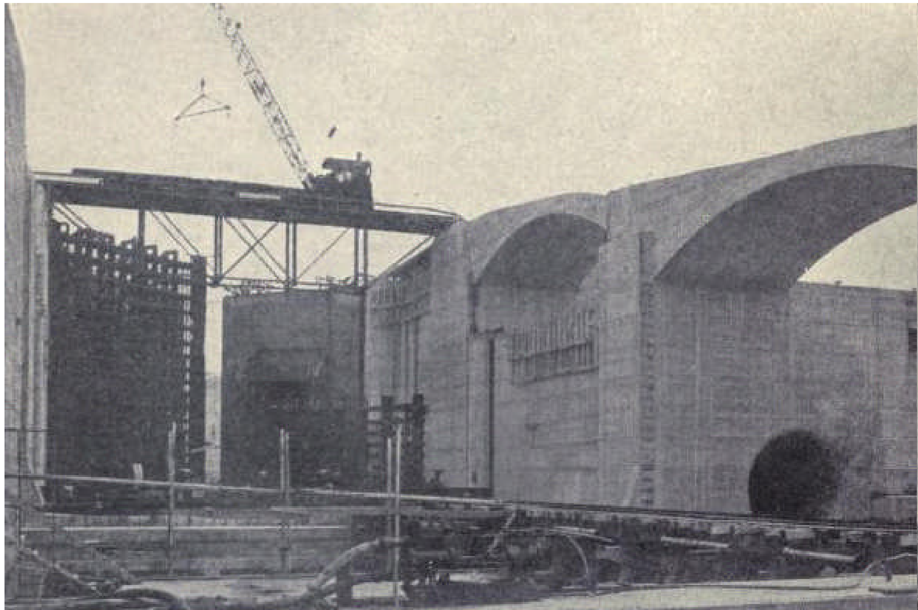
Left: caption: "Pedro Miguel Locks, East Chamber looking North"

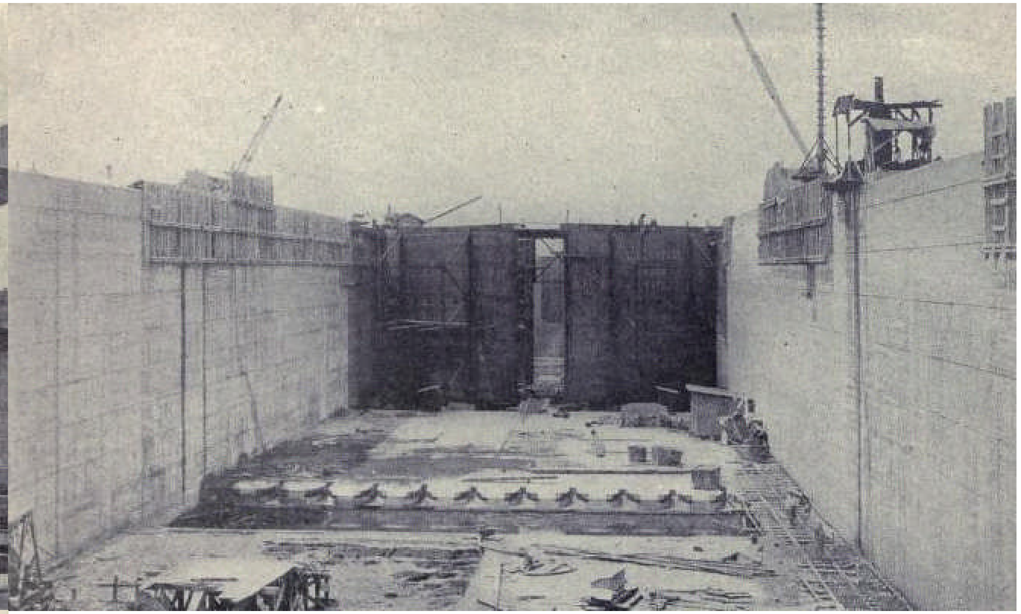


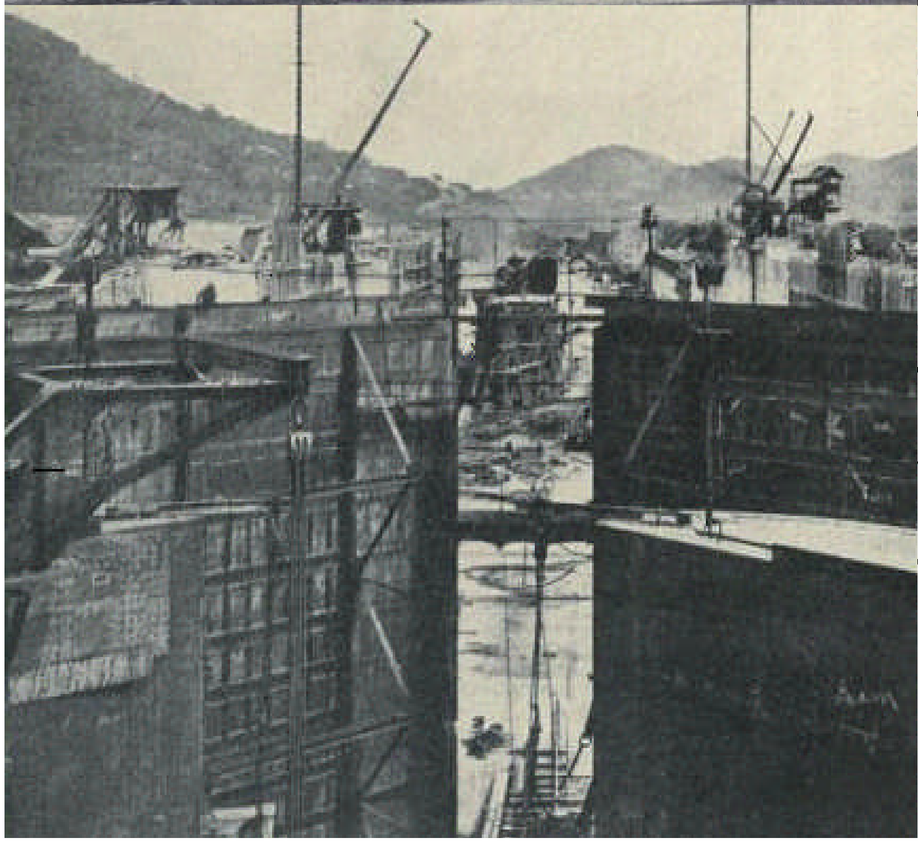




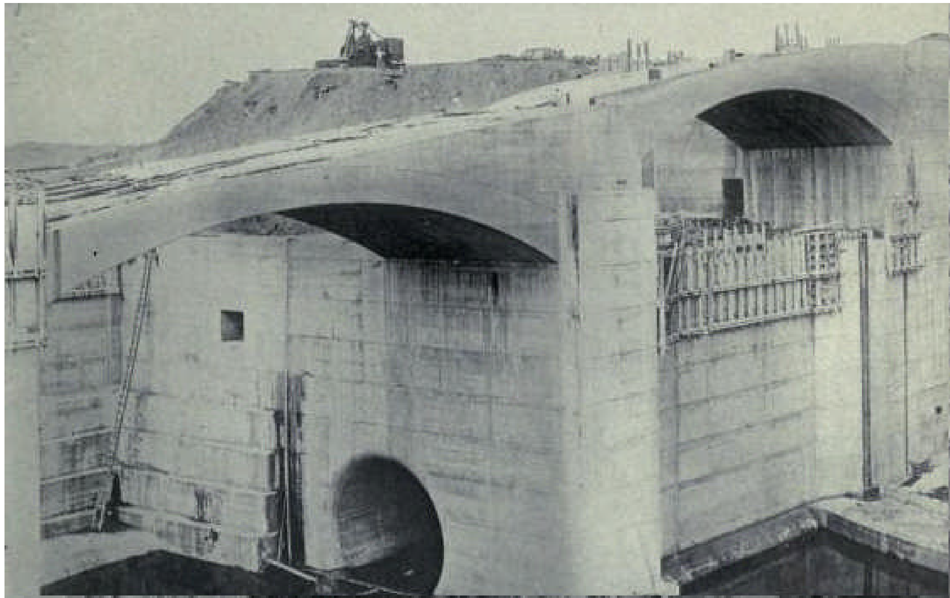
<u>Top Left</u>: caption: "A view looking South from top of Berm Crane at Pedro Miguel showing Stoning Trestles, Berm Crane and general view of Locks"
<u>Top Right</u>: caption: "Pedro Miguel Locks. Detail of construction of Electric Towing Locomotive Rail Track. All vessels will be towed by electricity through the Canal."
<u>Left</u>: caption: "Pedro Miguel Locks. Bird's-eye view from hill on East Bank, July 1912" 639

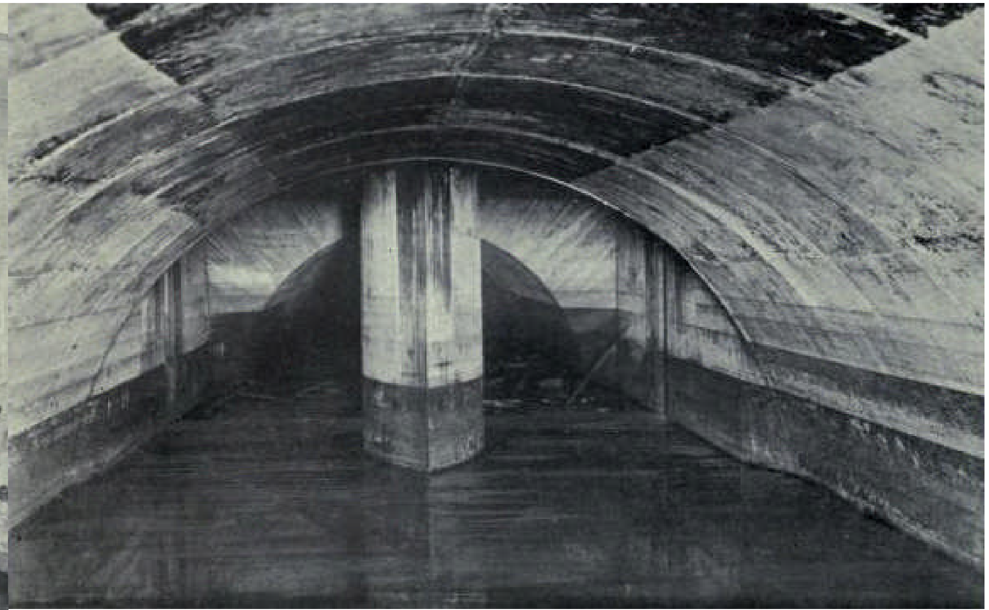


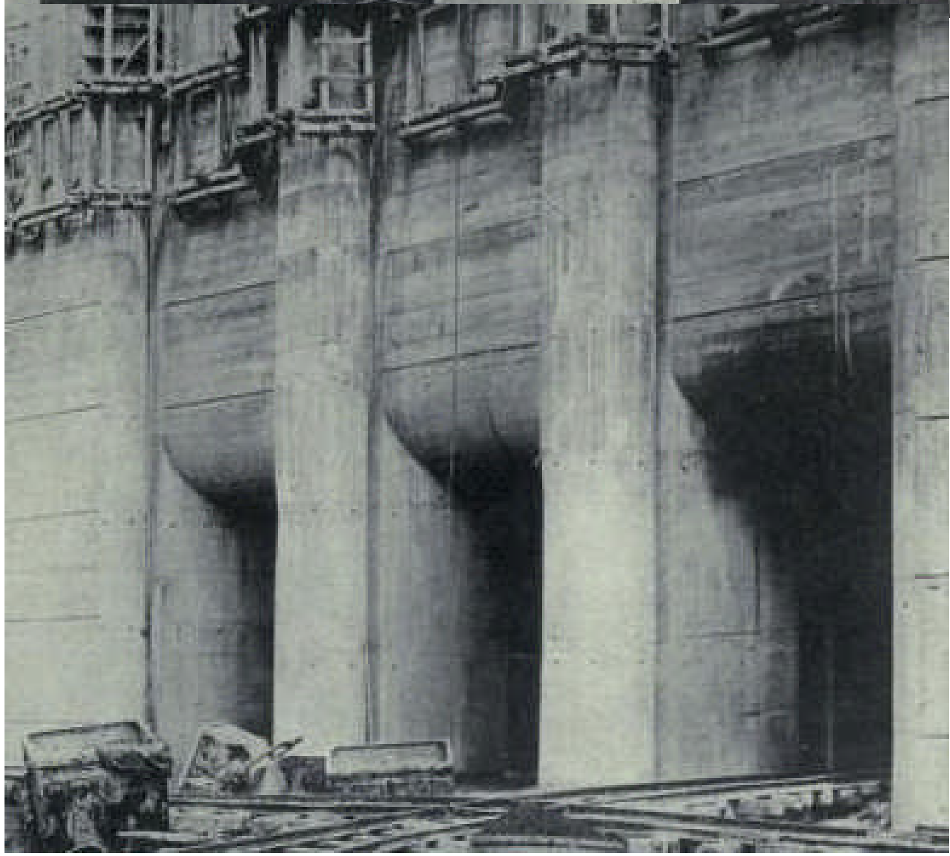




<u>Top Left</u>: caption: "Pedro Miguel Locks. South End of East Chamber showing construction of Safety and Lower Gates, June 1912"
<u>Top Right</u>: caption: "Pedro Miguel Locks, looking South. West Forebay with Emergency Dam Sill, June 1912."
<u>Left</u>: caption: "Pedro Miguel Locks, North End of West Chamber showing construction of Upper Guard Gates and Upper Gates, June 1912"



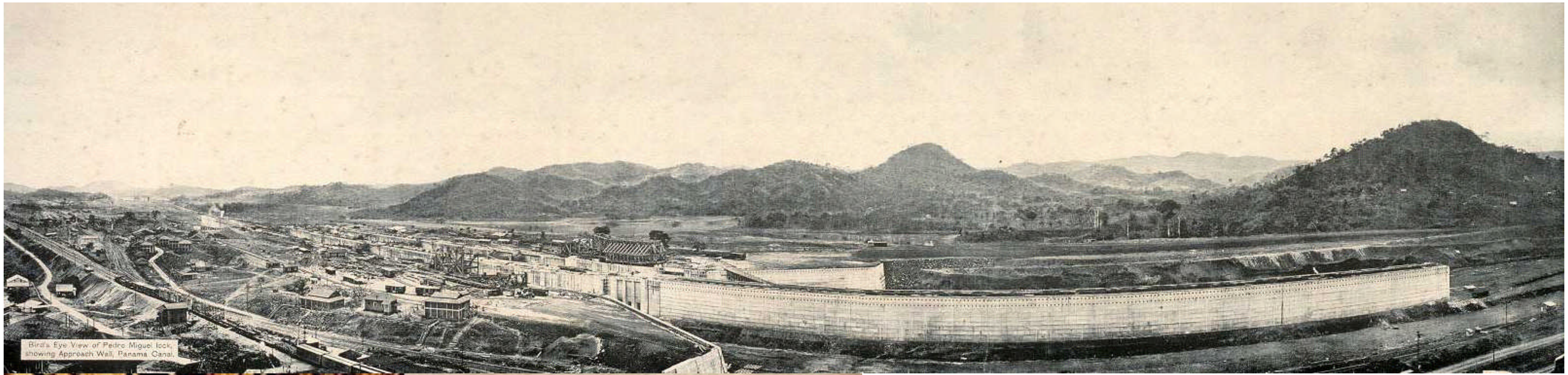


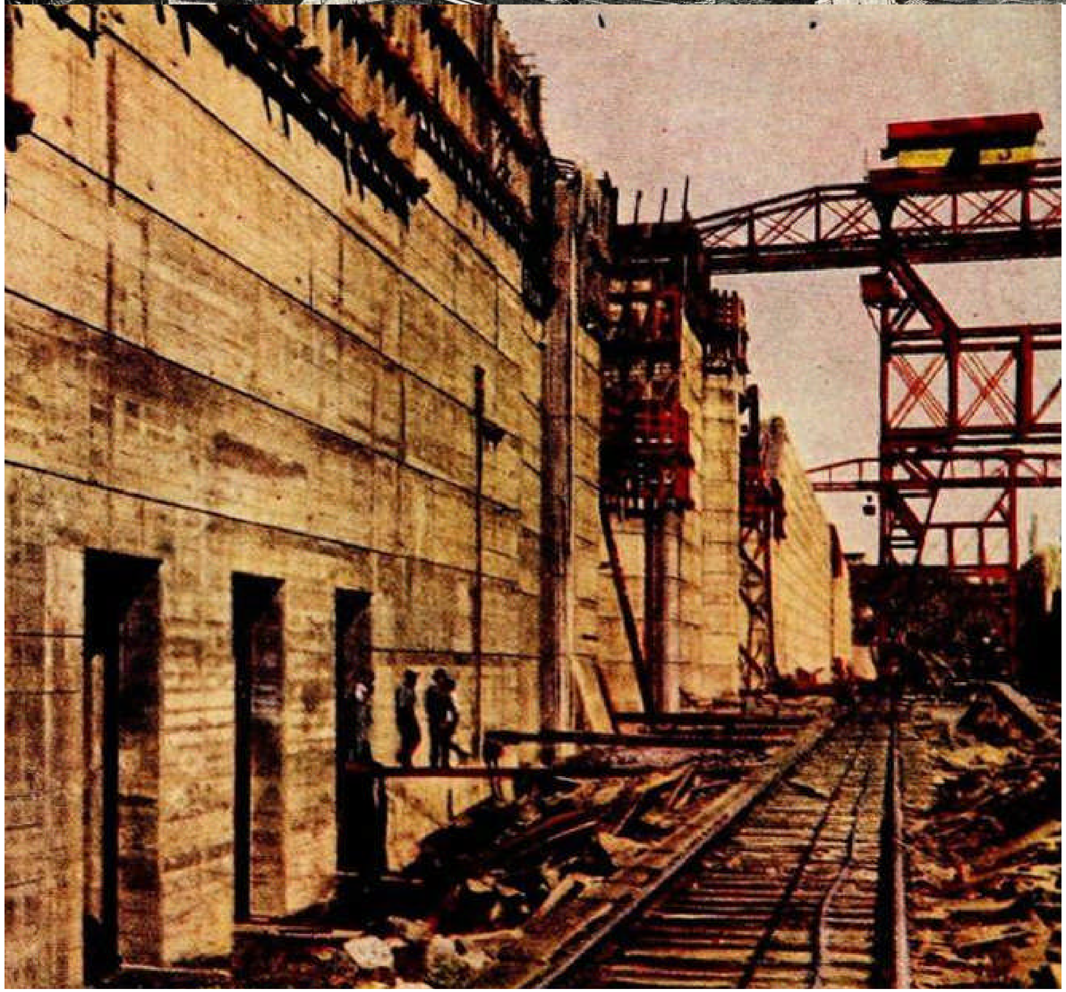


<u>Top Left</u>: caption: "Beautiful concrete arches at the lower end of the Pedro Miguel Lock. Showing also the outlet of the 18 foot water tunnel."

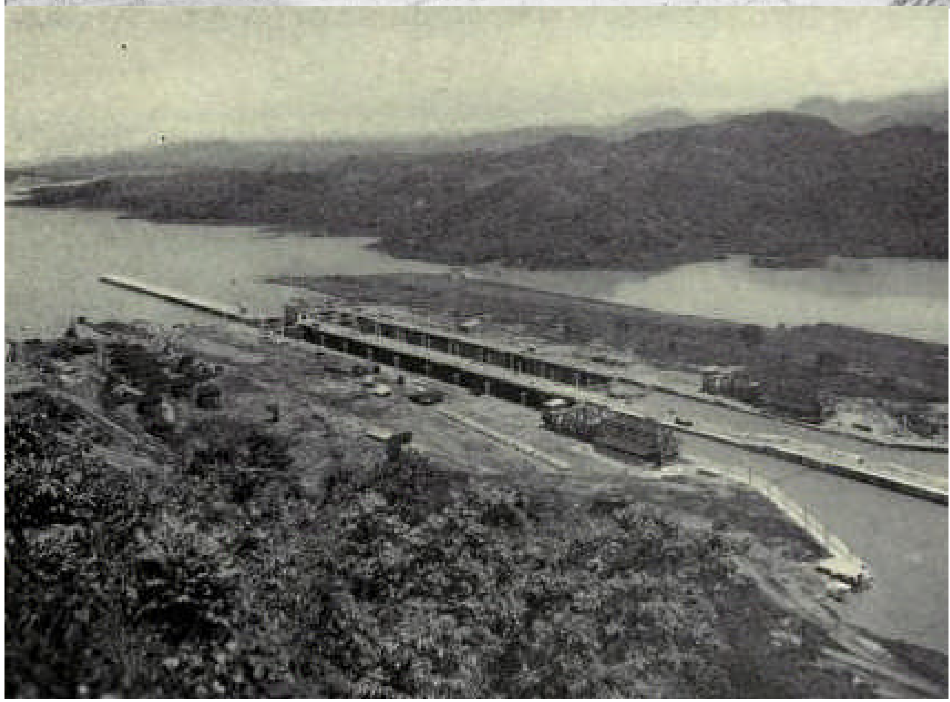
<u>Top Right</u>: caption: "From the intake, the surplus water will flow out through this 18 foot tunnel which passes through the solid concrete of the center lock wall"

<u>Left</u>: caption: "We have seen the overflow from Gatun Lake pouring over the Gatun Spillway. These outlets at Pedro Miguel take the overflow from the south end of the lake."



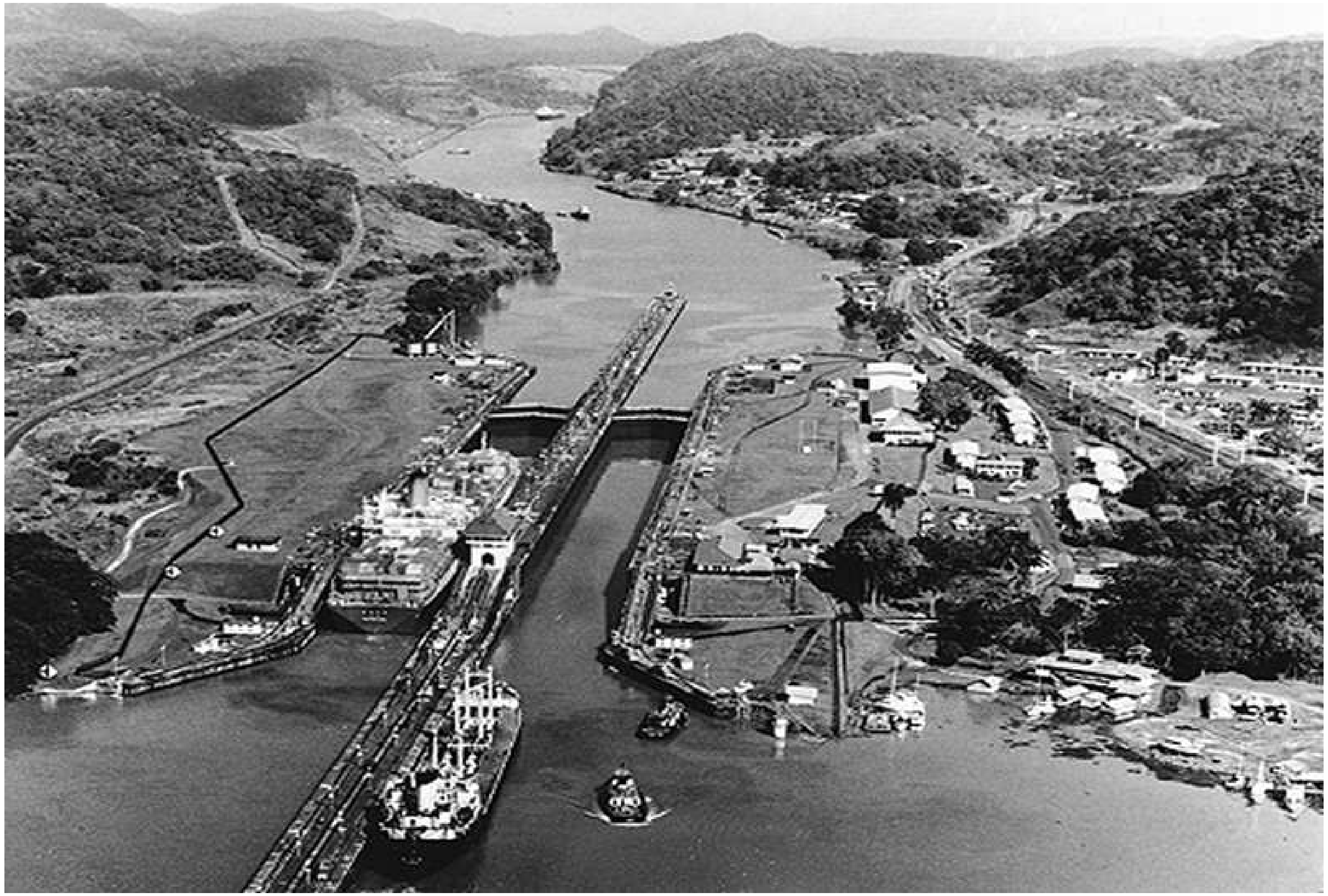


Above: caption: "Birds Eye View of the construction site at Pedro Miguel Locks, 1913"
Left: caption: "Pedro Miguel Locks. Showing center wall and intakes, looking North. In the upper right-hand corner are the great Berm Cranes used to carry the concrete from the mixers to the locks."



<u>Above L&R</u>: concrete mixer at work at the *Pedro Miguel Lock* work site
<u>Left</u>: caption: "The Pedro Miguel Lock"

<u>Above</u>: caption: "SS Advance arriving at Pedro Miguel Locks, going south on trip through canal. Attaching lines from towing locomotives, August 1914"

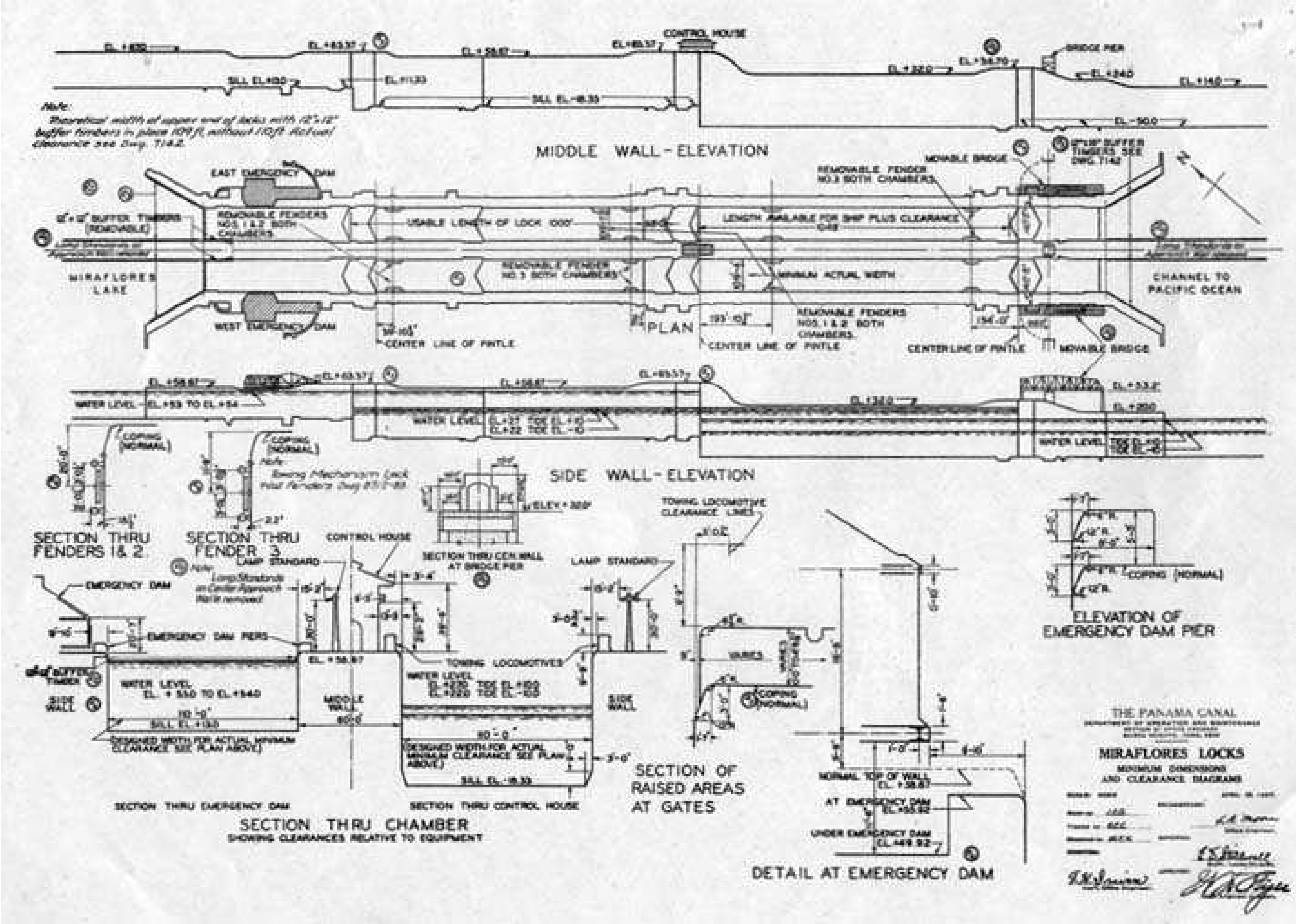



CANAL ZONE POSTAGE
25TH ANNIVERSARY 1939
OPENING PANAMA CANAL 1914
PEDRO MIGUEL LOCKS · AFTER
20
CENTS

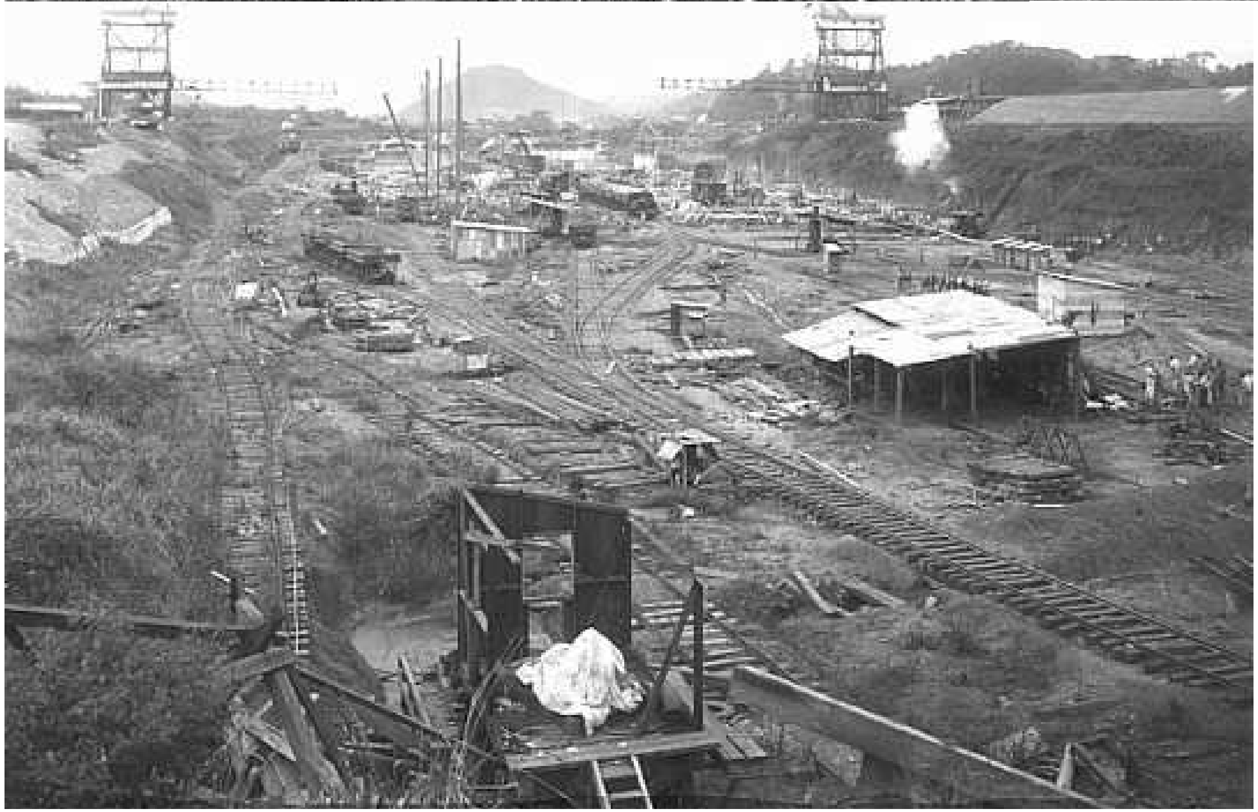
Miraflores

"…after steaming for a mile and a half through a small artificial lake, impounded by a dam at Miraflores, we reach the locks of the same name which drop us, in a single flight, down to sea-level on the Pacific side. About eight miles of steaming through the sea-level channel brings us to deep water on the Pacific side…"

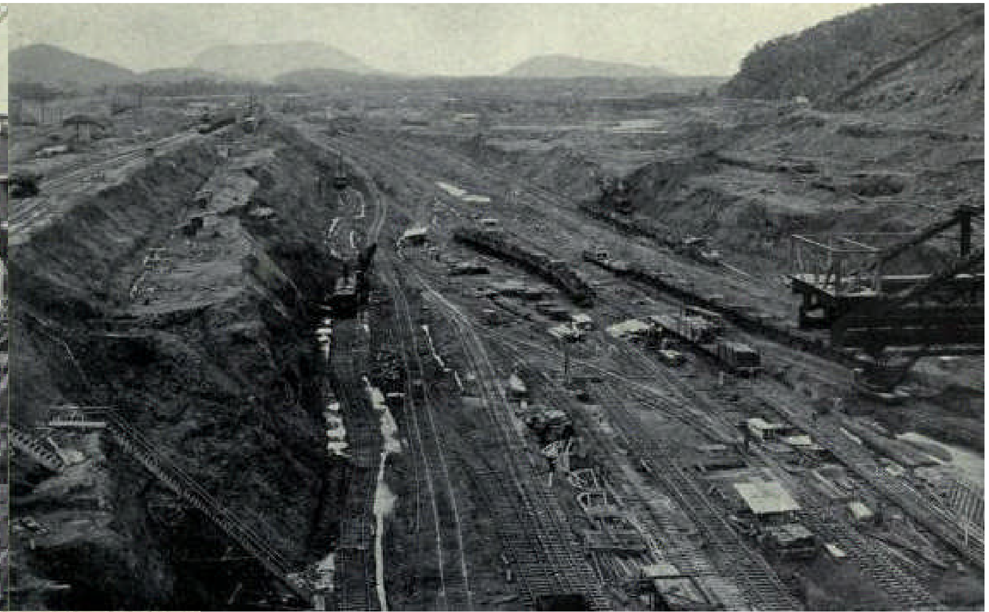
Scientific American Supplement, **November 23rd 1912**

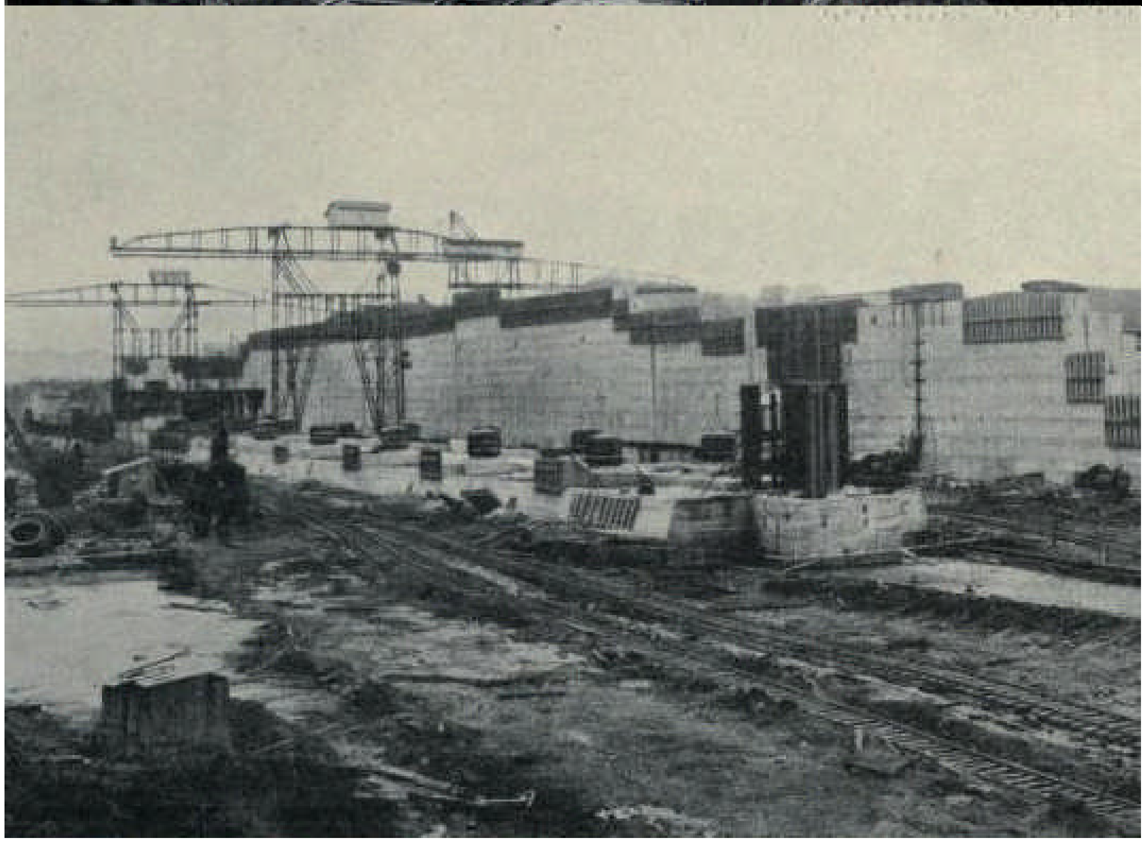


<u>Above</u>: *Miraflores* Locks Plan, Elevations & Sections



Top Left: caption: "Miraflores site before the Locks where built, 1907"
Top Right: caption: "Building the Miraflores Locks, 1908"
Left: caption: "Miraflores Upper Locks. General view looking North, November 1910."

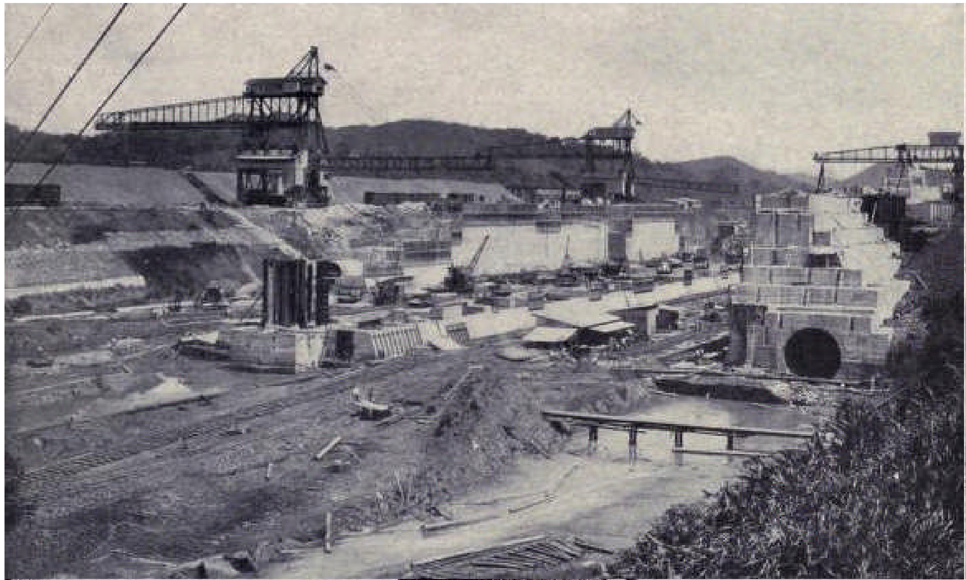


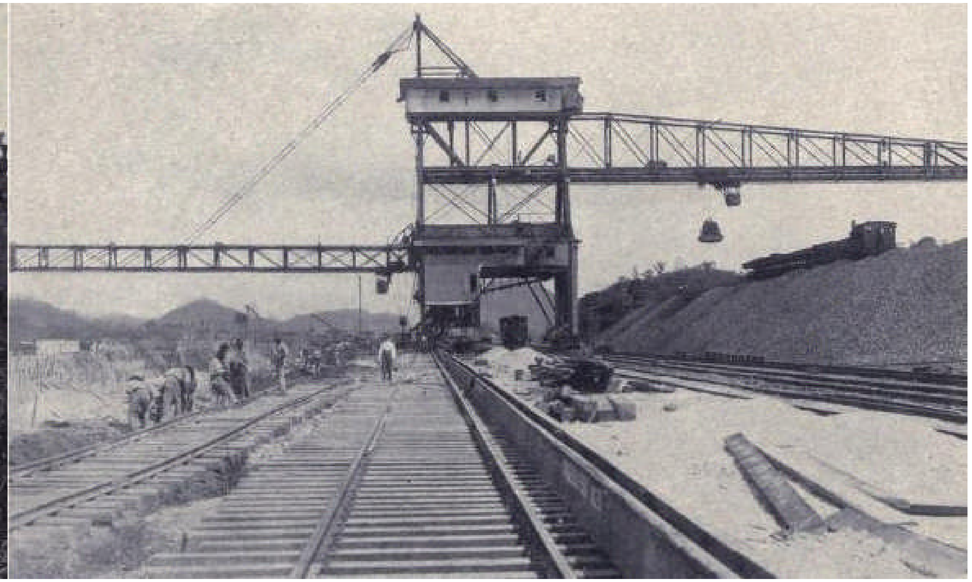


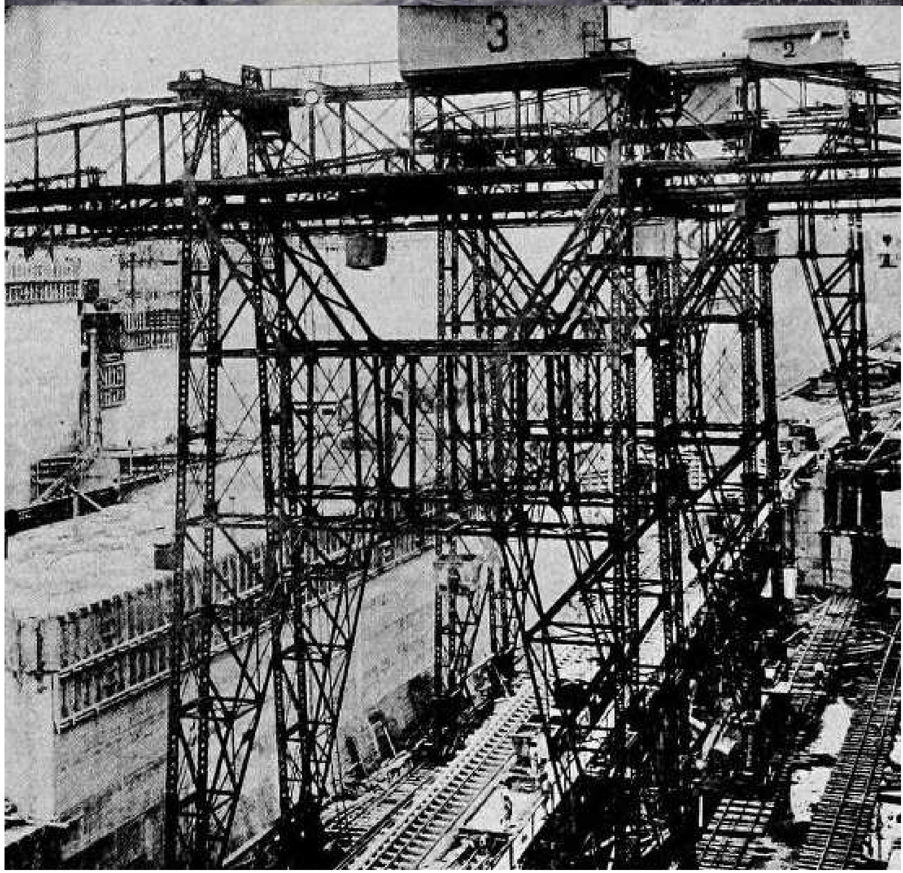
<u>Top Left</u>: caption: “At Gatun are three ‘Gates’ up to the level of Gatun Lake. At Pedro Miguel is one step down, and now here, at Miraflores Locks, two more which bring us down to sea-level again.”

<u>Top Right</u>: caption: “Now we look from the lower end of Miraflores Locks toward Panama City and the Pacific end of the Canal. From this point we are again at sea-level.”

<u>Left</u>: caption: “Miraflores Upper Locks. General view looking North fro lower West Bank, showing cylindrical valves, July 1911.”



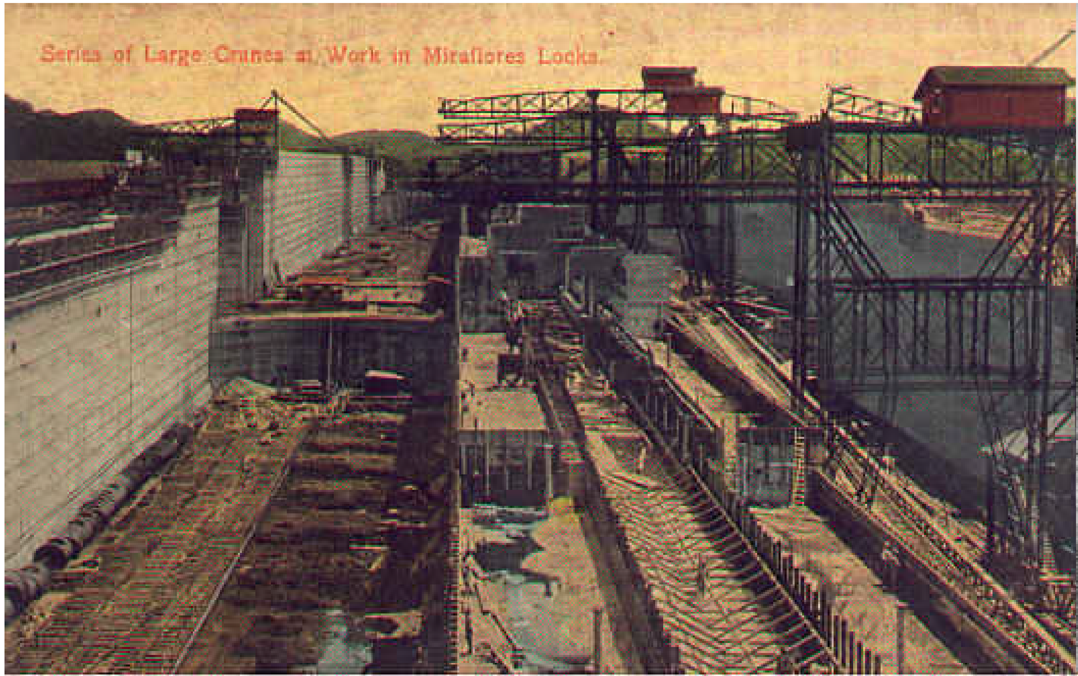


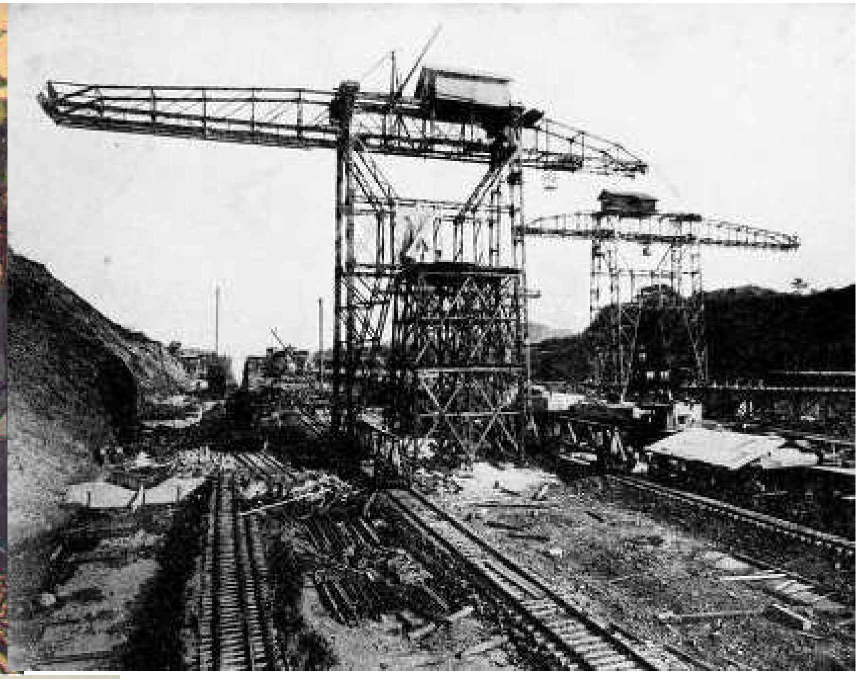


<u>Top Left</u>: caption: "Miraflores Upper Locks. General view looking North from Lower East Bank"

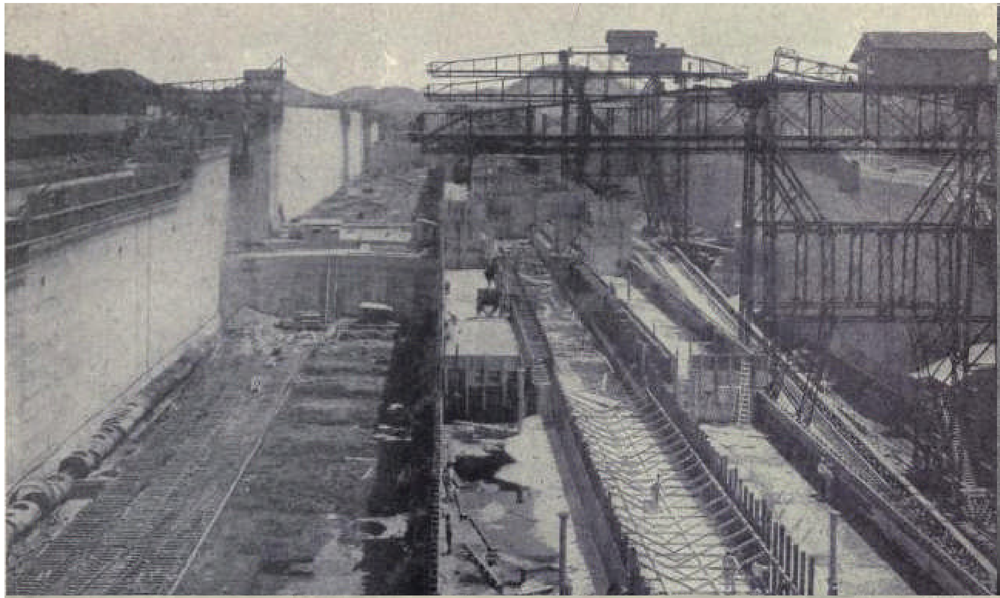
<u>Top Right</u>: caption: "A view of one of the Berm Cranes as they appear at Miraflores. They are used for mixing and conveying concrete."

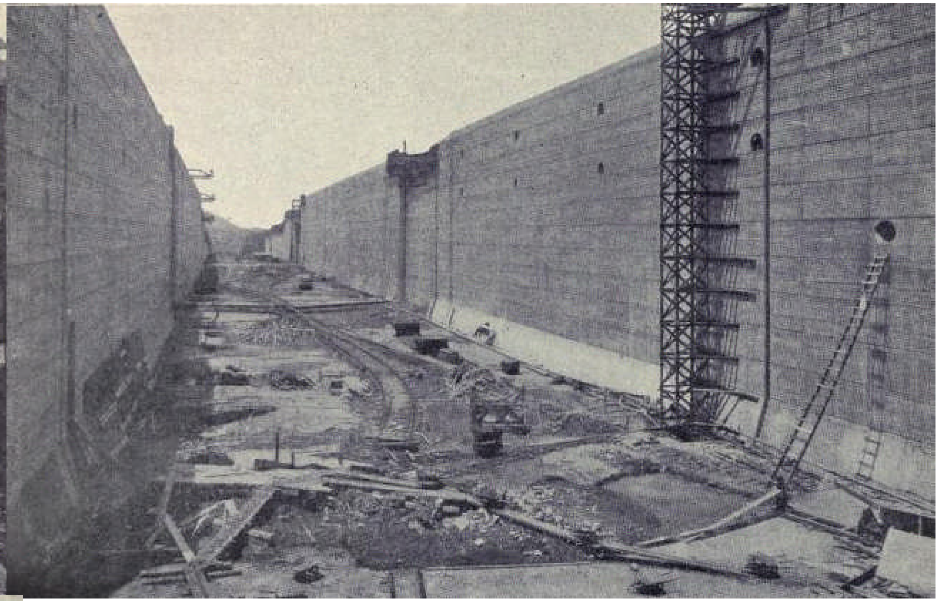
<u>Left</u>: caption: "Berm Cranes at Miraflores. These great cranes, which are movable on the tracks at the bottom of the picture, carry electric trolleys which transport the concrete from the mixers to the desired point on the lock walls."

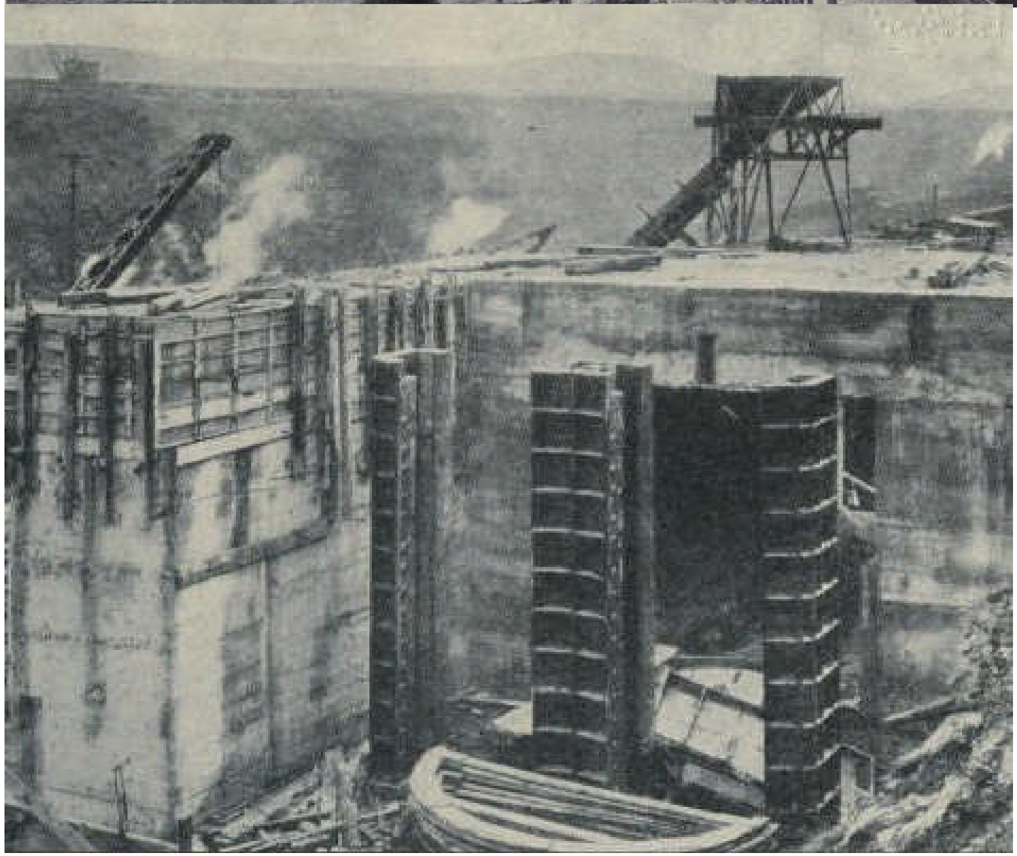




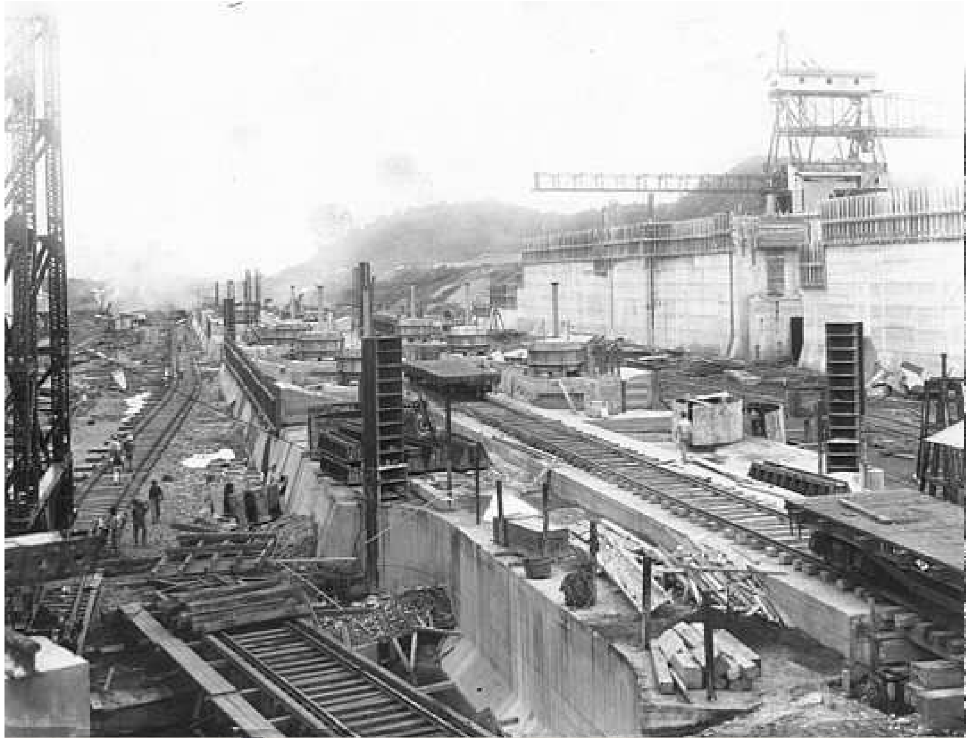

<u>Top Left</u>: (postcard) caption: "Series of Large Cranes at Work in Miraflores Locks"
<u>Top Right</u>: caption: "Traveling cranes that bear the brunt of burden carrying"
<u>Left</u>: caption: "Miraflores Locks. Sinking Caissons for foundation of North Approach Wall, June 1912."

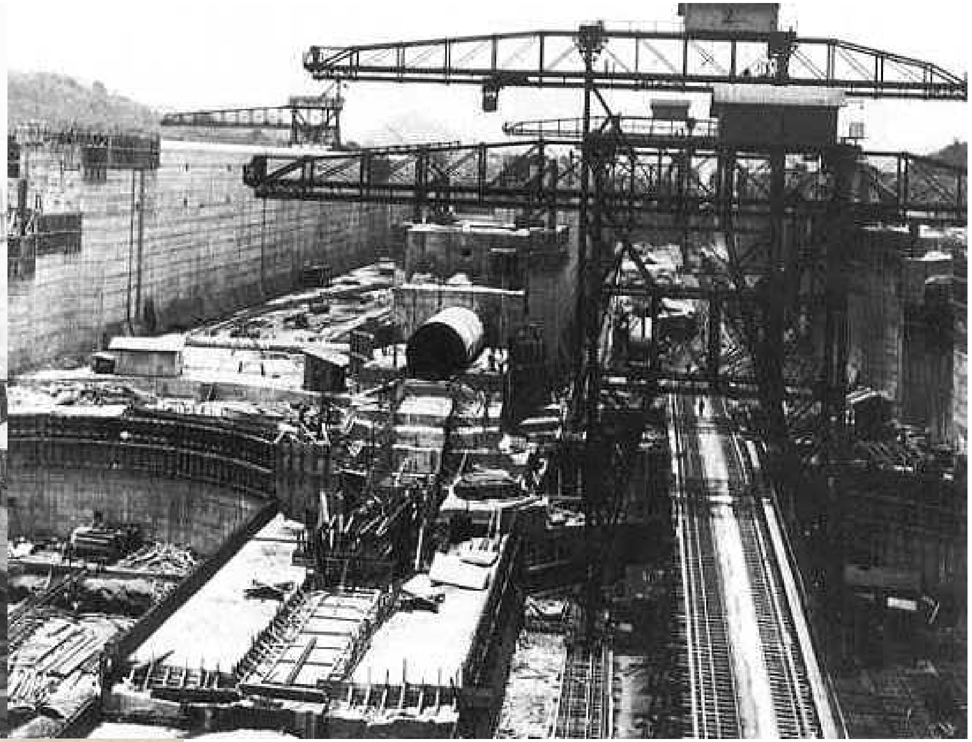


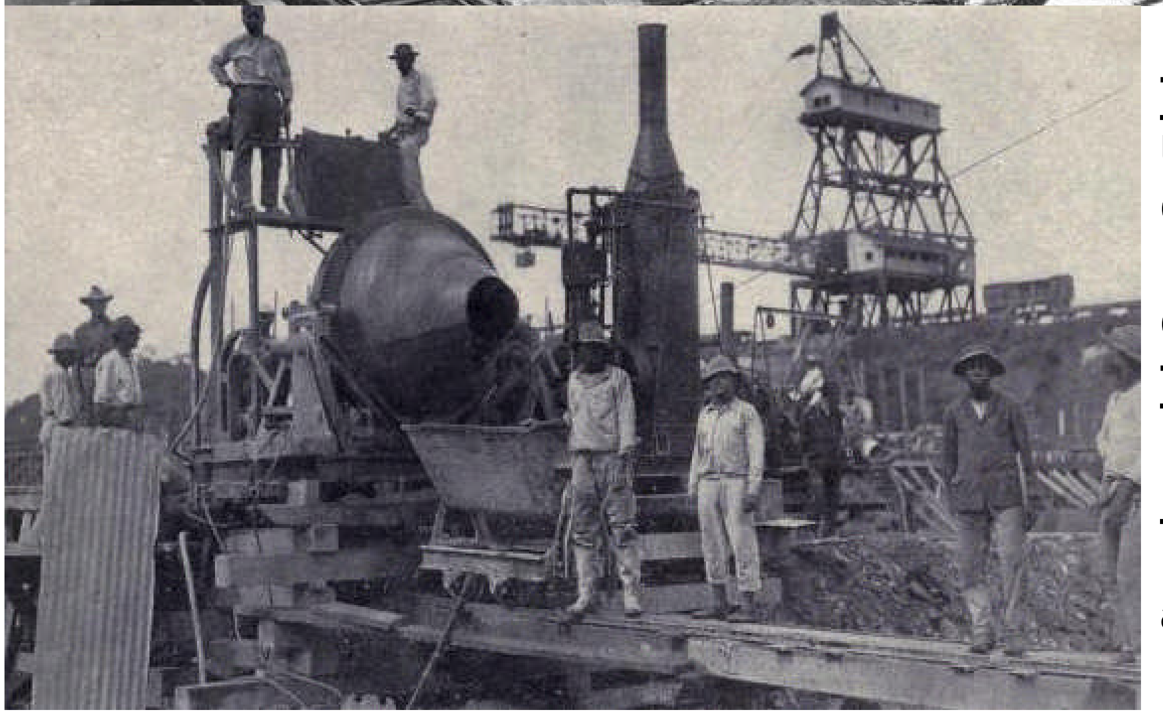




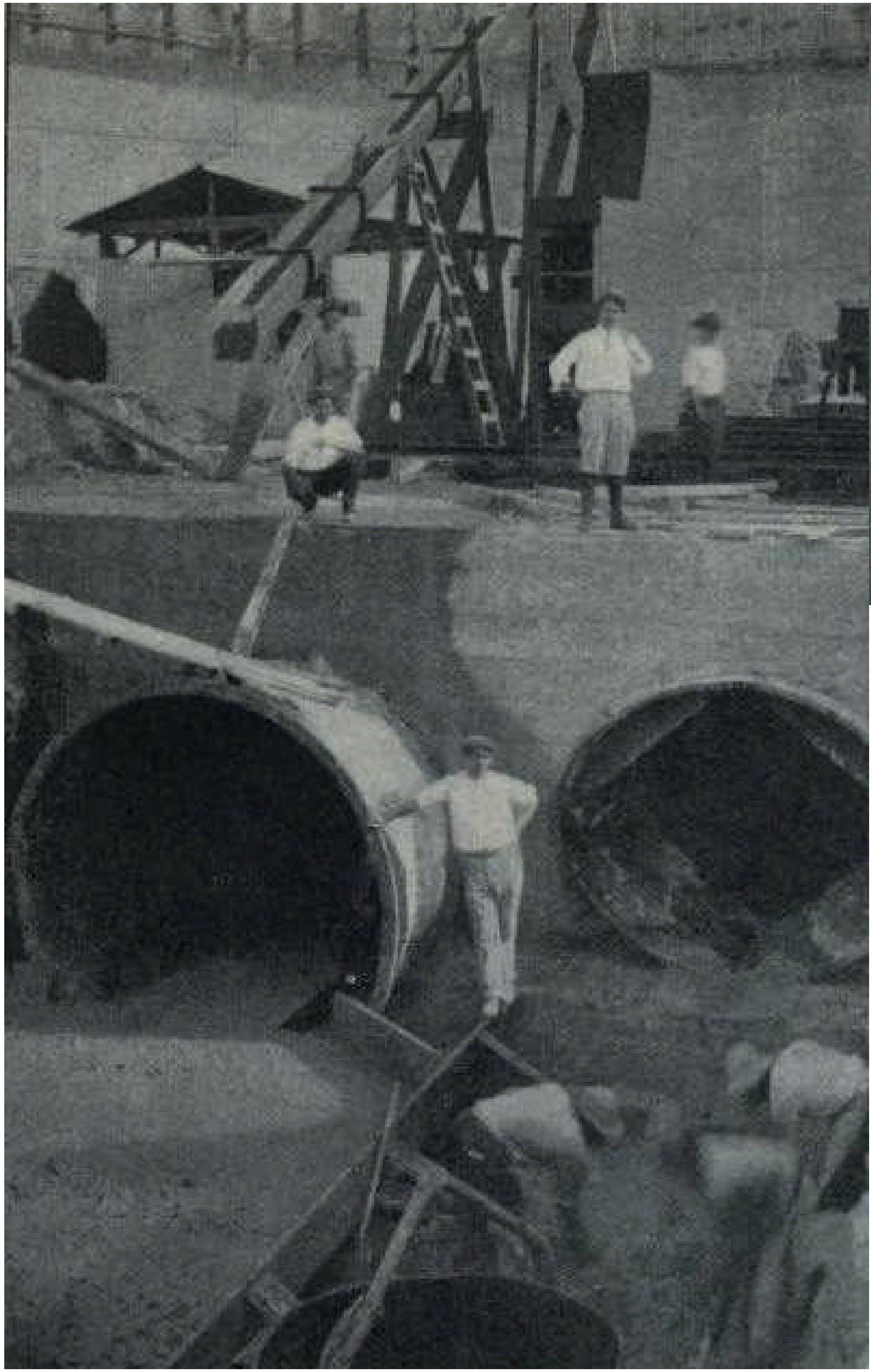
Top Left: caption: "Miraflores Locks looking North, June 1912"
Top Right: caption: "Miraflores Locks, West Chamber, looking South, June 1912"
Left: caption: "Miraflores Upper Locks. Showing Stoney Gate Valve frames in position in South end of West Wall, November 1911."

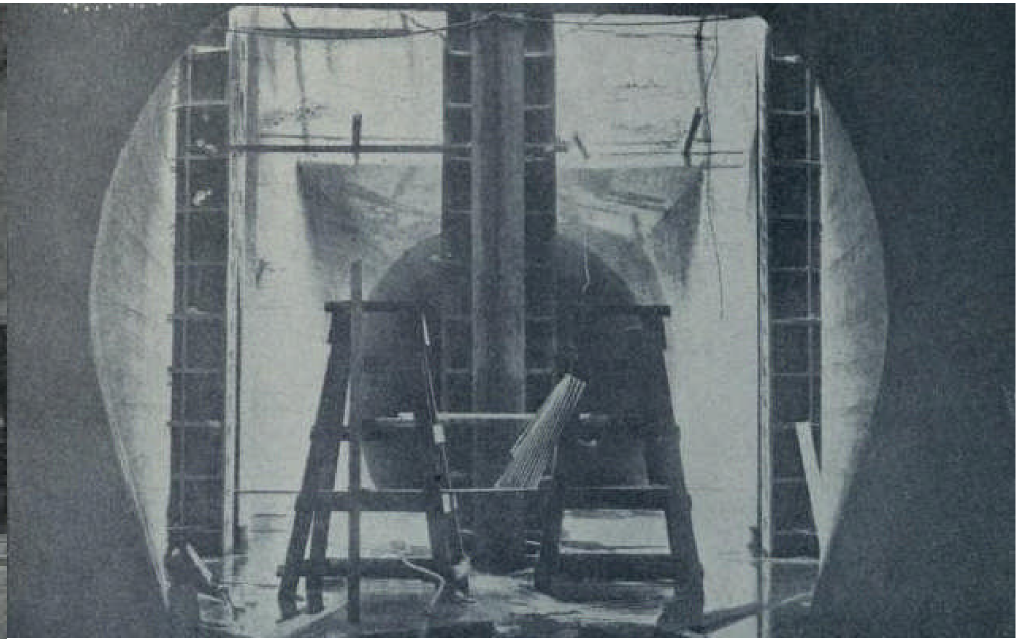




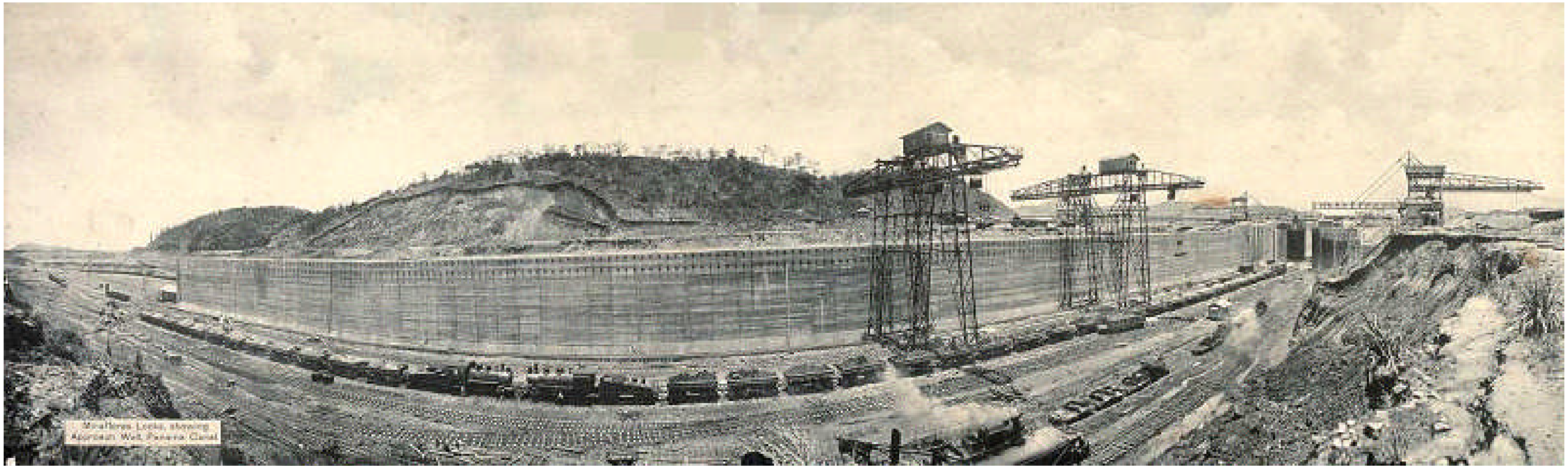


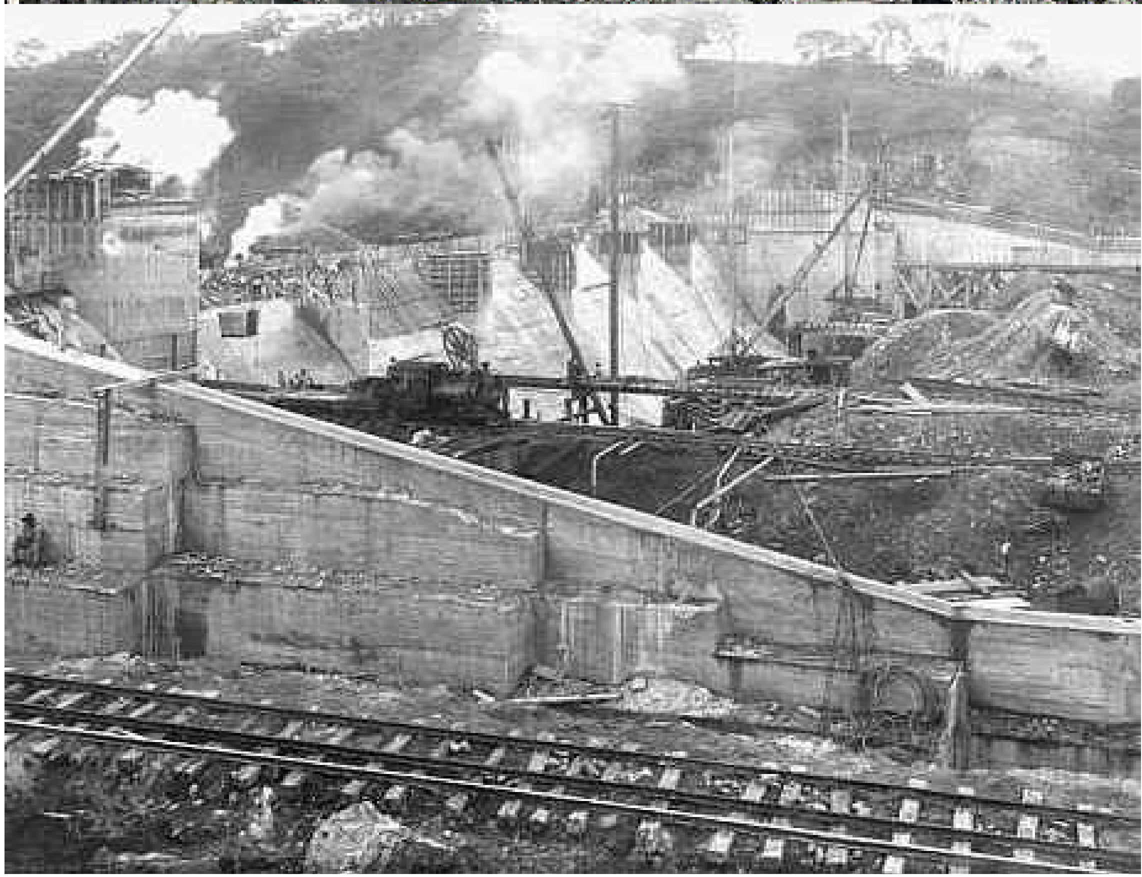
<u>Top Left</u>: caption: "Miraflores Upper Locks. Upper end of Center Wall, showing Gate Protection Castings and Cylindrical Valves, July 1911"
<u>Top Right</u>: caption: "Miraflores Locks Construction, 1912"
<u>Left</u>: caption: "Showing the portable concrete mixer in use at Miraflores Locks"





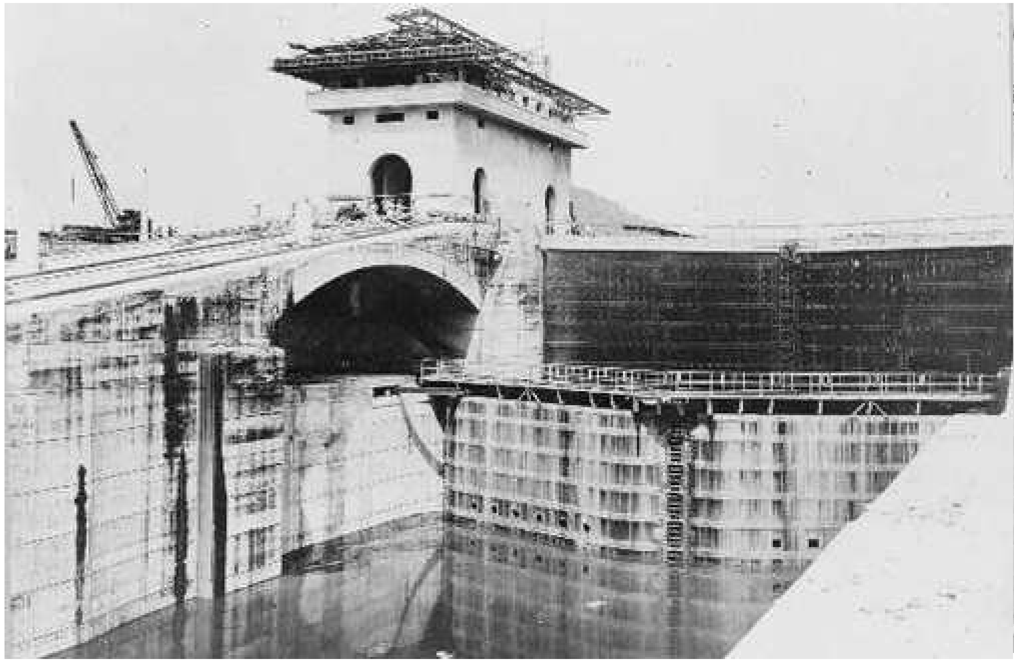
<u>Above</u>: caption: "Miraflores Upper Locks, Center Wall Culvert. Showing Stoney gate castings in place, June 1912"
<u>Left</u>: caption: "Miraflores Lower Locks, looking East. Electrical Conduit and floor culvrets at upper end of East Lock, January 1912."

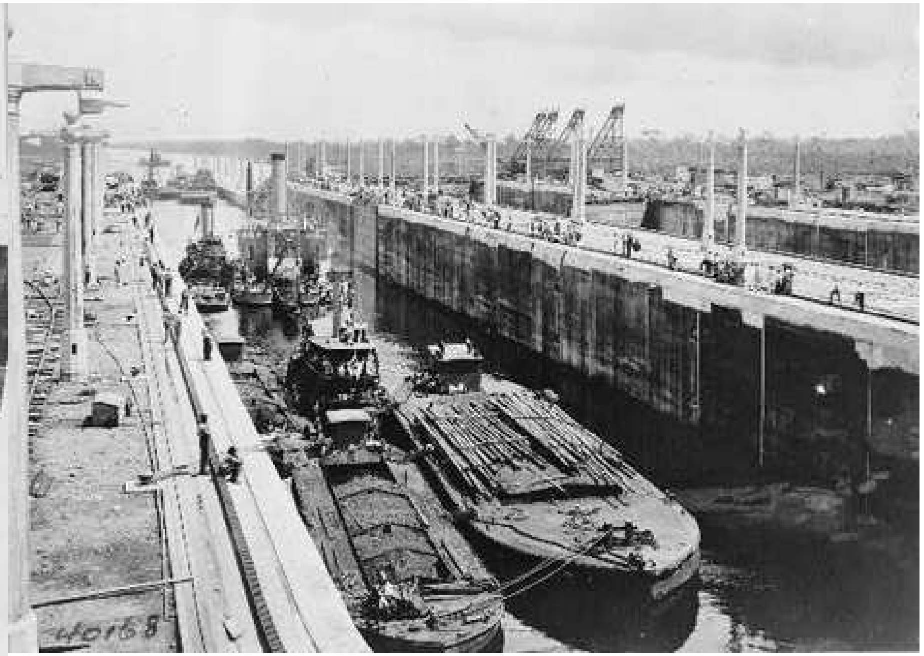




<u>Above</u>: caption: "Birds-eye view of the construction site at the Miraflores Locks, 1913"

<u>Left</u>: caption: "Miraflores Spillway Dam, view looking East from Locks, July 1913"



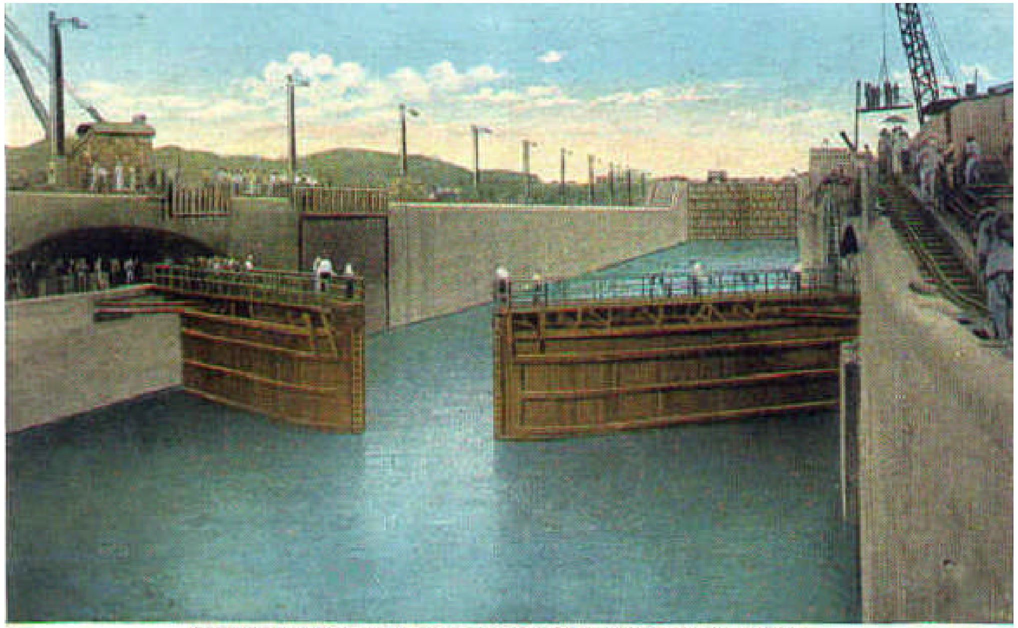


"…Water was first admitted to the Miraflores Locks on August 31, 1913, when the temporary dike that had kept the locks dry was blown up, and, on October 14, the tug 'Miraflores,' with three barges and two other vessels, was raised from the Pacific level to the surface of Miraflores Lake…"

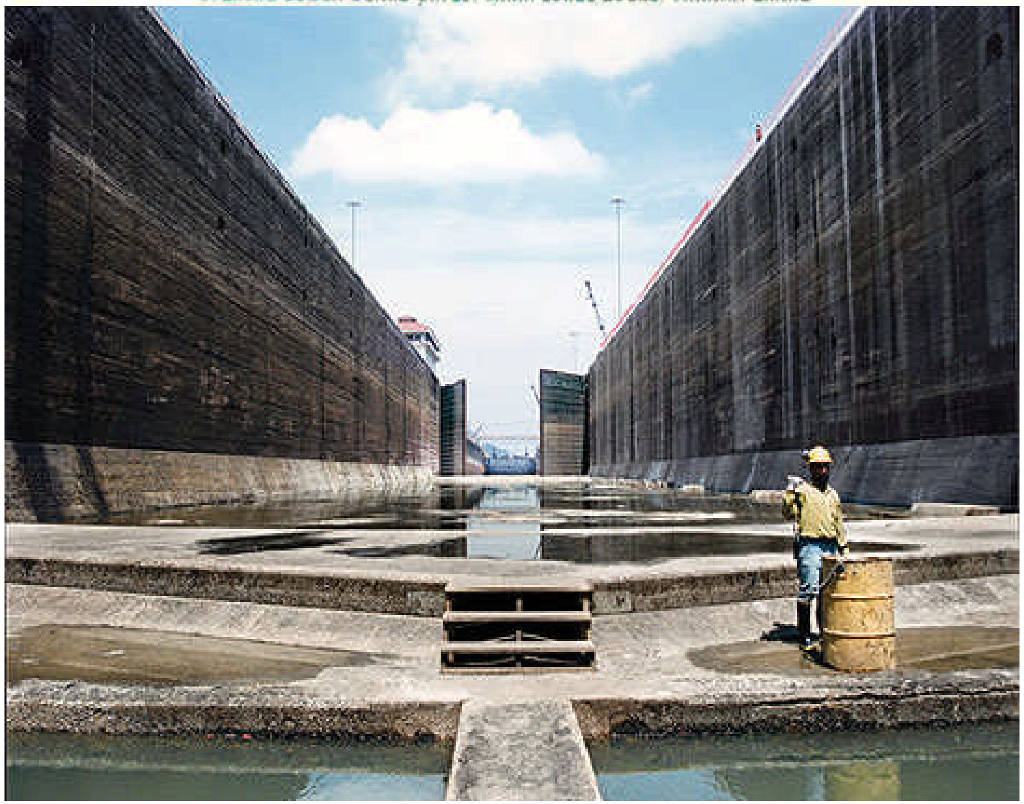
***Popular Mechanics,* December 1913**

Left: caption: "Miraflores Locks showing control house nearing completion and lock gates (in left) completed ready for passage of first ship"

Right: caption: "Tugs, dredges, and barges ready for first lockage up from Sea-level"



OPENING LOWER GUARD GATES, MIRAFLORES LOCKS, PANAMA CANAL



Approaching the Canal

"With the opening of the Panama Canal reliable charts of the Yucatan Channel, the Caribbean Sea, and the coasts bordering on these waters will become a necessity for the heavy shipping approaching and leaving the Atlantic terminus of the canal as well as for vessels engaged in coastwise trade. With this in view the United States government is already engaged in making extensive surveys of these waters, and as a result of the work carried out by the survey ship 'Hannibal,' the hydrographic office will be able to supply fruit steamers and other trading vessels with correct charts of the sea off the coast of Yucatan and the east coast of Central America. The 'Leonidas' is now being fitted up to take part in the work of surveying, which is to be prosecuted more vigorously than ever this year in preparation for the opening of the canal."

Popular Mechanics, **April 1914**

“In order to expedite the passage of ships through the Panama Canal, the authorities in charge are calling on ship masters to announce their approach by wireless. A general rule governing this point was posted with other regulations when the waterway was first opened, but according to recent advices it has not been closely followed. More than half of the ships crossing the Isthmus carry radio equipment, but only about a fourth of these have observed the practice of signaling their approach. Unnecessary delays and more or less trouble frequently result when the ships arrive at the portals unannounced. When their masters communicate with the canal authorities, on the other hand, sufficient time is allowed to prepare for meeting different problems and handling the traffic more smoothly than would otherwise be possible. There are few vessels equipped with wireless which would be unable to furnish advice of their probable time of arrival 24 hours in advance, if their masters were so disposed. Matter of this character is handled without charge at the government stations. At the present time 2,300 messages, most of them of this nature, are handled at the Colon plant and some 400 communications at Balboa…”

Popular Mechanics, December 1915

The Zone of Control

“…Regulations for the operation and navigation of the canal have been promulgated, and cover in every detail the behavior of all ships from the moment they arrive in port at either terminus until they leave the zone of control on the opposite side of the Isthmus. After entering one of the terminal ports no vessel is permitted to leave, either for the canal or the ocean, without being given authority to do so. It is within the power of the officials to deny passage to any vessel, or hold it for investigation, if its sanitary condition is questionable or the status of its cargo, hull, or machinery such as might endanger or obstruct the canal. Craft carrying explosives or inflammable oils are expected to seek permission for passage before leaving ports of departure, and such ships, while crossing the Isthmus, must display red flags by day and red lights at night. Each ship must take on a government pilot to direct the course through the canal. Responsibility for accidents resulting from a refusal to follow his advice is placed upon a ship’s owners or representatives. All radio apparatus is entirely under control of the canal authorities throughout a voyage. It may be used for canal business, must have an operator in attendance constantly, and must not interfere with the canal radio stations. Excepting while plying the waters of Gatun Lake, ships may not proceed faster than 6.9 miles an hour. Unnecessary whistling, the discharge of firearms, ‘cross-signaling,’ the general use of searchlights, the pollution of the canal waters, and the failure to disclose anything pertaining to a ship or its cargo which might cause trouble to either it or the canal, are prohibited. A steam vessel proceeding under sail carries a black ball 2 ft. in diameter, forward; and seagoing suction dredges, when under way and dredging, carry two black balls of the same size…”

***Popular Mechanics,* November 1914**

"…The maximum speed at which vessels are allowed to pass through the canal varies from 6.9 miles an hour, in Culebra Cut and Miraflores Lake, to 17.25 miles an hour over a part of Gatun Lake."

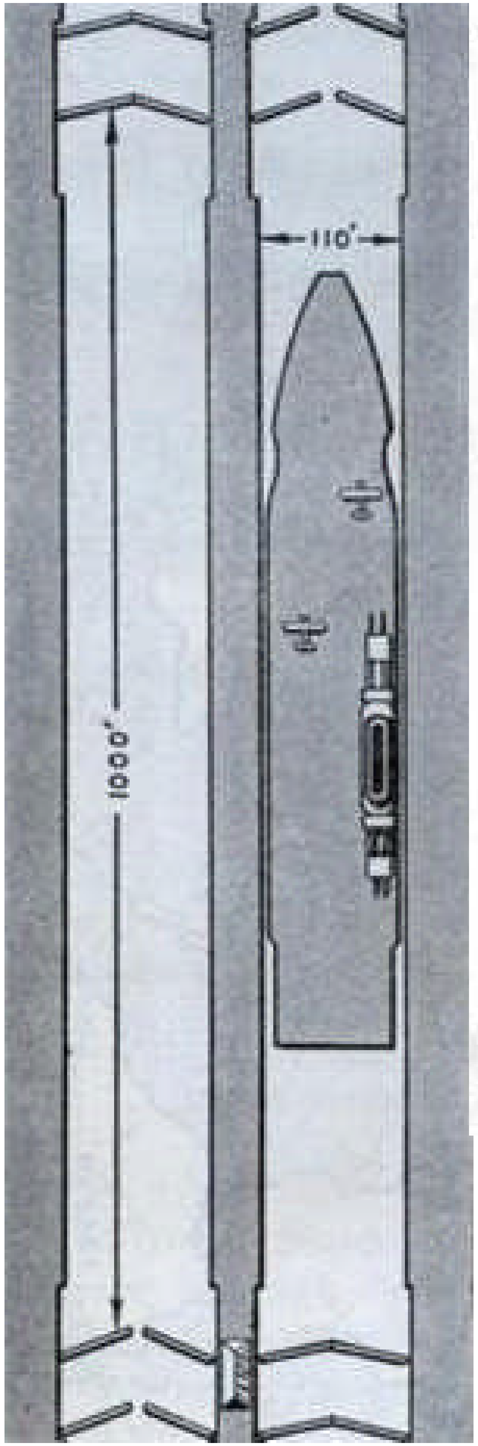
***Popular Mechanics,* May 1915**

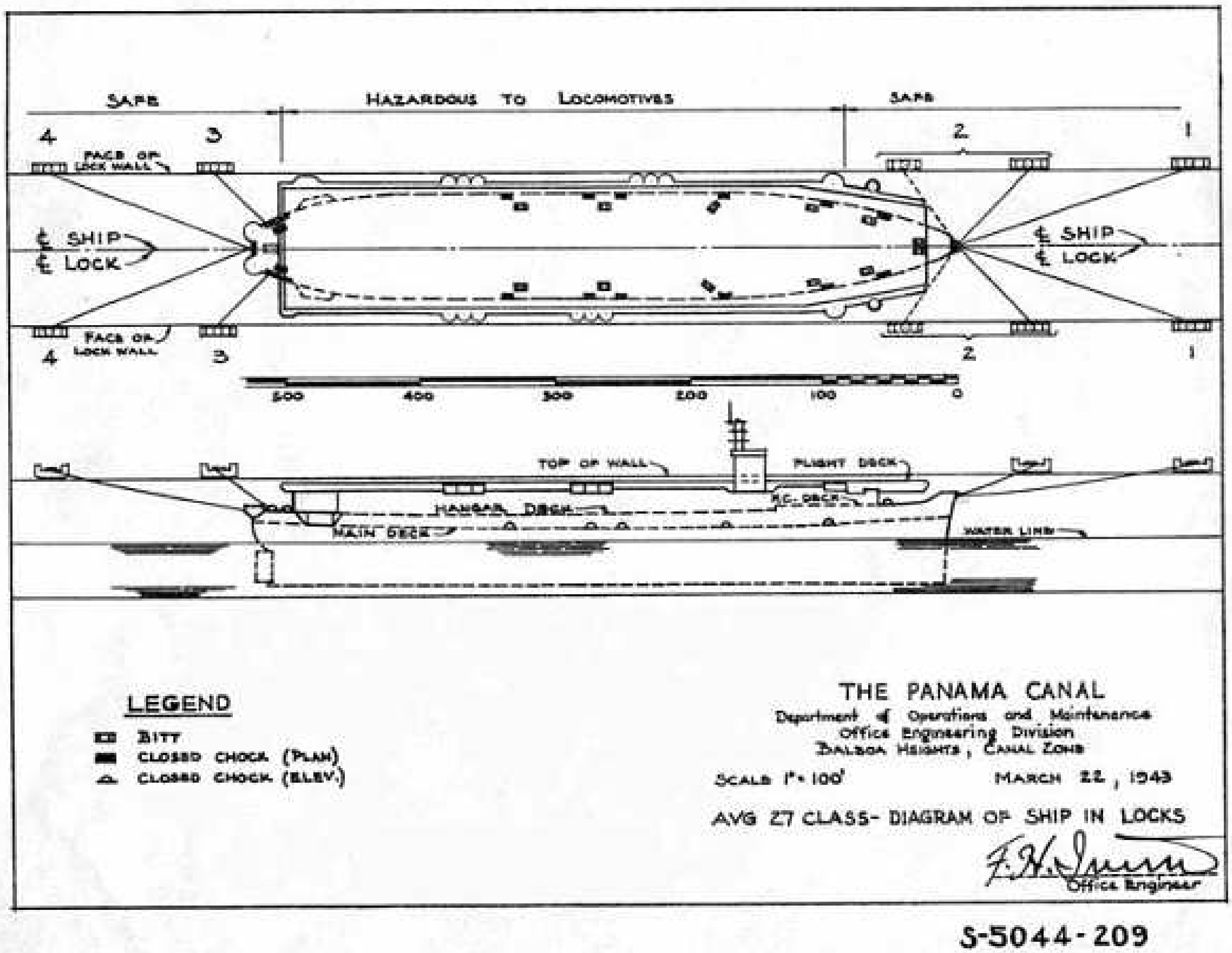
Transit Clearances

TRANSIT CLEARANCES FOR U. S. NAVAL VESSELS
GENERAL DISCUSSION
Aircraft Carriers

The transiting of aircraft carriers is the most complicated problem of this nature confronting the Panama Canal. Overhanging flight decks, galleries and gun sponsons on some of these ships in combination with recent protective works at the locks impose limits upon the ship's draft and require special conditions of lake and tide levels to insure adequate vertical clearances. These overhangs also present the hazard of contact with surface installations at the locks, including control houses, emergency dams, lamp posts and towing locomotives. The sides of these ships below the flight decks have numerous platforms, booms and other appurtenances of relatively frail construction which are subject to damage and present a hazard to the lock gates in passing, being difficult to fender in an adequate manner. Special features of the design require that certain of these vessels be towed off-center of the lock chamber, introducing unbalanced lateral forces of indeterminate magnitude which complicate the problem of control. The Chief Pilot is located in such a position that he cannot see the locomotives or the lock walls and he must rely on relayed information and must in turn relay his directives. Breadth of beam at or near the water line is at present a factor in the case of the Saratoga only, which must be handled much like a battleship. However, in most cases the net horizontal clearances at the level of the main batteries are so small that some contact with the lock walls must be expected during transit. The towing locomotives under individual manual operation cannot exert positive control over the lateral movement within such narrow limits, and it is very difficult to judge the ship's position with the required degree of accuracy. The most critical point of the transit is generally the south end of Pedro Miguel Locks, where the lock entrance, control house and greatest height of lock wall above the water occur in combination. These ships are hazardous at almost all points in the locks, however, and extraordinary vigilance must be employed at all times to keep them under a fair degree of controls. Experience indicates that the use of slow speeds, not to exceed one mile per hour, during lockages will contribute to better control and help to reduce the extent of damage from contact. The improvement of chock and bitt installations in the stern of some of these ships will enable better control by the towing locomotives and will allow the locomotives to be placed in safer positions. Damage can be reduced measurably by adequate stripping and fendering of the ship prior to transit.

RE: National Archives & Records Administration, Formerly Classified Ship Files 1942-53





Above: caption: "AVG 27 Class – Diagram of Ship in Locks"
Left: caption: "This drawing shows how the Panama locks limit the size of Naval vessels"

"Speaking of pilots, the most difficult ships they have to guide in and out of harbors are the Naval aircraft carriers. It's chiefly because their island bridges are off to one side of the flight deck, instead of dead center, making it awkward to judge the true fore and aft centerline. The problem is so acute that, when one is going through the Panama Canal, a temporary wooden scaffold is built on the deck's centerline and connected to the ship's bridge by telephone. The canal pilots give their orders to a talker in the wheelhouse and the entire operation is thus carried out by remote control."

***Popular Mechanics,* October 1960**

<u>Left</u>: over-head view of the aircraft carrier *Philippine Sea* passing through the Panama Canal Locks in 1946


U.S.S. Ranger entering Miraflores Locks - Panama Canal

Battleships

The problem of transiting the larger battleships is considerably less involved than in the case of aircraft carriers. There are no overhanging projections to introduce the complications of limitations on draft, water and tide levels; position in the lock chamber; and danger of contact with surface installations. In seaworthy condition these ships can transit at all normal lake and tide levels with almost equal facility. The principal difficulties are caused by the extreme breadth of these ships at or near the water line, which approaches the clear width of the lock chamber. Horizontal clearances are so small that the towing locomotives do not have complete control over lateral movement. Consequently these ships will inevitably rub against the lock walls at intervals during transit. Damage resulting from this contact will vary with the individual ship. The most critical points of the lockage are the entrance and departure, when the ship passes the knuckle of the wing wall, and much of the damage will probably be sustained at these points. The use of slow speed, not to exceed one mile per hour, will help to avoid or to reduce the extent of damage. The installation of adequate chocks and bitts in the exact stern of some of these ships will improve the control exerted by towing locomotives.

RE: National Archives & Records Administration, Formerly Classified Ship Files 1942-53

<u>Above</u>: caption: "This floating dry dock was so wide it had to be tipped on its side and welded to pontoons to pass through the canal"

The Port Captains

“A wall board, 12 ft. long and 3 ft. high, on which is painted a map of the Panama Canal and its approaches, has been mounted in the Port Captains office at each end of the canal, and push pins, each representing a ship, will be used in connection with this map for showing at a glance the status of traffic at any time. As soon as a vessel enters either end of the canal a report is telephoned to each port captain’s office. A pin representing the vessel is then placed on the map, and as the vessel passes the different locks and Culebra Cut the pin is moved to the corresponding positions…”

***Popular Mechanics,* May 1915**

“Two chronometers for the use of the Panama Canal have been placed in the offices of the captain of the port of Cristobal, and will be used in furnishing ships passing through the canal with standard time for the 75th meridian west.”

Popular Mechanics, **April 1915**

“Telegraph lines, a sending and a receiving radio station, and a telegraph operator are among the means used in transmitting daily the correct time from Washington D.C., to the Panama Canal for the purpose of correcting the chronometers in the port captains offices and on incoming ships. Absolutely correct time cannot be ascertained by this means, there being a variation of about one-tenth of a second. Correct time is highly important for a vessel, because in making observations of heavenly bodies, a variation of one second means an error of about one-fourth of a nautical mile in location. This time signal is sent by wire from Washington to Key West, whence a relay transmits it by wireless. The Darien wireless station in the Canal Zone in turn transmits the signal by ordinary telegraph to the port captain’s offices. The signal is sent from Key west in a series of dots. Five minutes before noon the wireless begins counting off the seconds by dots. After the twenty-eight second there is a pause, the twenty-ninth dot being omitted; similarly there is a pause from the fifty-fourth to the sixtieth second. The count is resumed exactly on the minute. This procedure is kept up until 10 seconds before 12 o’clock, when there is a pause followed by a long dash at exactly 12 o’clock. The aerial transmission is recorded at Darien by a current too slight to permit ordinary electrical relaying. Consequently an operator with a wireless receiver at his ears sends dots through an ordinary telegraph wire to the port captains. With practice he can strike the dots on his sending key in almost perfect synchronism with the dots received. The principal difficulty is in sending the final dash after a wait of 10 seconds. Here the human brain fails to act instantaneously, the tests showing that the lag is between two-tenths and three-tenths of a second. By making allowance for this lag the chronometers in the Canal Zone can be adjusted to within about one-tenth of a second of the correct time. Arrangements are being made to install a clock at Darien which will transmit the time exactly as received from Key West.”

Popular Mechanics, April 1916

For the Welfare of Navigators

"…The canal radio stations are performing quite an interesting service which is probably not generally known outside of commercial and shipping circles. Each afternoon at 3:30 o'clock the Colon station sends out general news bulletins which are picked up by vessels in various parts of both oceans. At noon weather predictions relating to the Caribbean, South Atlantic, and Gulf regions are also broadcast. Information concerning the position of dangerous derelicts, and other matters pertaining to the welfare of navigators, is filed at regular intervals."

***Popular Mechanics,* December 1915**

Part 7

A Path Between the Seas

Marking the Trail

“Ships which do not draw than 30 ft. of water nor register more than 30,000 tons are now permitted to pass through the Panama Canal from ocean to ocean. The steamship ‘Ancon,’ of the Panama Railroad line, on August 15 sailed through the canal, marking the trail for the world’s commerce. Aboard the vessel, which from its foremast, floated the flag of peace, were Colonel Goethals, the builder of the work and governor of the zone, and guests and officials of the administration…Although the canal has been officially opened to traffic, its formal opening will not take place before next spring. The ceremony which was marked by the passage of the ‘Ancon’ was merely local in character. While vessels of not more than 10,000 tons register are given entrance now, it would be possible to pass the super-dreadnoughts of the United States Navy, were it necessary. The condition at Cucharacha slide has been sufficiently remedied so that no difficulty is experienced by a ship in passing it. At the time of the passage of the ‘Ancon’ it would have been physically possible to have sent two or three vessels abreast through the narrowest part of Culebra cut…”

***Popular Mechanics,* November 1914**

With the end of construction, the *Panama Canal* team began to disassemble and go on to other things. Thousands of workers were laid-off, townsites were abandoned and/or moved with hundreds of buildings disassembled or demolished. Dr. Gorgas resigned from the canal commission to help fight pneumonia among workers in the South African gold mines, after which he was made *Surgeon General* of the *U.S. Army*. Effective April 1st 1914, the *Isthmian Canal Commission* ceased to exist and a new administrative entity; the *Canal Zone Governor*, was officially established. Colonel Goethals became the first Governor of the Panama Canal. Plans were made for a grand celebration to mark the official opening of the Panama Canal. A fleet of international warships was to assemble off *Hampton Roads* on New Year's Day 1915, then sail to *San Francisco* through the Panama Canal, arriving in time for the opening of the *Panama-Pacific International Exposition*; a world's-fair type celebration of the canal's opening. Although the Panama-Pacific Exposition went on as planned, the breakout of the European War within a fortnight of the Ancon's transit through the canal forced cancellation of the planned grand festivities. The Panama Canal cost America approximately $375 million, including the $10 million paid to *Panama* and the $40 million paid to the French canal company. It was the single most expensive construction project in U.S. history up to that time. Fortifications cost an extra +/-$12 million. The canal had cost less than estimated, with the final figure about $23 million below the 1907 estimate, this in spite of all the landslides and a design change to a wider canal.

Freight-Rate Reduction

"One of the effects of the opening of the Panama Canal upon the internal commerce of the United States is already being seen in the freight-rate reduction on dried goods and canned fruits. Against the rail charge of 100 cents per hundredweight on dried fruits shipped from Portland and Seattle to New York City, the new water rate will be will be 37.5 cents, to which is added dockage, lighterage and insurance costs, bringing the amount up to about 40 cents. This will mean a saving of approximately $160 on every carload of dried fruit sent by water. The same initial rate applies to canned goods, which will mean a saving of approximately $140 a car load to shippers."

Popular Mechanics, **November 1914**

Marking the Occasion

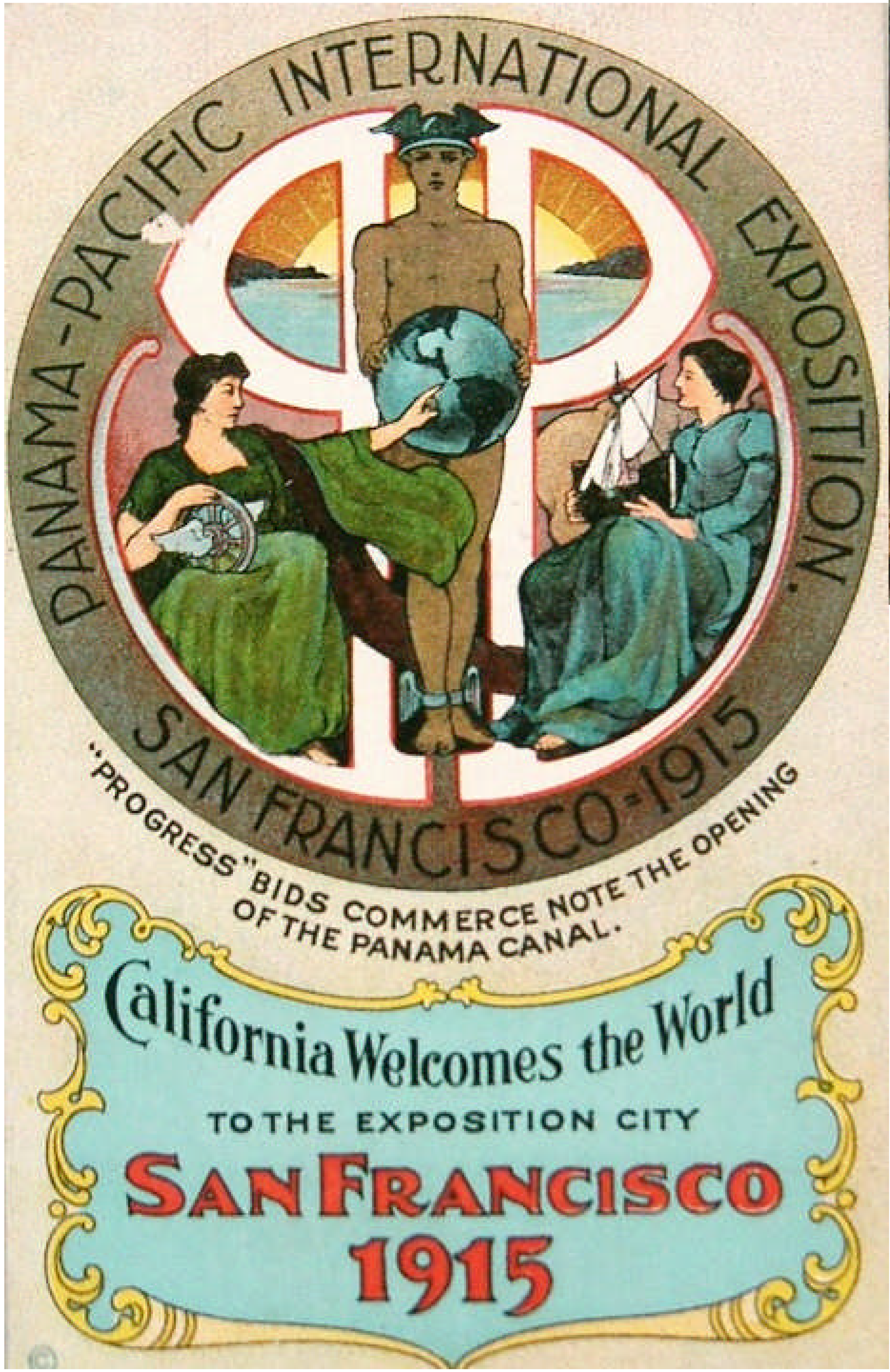
"In commemoration of the opening of the Panama Canal a special series of postage stamps has been issued and placed on sale at the different offices in the Zone. The stamps are made by the Republic of Panama in accordance with an agreement by which that country furnishes the stamps used in the Canal Zone postal service and in return receives 40 percent of their face value. They are printed in denominations of 1, 2, 5, and 10 cents. The one-cent size is green and carries a map of the canal; the two-cent kind red, with an engraving of Balboa at the Pacific Ocean; the five-cent variety blue, and bears a picture of the Gatun Locks, and the ten-cent class orange, and shows a view of Culebra Cut."

***Popular Mechanics,* July 1915**

Panama-Pacific

The *Panama-Pacific Commemorative Series* was a set of four stamps issued in celebration two world-changing events: the 400th anniversary of the discovery of the *Pacific Ocean* and the completion of the *Panama Canal*. The series comprises four denominations, 1, 2, 5 and 10-cents, all of which were first placed on sale in January 1913. They were issued to publicize the 1915 *Panama-Pacific International Exposition* held in *San Francisco*, *California*.

The *Panama-Pacific International Exposition* was a world's fair held in *San Francisco, California* between February 20th and December 4th 1915. Its ostensible purpose was to celebrate the completion of the *Panama Canal*, but it was widely seen in the city as an opportunity to showcase its recovery from the devastating 1906 earthquake. The fair was constructed on a 635 acre site in the area of San Francisco (part of the *Presidio*) now known as *The Marina*. The subsequent high price of land in this area, combined with the fact that the exposition buildings were constructed from temporary materials, meant that almost all the fair's various attractions were later taken down. The only surviving building is architect Bernard Maybeck's *Palace of Fine Arts* (outlined).



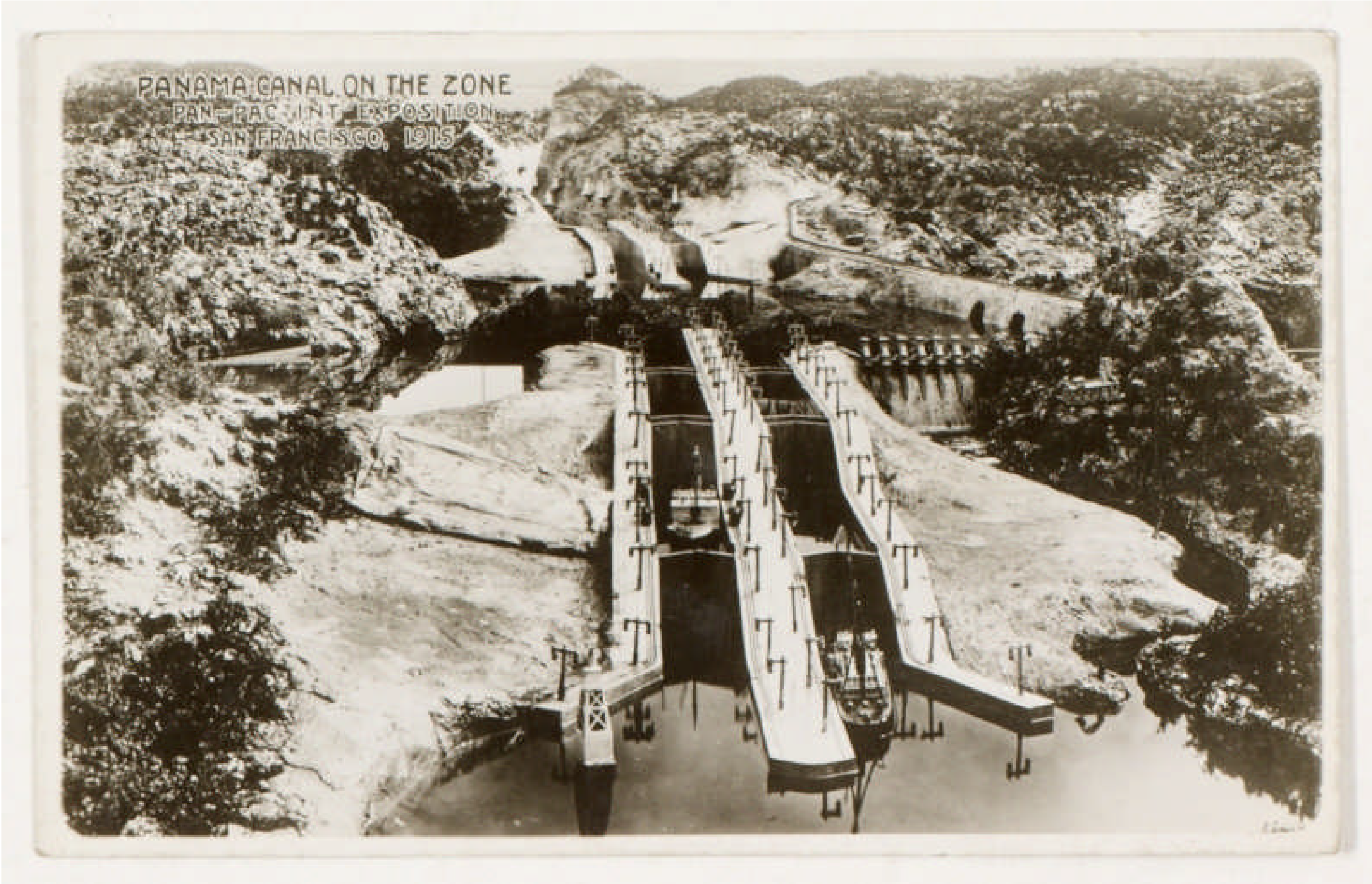
"I have seen tonight the greatest revelation of beauty that was ever seen on this Earth. I may say this meaning it literally and with full regard for all that is known of ancient art and architecture and all that the modern world has heretofore seen of glory and grandeur. I have seen beauty that will give the world new standards of art, and a joy in loveliness never before reached."

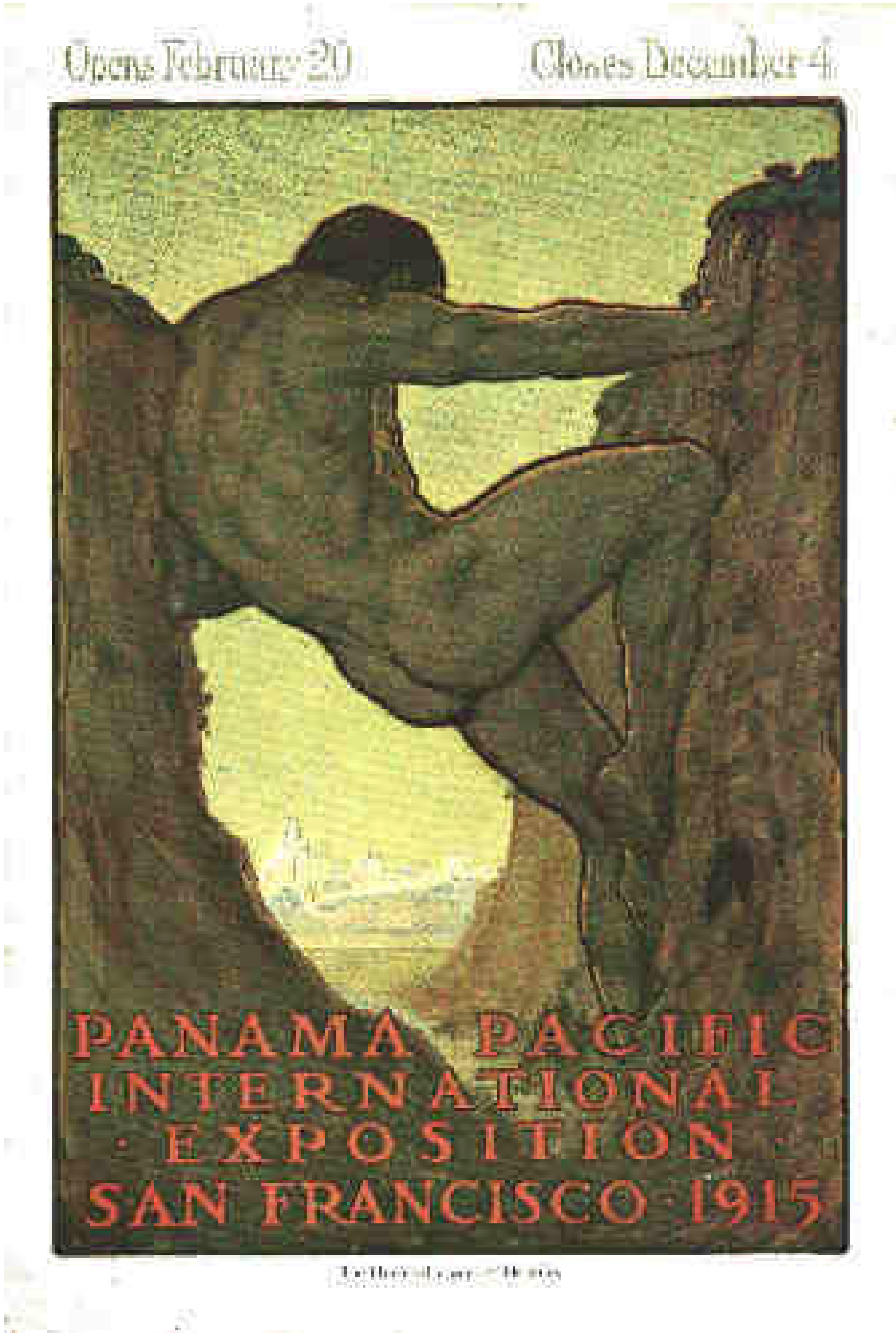
Edwin Markham, **Poet**

"By means of a model that represents its big original so faithfully that even such details as the shanties built for the watchmen are accurately shown, it is possible for visitors at the Panama-Pacific Exposition to obtain as comprehensive a view of the Panama Canal as can be obtained from an inspection of the canal itself. The locks, lakes, Gaillard cut, the buoys that mark the channel, and other features, big and little, are shown exactly as they are, while through the canal move ships that are accurate miniatures of real ships…The Panama Railroad is shown, and over it run miniature trains…The topography of the Canal Zone is faithfully duplicated…Even the tropical foliage is accurately represented…"

***Popular Mechanics,* September 1915**

Left: *Panama-Pacific Exposition* postcard


PANAMA CANAL ON THE ZONE
PAN-PAC INT EXPOSITION
SAN FRANCISCO, 1915



"All that is required of the spectator is to take his place on the moving platform that encircles the model and place to his ears the telephone receivers that are provided for each of the seats. As the platform moves around the model a complete view, accompanied by a phonograph lecture explaining the features, is given of the canal in operation…The model is divided into 15 zones, and as the spectator is carried past the successive zones he sees the canal in operation just as he would see it making a trip from the Pacific terminus to Colon. At night, every lighthouse, buoy, ship, station, and city is brilliantly lit…"

***Popular Mechanics,* September 1915**

Left: "Panama Pacific International Exposition, San Francisco, 1915" - promotional booklet

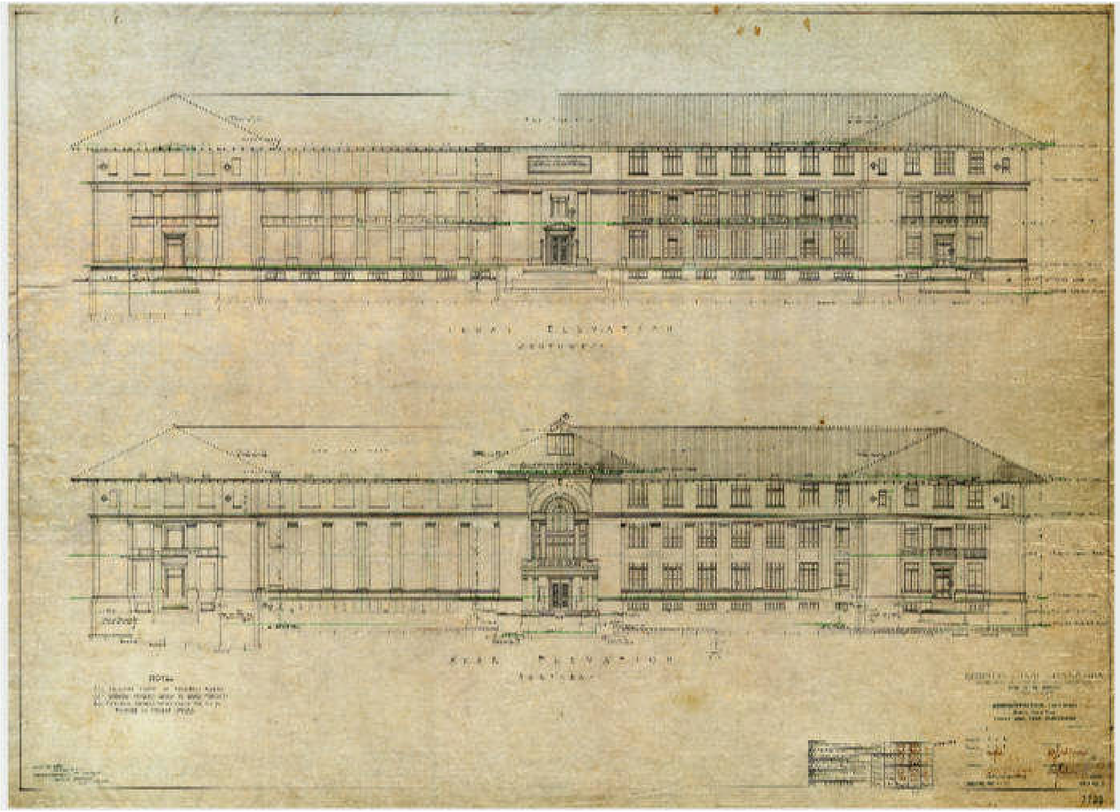

UNITED · STATES · OF · AMERICA
IN GOD WE TRUST
MCMXV
FIFTY · DOLLARS
PANAMA-PACIFIC · EXPOSITION
E PLURIBUS UNUM
SAN FRANCISCO

The Administration Building

"…The grandest public building in Panama is not the president's residence or the National Assembly. It is the Panama Canal Administration Building, a stately, tile-roofed structure that sits atop a pyramid-shaped hill near the Pacific end of the canal. It was inaugurated in 1914 as the headquarters for America's canal officials…"

***Popular Mechanics,* October 2009**

The *Panama Canal Administration Building* (above) was inaugurated on July 15th 1914, exactly a month before the opening of the *Panama Canal*. According to records dating back to the construction era, the entire building cost $879K; a sizeable sum at the time. The building is at the top of *Ancon Hill*, prominently overlooking the canal, the town and port of *Balboa* and parts of *Panama City*. Since 1999, when control of the canal was transferred to *Panama,* the building has served as headquarters of the *Panama Canal Authority* (ACP, in Spanish) housing its administrative offices. The ACP is a branch of the Panamanian government.



"On the toe of the northwest slope of Ancon Hill, overlooking Balboa, the first permanent town of the Zone, the administration building, in which are concentrated the various departmental offices of the Panama Canal, has been erected. It is a low, broad structure, drawn after the plan of the architecture of the Italian Renaissance period and surrounded on all sides by wide concrete terraces flanked by heavy balustrades and broken, at the front, by longitudinal panels of lawn…"

***Popular Mechanics,* June 1915**

<u>Above</u>: original front and rear elevations of the *Administration Building*

"…In order to compress the building and at the same time provide for adequate light and ventilation, it was designed in the form of the letter 'E'…"

***Popular Mechanics,* June 1915**

<u>Above</u>: the Administration Building's "E" shape is apparent in this aerial view

<u>Left</u>: in January 1914, the exterior of the Administration Building was complete, but *Albrook Field* was still a swamp and the *Ancon Cemetery* had yet to be moved to what is now *Corozal* to make way for new houses. Miraflores *Locks* is visible in the distance.

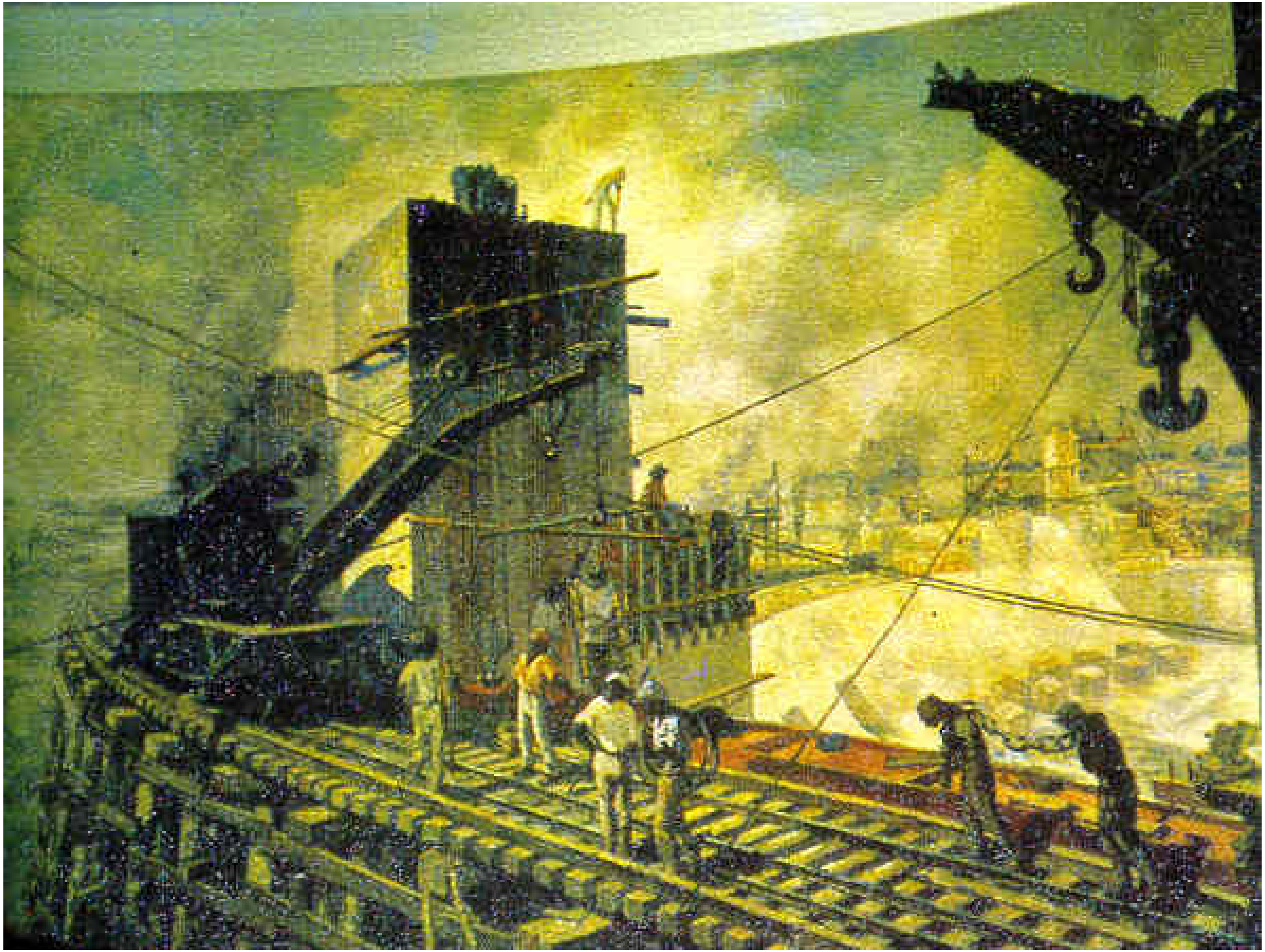
"It is three stories in height and, unlike other structures erected in the Zone, has a sub-basement. Both its front and outer wings are lined by a colonnade of square Italian marble columns which support the projected third story wall and the eaves. The overhanging roof shades the windows of the top floor from the intense rays of the sun, so that a gallery is unnecessary. Below, however, a broad band balcony extends around the outside, shading the interior and providing communication to the different offices. The building is honeycombed with large windows, which are necessary to provide for an ample circulation of air during the rainy season, when the atmosphere is depressing because of its humidity…"

***Popular Mechanics,* June 1915**

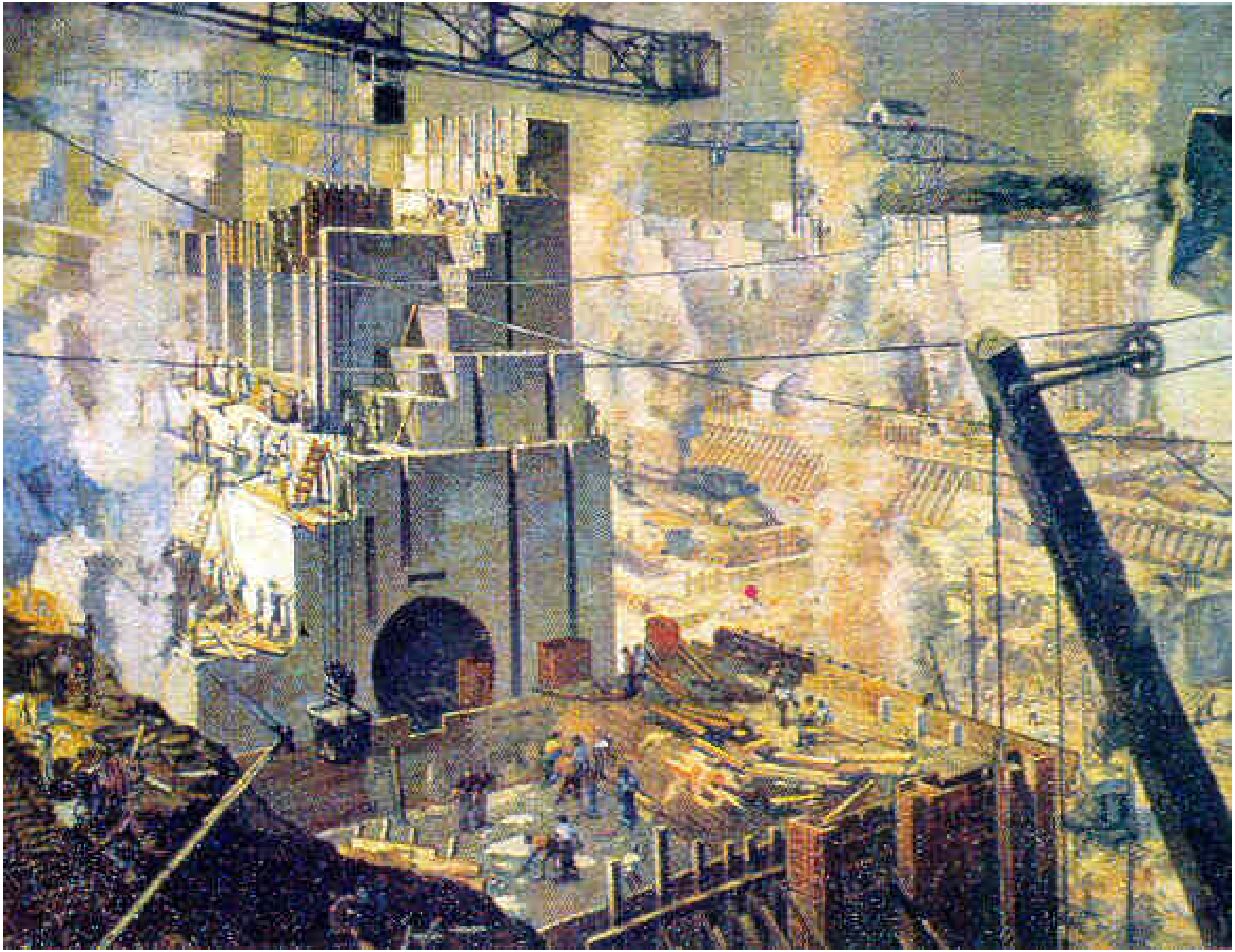
Left: arched window at the third story landing of the central staircase, typical of *Italian Renaissance* architecture

Of particular interest to tourists are the Administration Building's colorful murals that adorn the ceiling of the inner rotunda. These murals were painted by *New York* artist *William B. Van Ingen*, who is also known for his murals in the *Library of Congress*, and the *Philadelphia Mint.* They depict the monumental labor involved in building the *Panama Canal* through four scenes: the *Culebra Cut* excavation, the Gatun *Dam Spillway* construction, the *Miraflores Locks* construction and the erection of one of the *Lock Gates*. These murals commemorate the efforts, courage, and heroism of the multinational workforce that united the world's two greatest oceans via the construction of the Panama Canal.

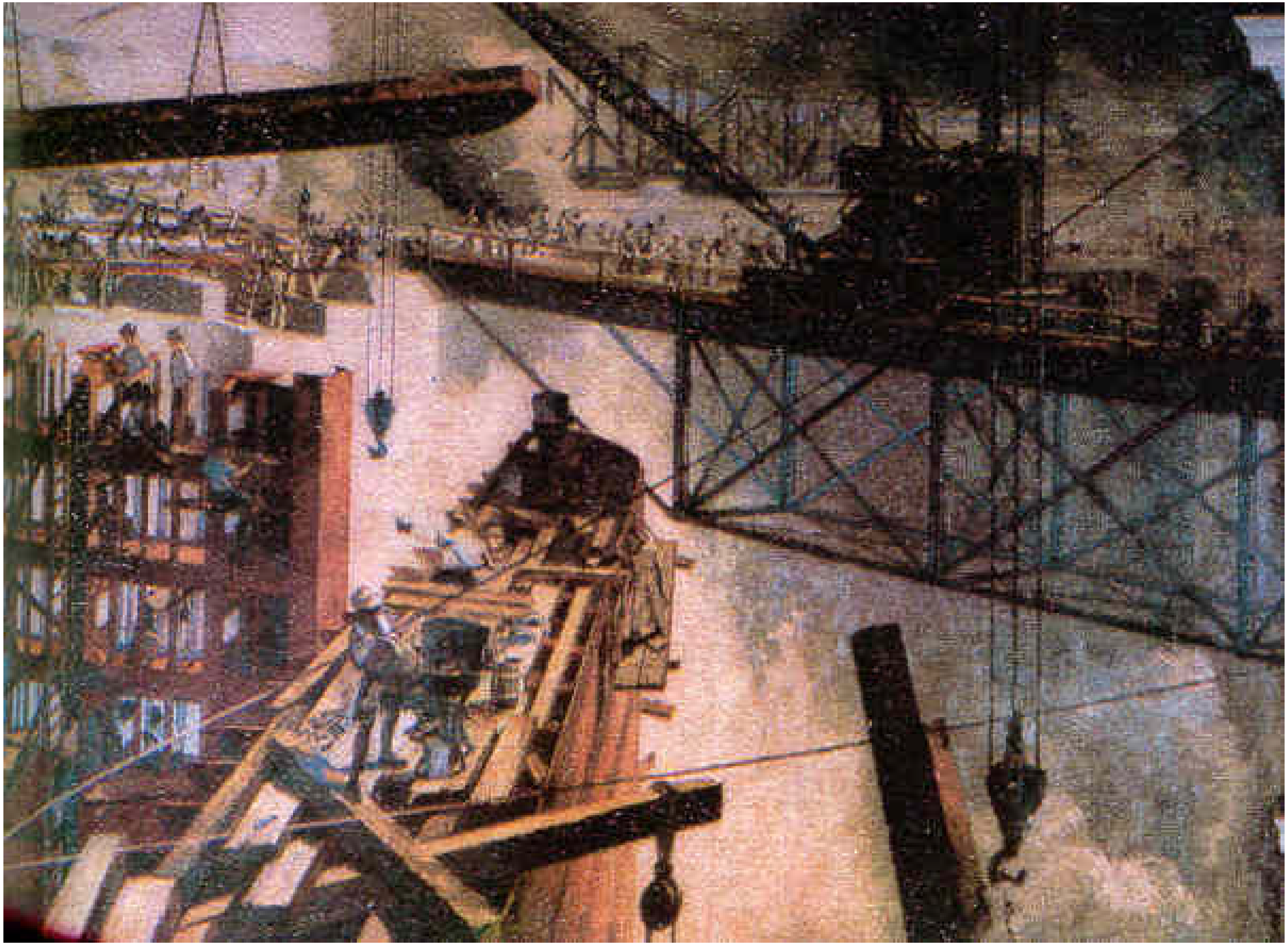
<u>Above</u>: "The digging of Gaillard (Culebra) Cut at Gold Hill"



<u>Above</u>: "The Construction of the Spillway at Gatun Dam"



<u>Above</u>: “The Construction of Miraflores Locks”



<u>Above</u>: "The Erection of a Lock Gate "

“Hollow concrete tile blocks are to be used in the construction of many of the permanent government buildings in the Panama Canal Zone and a factory for making these blocks is now in operation under the supervision of the Canal Commission. The process used is a new one and employs steam instead of dry heat for drying the blocks…they are treated with a combined steam and water dripping process calculated to set up and harden the blocks so that within a period of 48 hours they are ready for removal to the storage yard. The plant is to be operated in two shifts of 7.5 hours each, and it is estimated that the daily output under this arrangement will be about 5,000 blocks.”

***Popular Mechanics,* March 1914**

"…Concrete enters largely into the construction of the building. The foundation for the steel framework is made of concrete, as are the floor arches, while the curtain walls are of concrete blocks, and the roof arches of reinforced sawdust concrete. The spandrels are of poured concrete, and the same material, reinforced, has been use in building all the stairways…"

***Popular Mechanics,* June 1915**


ADMINISTRATION
BUILDING
4c
CANAL ZONE POSTAGE

Changing Hands

In 1977, the *United States* and *Panama* joined in a partnership for the management, operation and maintenance of the *Panama Canal*. According to two treaties signed at a ceremony in the offices of the *Organization of American States* (OAS) in *Washington, D.C*. on September 7th 1977, the canal was to be operated until the end of the century under arrangements designed to strengthen ties of friendship and cooperation between the two countries. President *Jimmy Carter* signed the *Torrijos-Carter Treaty* which set in motion the process of handing over the canal to Panamanian control. The treaty came into force on December 31st 1999. The treaties were approved in Panama in a plebiscite on October 23rd 1977 and the *U.S. Senate* gave its advice and consent to ratification in March and April of 1978. The new treaties went into effect in October 1979. The *Panama Canal Commission*, a government agency of the United States, operated the canal during the transition that began twenty years after the implementation of the *Panama Canal Treaty* (October 1st 1979). The Commission worked under the supervision of a bi-national board consisting of nine members. The Panama Canal Commission replaced the old *Panama Canal Company*, which together with the former *Canal Zone* and its government, was dissolved in October 1979. The treaty came into force on December 31st 1999 and, since then, the canal has been run by the *Panama Canal Authority* or the *Autoridad de Canal de Panama* (ACP).


PANAMA
23¢
fin a la perpetuidad, 1 de octubre 1979

The *Republic of Panama* assumed full responsibility for the management, operation and maintenance of the *Panama Canal* at noon on December 31st 1999. *Panama* meets its responsibilities through a government agency called the *Panama Canal Authority*, created by the Constitution of the Republic of Panama, organized by *Law 19* of June 11th 1997. The Panama Canal Authority is the autonomous agency of the government of Panama in charge of managing, operating and maintaining the Panama Canal. The operation of the Panama Canal Authority is based on its organic law and the regulations approved by its board.

Above: celebration in front of the canal *Administration Building* at noon on December 31st 1999

The treaty was highly controversial in the *United States*, and its passage was difficult. The controversy was largely caused by contracts to manage two ports at either end of the canal, which were awarded by *Panama* to a *Hong Kong*-based conglomerate; *Hutchison Whampoa*. Conservatives contend that the company has close ties to the Chinese government and the Chinese military. Many Americans were also wary of placing this strategic waterway under the protection of the Panamanian security force. There was much concern in the U.S. and in the shipping industry after the handover. In the interceding time overall, Panama appears to have done quite well in its management of the canal;

- **The Panama Canal's income has increased from US$769 million in 2000, the first year under Panamanian control, to US$1.4 billion in 2006, according to *Panama Canal Authority* figures;**
- **Traffic through the canal went up from 230 million tons in 2000 to nearly 300 million tons in 2006;**
- **The number of accidents has gone down from an average of 28 per year in the late 1990s to just 12 accidents in 2005;**
- **Transit time through the canal is averaging about 30 hours, about the same as in the late 1990s;**

On October 22nd 2006, after many studies made by the agency, Panamanian citizens approved by a wide margin a referendum for a project to expand the Panama Canal. Former U.S. Ambassador to Panama *Linda Watt*, who served in Panama from 2002 to 2005, said that the canal operation under Panamanian hands has been "outstanding." She added, "The international shipping community is quite pleased."

PANAMA CANAL TRAFFIC, FISCAL YEARS 1915 THROUGH 1969

Fiscal Year	Total Transits	Commercial Ocean Transits	Total Traffic Long Tons of Cargo	Commercial Ocean Long Tons of Cargo	Total Tolls and Credits	Tolls Commercial Ocean Traffic	Average Toll/Credit per Total Long Ton of Cargo*	Av. Toll per Comm. Ocean Long Ton of Cargo
1915	1,108	1,058	4,937,340	4,888,400	$ 4,367,602	$ 4,366,747	$.901	$.893
1916	807	724	3,166,200	3,093,335	2,407,047	2,403,089		
1917	1,937	1,738	7,210,065	7,054,720	5,628,068	5,620,800		
1918	2,210	1,989	7,570,178	7,525,768	6,439,066	6,428,780		
1919	2,230	1,948	7,015,400	6,910,097	6,173,028	6,164,291		
1920	2,777	2,393	9,731,232	9,372,374	8,514,207	8,504,939	.960	.908
1921	3,371	2,791	12,025,808	11,595,971	11,276,483	11,268,681		
1922	3,050	2,655	11,085,194	10,882,607	11,198,000	11,191,829		
1923	4,449	3,908	19,780,163	19,566,429	17,508,701	17,504,027		
1924	5,787	5,158	27,219,471	26,993,167	24,291,596	24,284,660		
1925	5,174	4,592	24,170,360	23,956,549	21,400,994	21,393,718	.915	.893
1926	5,923	5,087	26,153,375	26,030,016	22,931,764	22,919,932		
1927	6,259	5,293	27,976,818	27,733,555	24,230,027	24,212,251		
1928	7,116	6,253	29,863,398	29,615,651	26,945,862	26,922,201		
1929	7,197	6,289	30,781,755	30,647,768	27,128,893	27,111,125		
1930	6,875	6,027	30,163,735	30,018,429	27,077,267	27,059,999	.935	.901
1931	6,217	5,370	25,214,573	25,065,283	24,646,109	24,624,600		
1932	5,075	4,362	19,929,450	19,798,986	20,707,856	20,694,705		
1933	5,040	4,162	18,269,917	18,161,165	19,621,181	19,601,077		
1934	6,211	5,234	24,889,799	24,704,009	24,065,707	24,047,183		
1935	6,369	5,180	25,400,052	25,309,527	23,339,239	23,307,063	.919	.921
1936	6,453	5,382	26,632,360	26,505,943	23,510,629	23,479,114		
1937	6,695	5,387	28,225,212	28,108,375	23,147,640	23,102,137		
1938	6,930	5,524	27,552,904	27,385,924	23,215,208	23,169,889		
1939	7,479	5,903	27,993,144	27,866,627	23,699,430	23,661,021		
1940	6,945	5,370	27,523,907	27,299,016	21,177,759	21,144,675	.800	.775
1942	4,643	2,688	14,187,080	13,607,444	$ 9,772,113	$ 9,752,207		
1943	4,372	1,822	11,030,105	10,599,966	7,368,739	7,356,685		
1944	5,130	1,562	11,592,677	7,003,487	5,473,846	5,456,163		
1945	8,866	1,939	19,369,141	8,603,607	7,266,211	7,243,602	$1.06	$.842
1946	9,586	3,747	22,469,162	14,977,940	14,796,406	14,773,693	1.34	.986
1947	6,375	4,260	22,688,425	21,670,518	17,634,361	17,596,602	.878	.811
1948	6,999	4,678	25,664,205	24,117,788	20,017,439	19,956,593	.850	.827
1949	7,361	4,793	27,782,588	25,305,158	20,617,635	20,541,230	.831	.812
1950	7,694	5,448	30,364,982	28,872,293	24,511,713	24,430,206	.874	.846
1951	7,751	5,593	31,281,525	30,073,022	23,958,879	23,906,082	.855	.795
1952	9,169	6,524	36,902,908	33,610,509	30,409,500	26,922,532	.824	.801
1953	10,210	7,410	41,203,401	36,095,349	37,530,327	31,917,515	.911	.884
1954	10,218	7,784	41,882,368	39,095,067	37,191,107	33,247,864	.888	.850
1955	9,811	7,997	41,548,037	40,646,301	35,136,529	33,849,477	.846	.833
1956	9,744	8,209	46,331,901	45,119,042	37,450,759	36,153,842	.809	.801
1957	10,169	8,579	50,659,057	49,702,200	39,653,712	38,444,128	.783	.773
1958	10,608	9,187	48,982,036	48,124,809	42,834,005	41,795,905	.874	.868
1959	11,192	9,718	52,328,987	51,153,096	46,546,620	45,528,728	.890	.890
1960	12,147	10,795	60,401,733	59,258,219	51,803,032	50,939,428	.858	.860
1961	12,019	10,866	65,216,581	63,669,738	55,172,719	54,127,877	.846	.850
1962	12,106	11,149	69,063,475	67,524,552	58,347,290	57,289,705	.845	.848
1963	12,005	11,017	63,877,200	62,247,092	57,885,931	56,368,073	.906	.906
1964	12,945	11,808	72,168,690	70,550,090	62,546,390	61,098,312	.867	.866
1965	12,918	11,834	78,922,931	76,573,071	67,148,451	65,442,633	.851	.855
1966	13,304	11,925	85,323,463	81,703,514	72,594,110	69,095,129	.851	.846
1967	14,070	12,412	92,997,958	86,193,430	82,296,638	76,768,605	.885	.891
1968	15,511	13,199	105,538,318	96,550,165	93,153,649	83,907,062	.883	.869
1969	15,327	13,150	108,793,069	101,391,132	95,914,608	87,457,895	.882	.863

*Note: Tolls credits for U.S. Government Traffic commenced in FY 1952. Figures for preceding years show adjusted average toll/credit if U.S. Government Traffic had been included.

SOURCE: Panama Canal Company Annual Reports

ACP
AUTORIDAD DEL CANAL DE PANAMA

In 2010, nearly 300 million tons of ships and cargo moved between the *Atlantic* and *Pacific Oceans* through the *Panama Canal*. This total would have no doubt astounded the canal's builders, but to the *Panama Canal Authority* (ACP), which operates the canal today, it's a sign that canal's original infrastructure was/is no longer adequate. Many ships are forced to wait up to ten days to cross the canal costing shippers about $50K per day. Bidding wars often erupt between ships, with some paying up to $200K to move ahead in line. To ensure that congestion in the canal does not drive away traffic, in 2006 Panamanians overwhelmingly passed a referendum proposed by former president *Martín Torrijos* authorizing a $5.25 billion expansion project. The project is generally considered a good investment by outside groups, and received A2 investment grade status from the credit rating agency *Moody's*.

Part 8

Strategically & Otherwise

Deja Vu All Over Again

"In ratifying a treaty by which the United States agrees to pay the Nicaraguan government $3,000,000 for the perpetual and exclusive right of cutting a canal across that republic's territory and thereby establishing a new passageway between the Atlantic and Pacific oceans, the government has made a significant, not to say important, move. The agreement gives us the Great and Little Corn islands as well as the authority to establish in the Gulf of Fonesca – which is considered to be, strategically and otherwise, the best Pacific-coast harbor south of San Francisco – a naval station. The Corn islands and Tigre Island, the latter within the mouth of the gulf, are to be heavily fortified. As a protection for Panama Canal, the value of a naval station in Central America and fortified bases in the Caribbean is obvious. On the other hand the Nicaraguan canal rights are probably of equal, if not even greater, importance. In recent years the practicability of constructing the long-proposed waterway, which would make use of the natural advantages offered by Lake Nicaragua and its outlet, the San Juan River, cost less than half as much as did Panama Canal, and provide a route shorter than the existing one, has come to be realized by engineers. The military and commercial danger to Panama Canal would have been momentous had a foreign power taken over the enterprise. And of late two great nations are understood to have discussed the project in secret. The purchase of the option by the United States has therefore been timely."

Popular Mechanics, **April 1917**

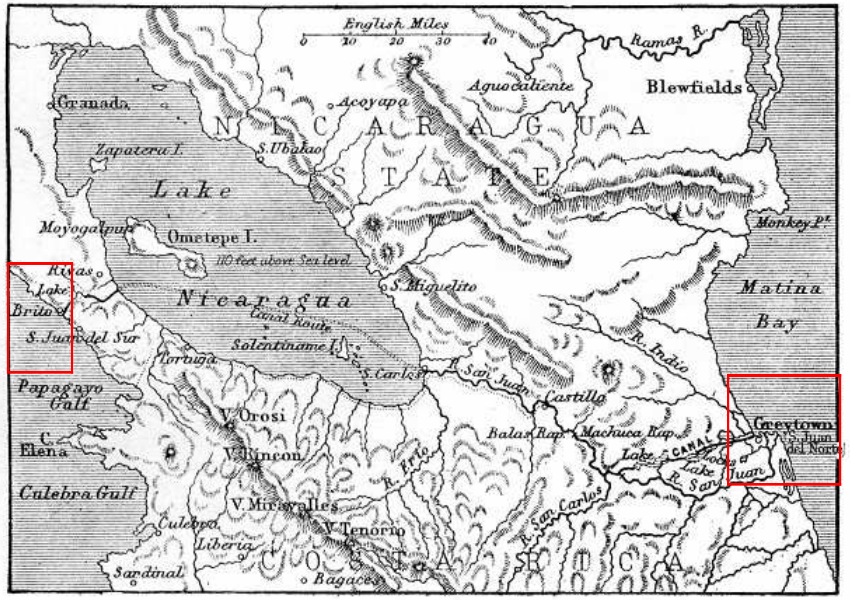
"…there has been recent agitation in Washington for the revival of the Nicaraguan project. The navy department is particularly interested in this, as the Panama Canal is not easily fortified against aerial attack, lacking outlying islands and headlands for defensive purposes, while the Nicaraguan route has the Corn islands in the Caribbean and the Bay of Fonesca headlands on the west coast for defensive purposes. Since the completion of the canal American naval strategy has been based on the possibility of shifting the fleet hurriedly from one coast to the other, but if an enemy can destroy one canal the fleet might be caught divided and annihilated. Naval strategists claim with two canals, the second easily defendable, the danger would be reduced, while the additional route would care for the traffic which the present canal eventually will not be able to handle…"

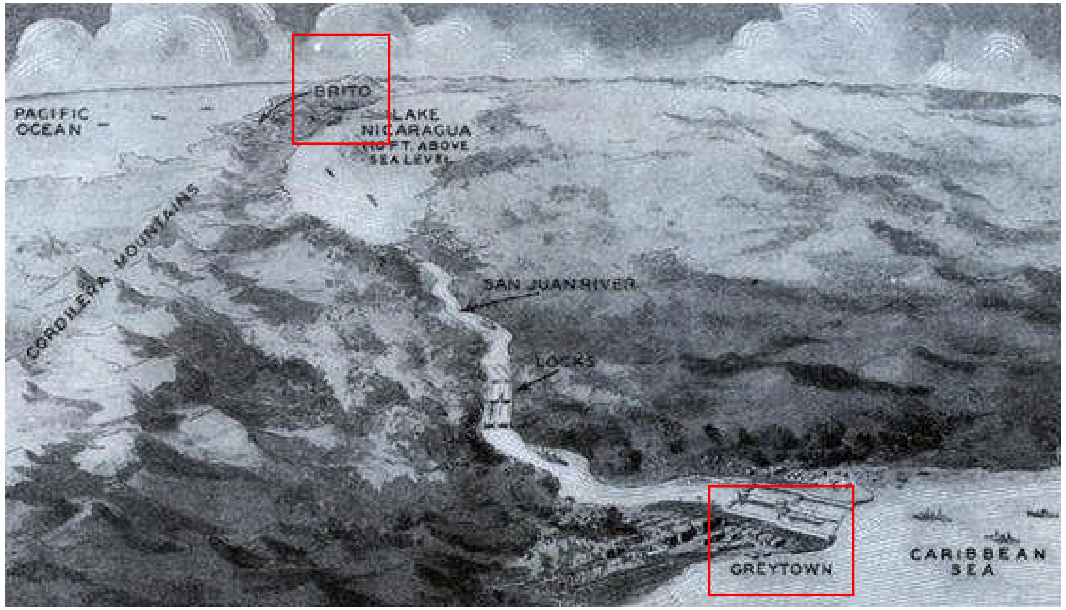
H.H. Windsor, Jr., **September 1st 1924**

The 1929 Survey

The *Panama Canal* was opened to traffic on August 15th 1914. Several years later, those responsible for its operation grew concerned that demands for transit might eventually exceed its capacity. Thus, in 1929 *Congress* directed that surveys be made in *Panama* and *Nicaragua* to determine the practicability of providing additional locks to the Panama Canal or of constructing a canal elsewhere. The *U.S. Army Interoceanic Canal Board of 1929-1931* was created by the POTUS and the board's report, submitted in 1931, considered three long-term alternatives:

- **add a third set of locks to the Panama Canal;**
- **convert the Panama Canal to a sea-level canal;**
- **construct a new lock canal in Nicaragua**





"…As far back as 1930 an army engineer battalion, carrying out the orders of Congress, conducted a large scale survey in Nicaragua over the route of a proposed second canal. This new canal would extend 173 miles across Nicaragua from Brito on the Pacific via the Rio Grande, Lake Nicaragua, the Rio San Juan and the Rio Deseado to Greytown on the Atlantic…the atom bomb may force the United States to build the second canal through Nicaragua. In building it our engineers would face an even greater task than the Panama project…"

***Popular Mechanics,* June 1946**

<u>Left</u>: map of proposed *Nicaragua Canal* route (ca. 1906)

<u>Right</u>: caption: "A bird's-eye view of the canal as it will appear when completed. The San Juan River will be dammed to provide deep water through the hilly country, while a deep channel will be dredged through the muddy bottom of Lake Nicaragua."

Lost to History

"…Explorations and surveys have been going on in this region ever since 1826. Later, between 1850-1852 the famous so-called instrument survey was made by Colonel Childs. Congress was on the verge of appropriating funds for the undertaking but some great stumbling block, now lost to history, appeared to obstruct work and it was abandoned. As many as five other surveys followed…"

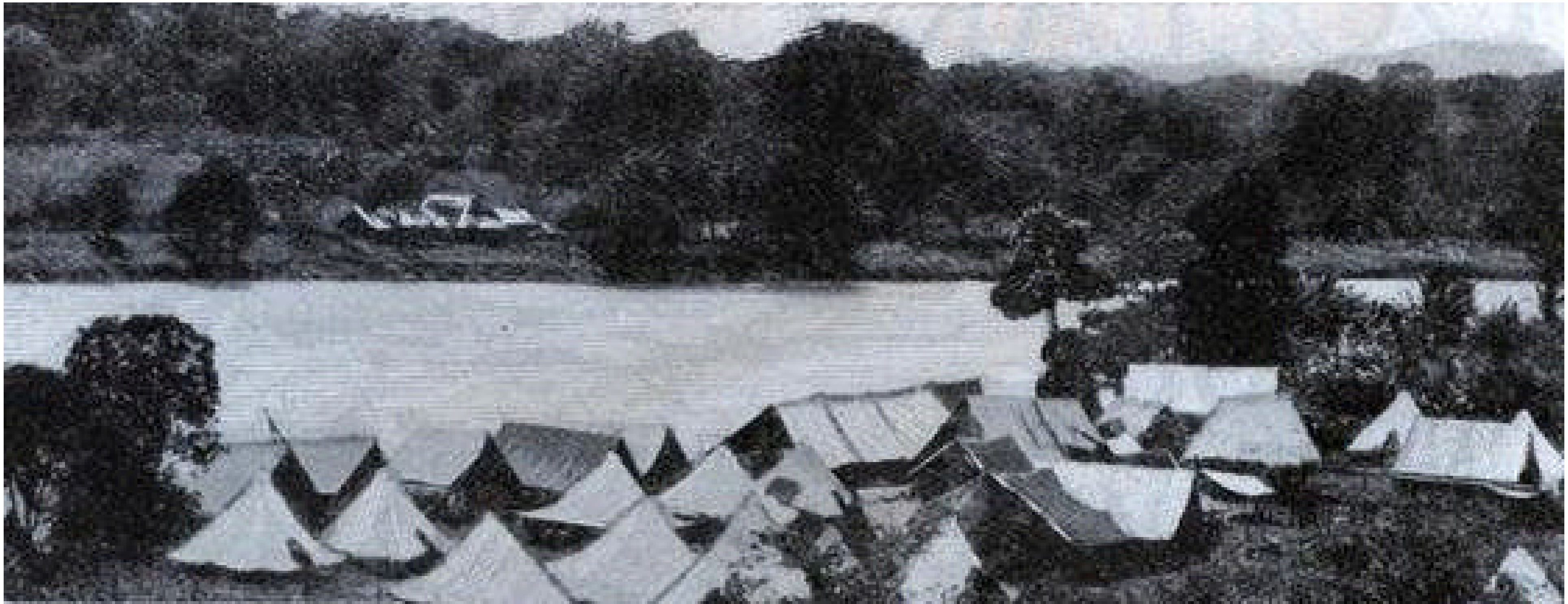
***Modern Mechanix,* June 1931**

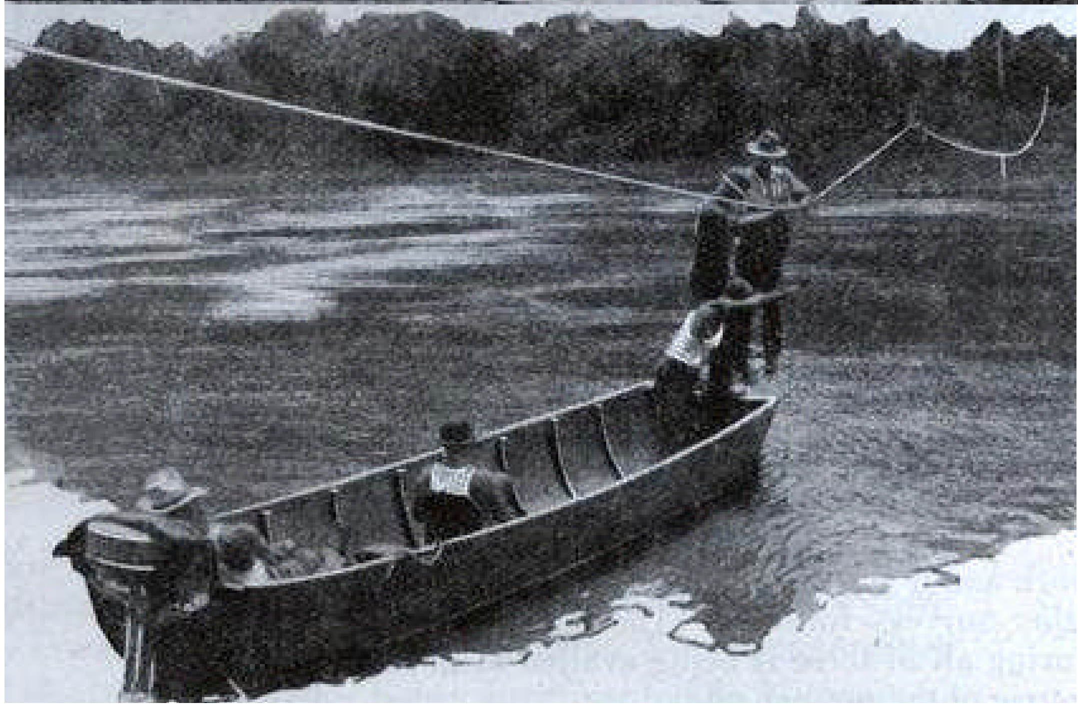
RE: during the *California Gold Rush* of the 1850s, the American shipping and railroad mogul "Commodore" *Cornelius Vanderbilt* operated a stagecoach line across the *Isthmus of Rivas* in *Nicaragua* called the "Accessory Transit Company" for gold-seekers traveling west. Vanderbilt was soon granted rights to build a canal to the *Pacific*, though his plans were never carried out.

"For a little over a year a picked battalion of United States army engineers has been foraying through matted jungle regions and over perilous mountain passes in making a survey for the proposed Nicaragua Canal, to link the Atlantic and Pacific Oceans for a distance of 183 miles. The decision of the American government to construct a canal over the surveyed area, a project which will require ten years, will depend on the reports of the engineers down there at present. The United States is prepared to spend $1,000,000,000 in the event that conditions warrant the construction of a canal to relieve the traffic on the Panama. According to the present proposals, the Atlantic end of the canal will be Greytown where two jetties and a harbor, two miles long, will be constructed. From there the Canal will run along the north side of the San Juan River, which would be changed into an arm, fifty miles long, to Lake Nicaragua. At Conchuda it is planned to have a dam. Across Lake Nicaragua the engineers are making soundings and maps for a channel. This channel, which will be seventy miles long, will have to be dredged. Then it will pass through the continental divide, west of Lake Nicaragua, and dropped to the level of the Pacific Ocean by means of four locks, this distance being 16 miles…"

***Mechanix Illustrated,* June 1931**

Above: caption: "Map shows line of proposed Nicaraguan Canal"

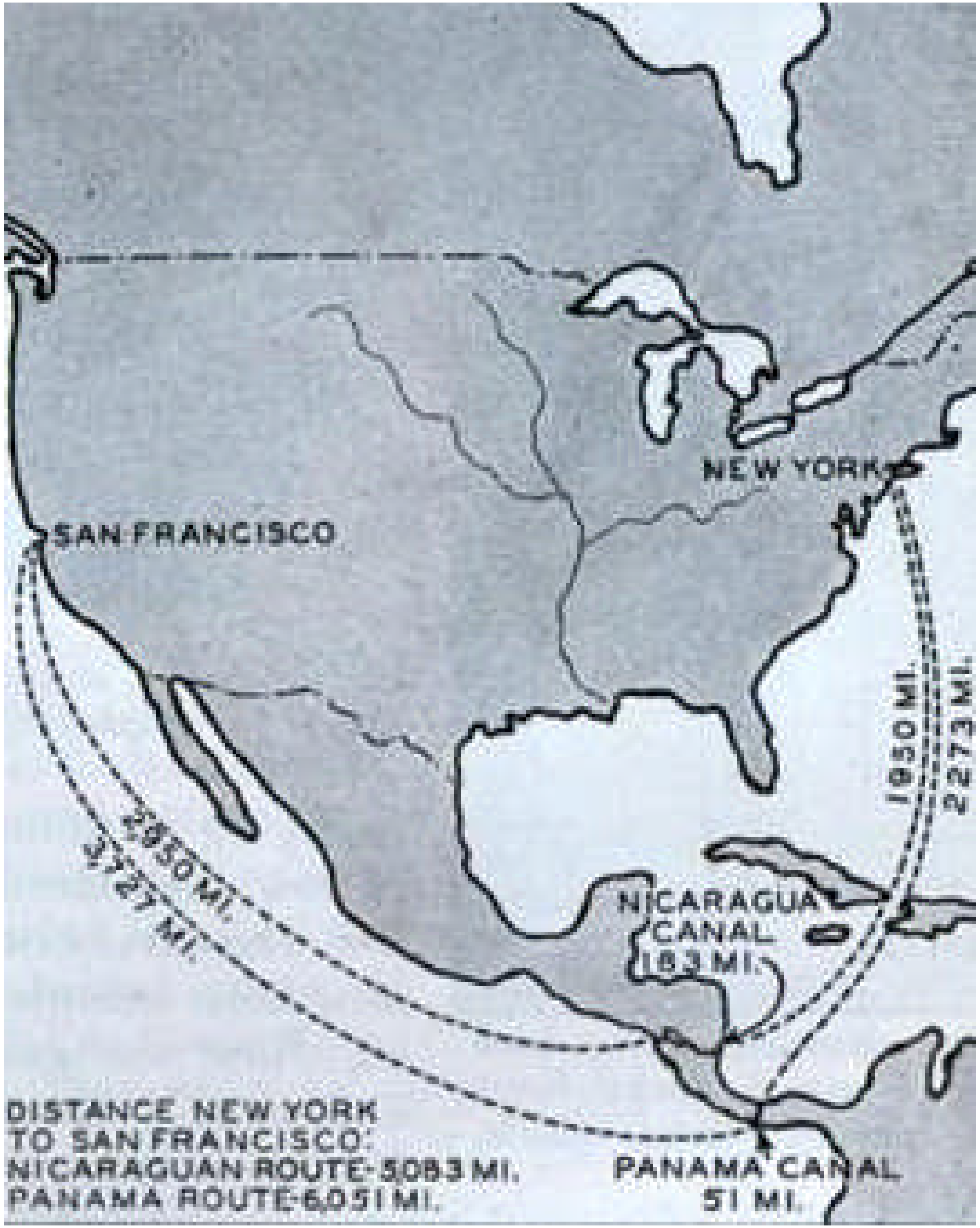




<u>Above</u>: caption: "Camp Hoover, the base on the San Juan River, from which the army engineers worked in staking out the route of the Nicaragua canal"

<u>Left</u>: caption: "U.S. Army sounding the depth of the treacherous San Juan River prior to employing diamond point drills to test the underlying soil"

<u>Above</u>: caption: "This picture gives you an idea of the treacherous jungle swamps through which the army engineers must battle with transit, rod, and level. Venomous snakes and insects abound in sweltering tropical jungle."



"…Aside from its commercial advantages, which a glance at the map will make apparent at once, the canal will more than pay for itself should this nation ever be threatened by one of the great naval powers. In event of hostilities, it is presumed that one of the first things attempted by the enemy would be the destruction of the Panama Canal locks, thus making it impossible to transfer the fleet from one coast to the other. With two canals, the probability of cutting this important link in communications would be cut in half. The Nicaragua Canal would also be easier to defend, owing to its topographical advantages."

***Mechanix Illustrated,* June 1931**

<u>Left</u>: caption: "This map shows the location of the two canals and illustrates how ships will save from two to four days on the New York – San Francisco run"

“The present traffic seeking transit through the Isthmus and the prospective increase in such traffic in the next few years do not require that any steps be taken now to provide further capacity to Panama.”

U.S. Army Interoceanic Canal Board of 1929-31

RE: excerpt for their report to *Congress* in 1931. The construction and anticipated completion of *Madden Dam* (1935) would increase the capacity of the *Panama Canal*, negating the need for expanding the existing canal with a third set of locks, converting it to a sea-level canal or constructing a new lock canal in *Nicaragua*.

"…But while every precaution was taken to protect Panama, the possibility of the Nicaraguan Canal was not forgotten. Following the survey ordered by Congress in 1929, an Army officer and one non-commissioned officer remained behind to continue the collection of hydrological and meteorological data pertaining to the proposed canal. These men are in Nicaragua today, operating rainfall stations, collecting evaporation data and recording lake levels, barometric pressure and wind velocity…"

***Popular Mechanics,* June 1946**

<u>Above</u>: caption: "U.S. Army engineers engaged in Nicaragua survey move diamond drill parts"

A Clear and Present Danger

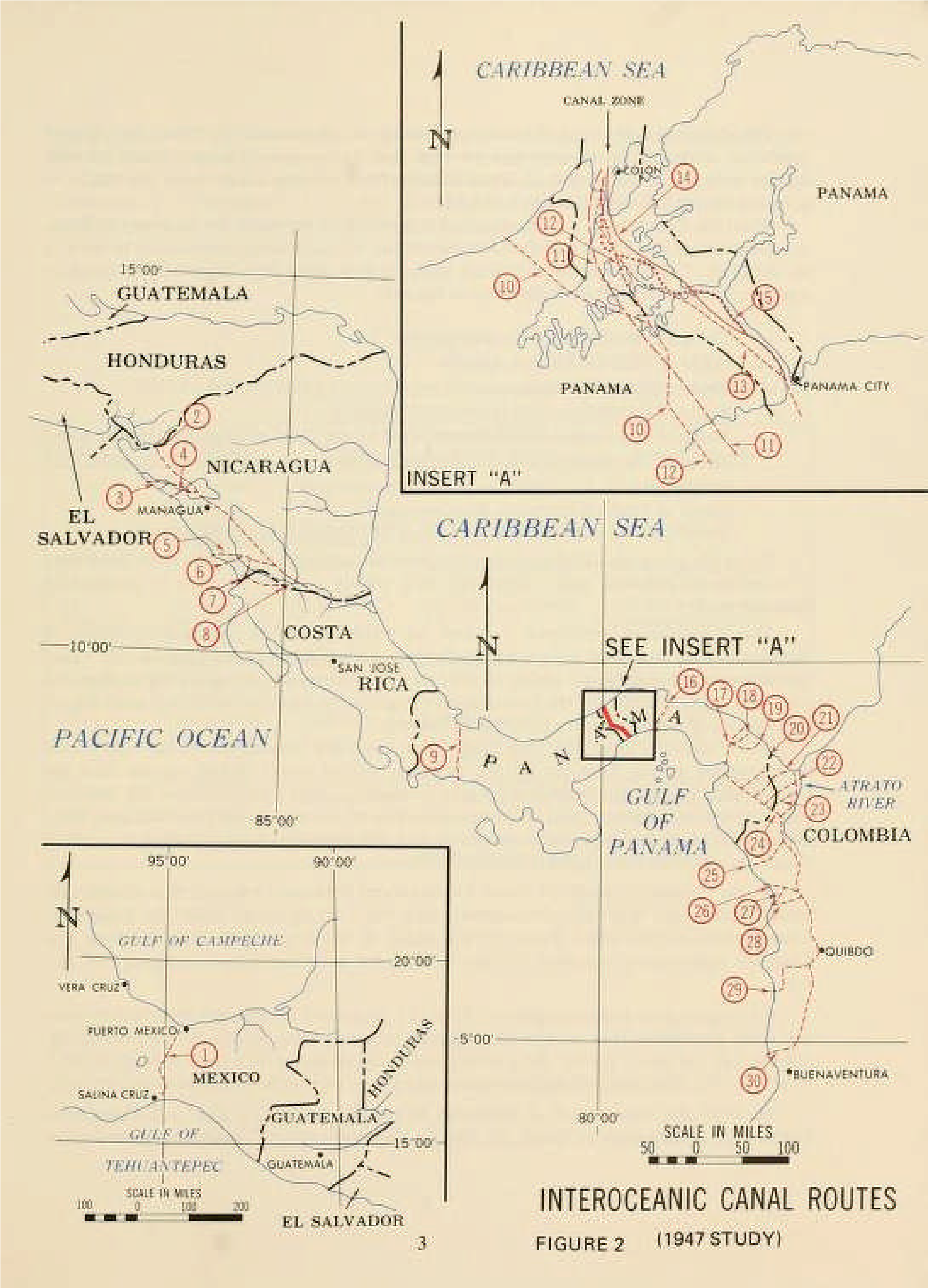
“‘A single plane, dropping one bomb, could destroy it. What we’ll do about protecting it I don’t know – but we’ll do something.’ These were the recent words of Major General Leslie R. Groves, the Army’s atom bomb chief, when speaking of the power of the atom bomb and what it could do to America’s lifeline – the Panama Canal. The vulnerability of the canal has long been recognized by our military leaders, and when Hitler’s armies started their rampage of devastation, additional troops were rushed to the already large defense garrison in the Canal Zone. The war also brought up once more the necessity of a second canal in the event Panama was damaged by enemy action…”

***Popular Mechanics,* June 1946**

"…In 1931 the Army's Inter-oceanic Canal Board said a new canal would lessen traffic demands on the Panama Canal and provide an alternate link between the oceans during emergency. By an ironic coincidence*, *one of the Army's engineers who helped prepare the 1931 report on how to protect the canal, Major General Groves, also helped make the atom bomb – the weapon which can destroy it."

***Popular Mechanics,* June 1946**

Left: Major General *Leslie R. Groves*



<u>Left</u>: map of the <u>1947</u> inter-oceanic canal route study which was conducted by the Governor of the *Panama Canal Zone*. Subsequent studies were made in <u>1957</u> (by the *House Committee on Merchant Marine and Fisheries*), in <u>1960</u> by the *Panama Canal Company* and in <u>1964</u> (again by the Panama Canal Company). The landmark study would be completed in <u>1970</u> by a presidential commission.

The 1947 report: In December 1945, Congress again directed the Governor of The Panama Canal to make new investigations to determine the best means for increasing the canal's capacity and for improving its security, and to consider other possible routes. This comprehensive effort, reported in *Isthmian Canal Studies-1947*, identified 30 possible routes in five geographical areas ranging from the Isthmus of Tehuantepec, in Mexico, to northwestern Colombia. It went on to select the best route in each area for further consideration; and to compare these routes with one another.

In his report, the Governor concluded that a sea-level canal was both desirable and feasible, and that the best and most economical means for its development lay in converting the Panama Canal (called Route 15) to sea level. This conversion would be made by deepening and straightening the existing canal along a new alinement called Route 14.

Another investigation, conducted concurrently with the 1947 studies, sought to determine the effects of nuclear attacks upon lock and sea-level canals. Since principles of nuclear excavation were not clearly defined at that time, the possibility of using nuclear energy to excavate a new canal was not considered.

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970 (regarding the 1947 report)

The Board of Consultants' report: Ten years later (1957) the House Committee on Merchant Marine and Fisheries appointed a Board of Consultants on Isthmian Canal Studies to investigate both short- and long-range plans for improving the Panama Canal. In 1958 the Board submitted its short-range program to increase the existing canal's capacity; and, in 1960, it made additional recommendations providing for a long-range program of improvements. Although stating that "no sea-level canal project in the Canal Zone should be undertaken in the near future," the consultants called for further studies and developmental efforts, particularly in the field of nuclear excavation, and recommended a review of the entire situation by 1970.

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970 (regarding the 1957 report)

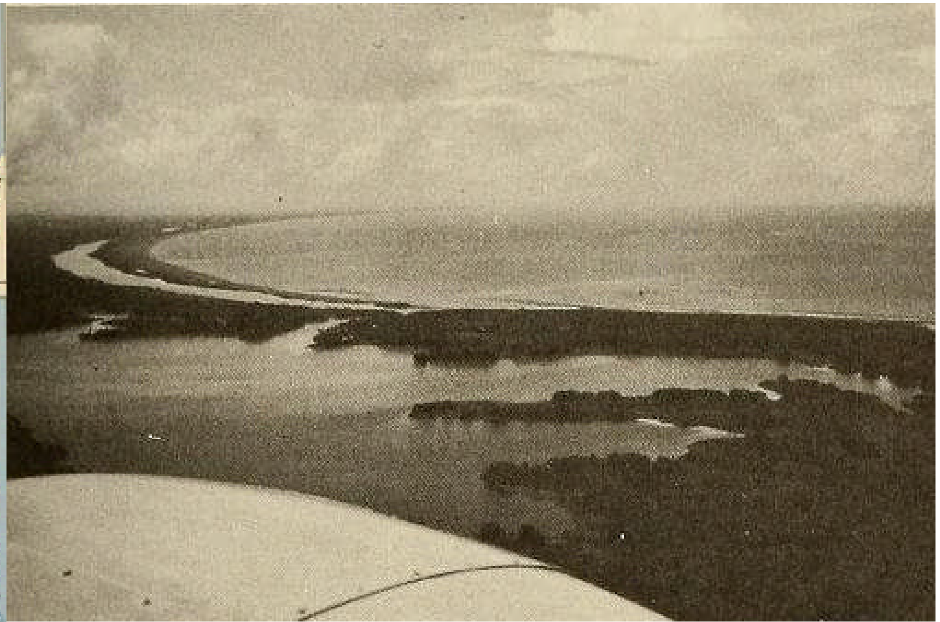
The 1960 report: In 1957 the Board of Directors of the Panama Canal Company appointed the *Ad Hoc* Committee for Isthmian Canal Plans to revise the 1947 report, taking full advantage of developments in construction techniques, and to adjust previous cost estimates to 1960 price levels. The Atomic Energy Commission participated in this study, identifying routes that might be suitable for nuclear excavation which, by then, had begun to emerge as a new technology. The Committee's recommendations did not address the construction of lock canals because, in its opinion, their operating costs would eventually escalate beyond available revenues. Among the more significant recommendations developed by this study were those calling for:

- Completion, as an interim measure, of the Board of Directors' canal improvement program, calling for expenditures of $90 million through 1968 to increase the capacity of the lock canal;
- Initiation by the Company of planning for the construction of a sea-level canal outside the Canal Zone by nuclear methods;
- Improvement by the Atomic Energy Commission of nuclear explosives; and,
- Planning by the Company for construction of a sea-level canal in the Canal Zone by conventional methods if definite plans for constructing a sea-level canal by nuclear methods were not developed by the early 1970's.

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970 (regarding the 1960 report)

The 1964 report: The report entitled *Isthmian Canal Studies, 1964*, was prepared by the President of the Panama Canal Company, pursuant to authorization in 1963 by the Company's Board of Directors. The Corps of Engineers, the Atomic Energy Commission and private consultants participated in its preparation. The report summarized studies of canal capacity, canal traffic projections, and ways of improving the lock canal facilities to meet projected requirements of ocean commerce. The report contained a detailed analysis of a Third Locks Plan, a Terminal Lakes Plan† and a sea-level canal in the Canal Zone. The report also examined the present canal's transiting capacity, and concluded that a maximum of 71 ships (65 lockages) per day (about 26,000 per year) could be accommodated, assuming no maintenance shutdowns, and further assuming that either lockage water could be reused or sea water could be pumped into Gatun and Miraflores Lakes to augment the lockage water supply. The report also evaluated the technical feasibility of employing nuclear explosives to construct sea-level canals in eastern Panama and northwestern Colombia.

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970 (regarding the 1964 report)



Route 5 Lock Canal (Figure 29)

Data available from 1931, 1947, and 1964 studies of the 167-mile route in Nicaragua indicate that a lock canal capable of accommodating 110,000 DWT ships and having approximately the same annual transit capacity as the existing Panama Canal would cost about $4 billion. A lock canal designed to meet the 150,000 DWT ship size and 35,000 annual transit capacity criteria would cost much more.

Route 8 Sea-Level Canal Excavated by Either Nuclear or Conventional Excavation

A sea-level canal on Route 8 through Nicaragua and Costa Rica (Figure 29) would cost an estimated $5 billion to construct by nuclear methods, if available, and $11 billion by conventional methods. This latter cost is prohibitive, and nuclear excavation is infeasible for the reasons given in Chapter IV.

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

<u>Above</u>: caption: "The Caribbean coast, looking north, at the site of the Atlantic terminus of Route 8. The town of San Juan del Norte is at the right of the picture."

<u>Left</u>: Figure 29 (Routes 5 & 8)

CHARACTERISTICS OF ROUTE 5

Canal dimensions	500 ft x 65 ft[a] (centerline depth 75 ft)
Lock dimensions	160 ft x 1,450 ft x 65 ft
Length of land cut	173 miles
Length of approaches	4 miles
Design vessel	150,000 dwt
Capacity[b]	25,000 transits/yr (36 hrs. average TICW)
Construction time	12 years
Excavation volume	1,700,000,000 cu. yd.
Cost of locks	$1,200,000,000[c]
Excavation cost	$2,200,000,000
Other facilities	$1,300,000,000
Contingencies	$ 600,000,000
EDS&A[d]	$ 400,000,000
TOTAL CONSTRUCTION COST	$5,700,000,000
Operation and maintenance:	
Fixed cost	$71,000,000/year
Variable cost	$1,240/transit

[a]Includes 49 miles of two-lane channel necessary to obtain capacity.

[b]Length of canal prohibits operation within 20 hour TICW standard.

[c]Includes the Conchuda Dam on the San Juan River.

[d]Engineering, design, supervision, and administration.

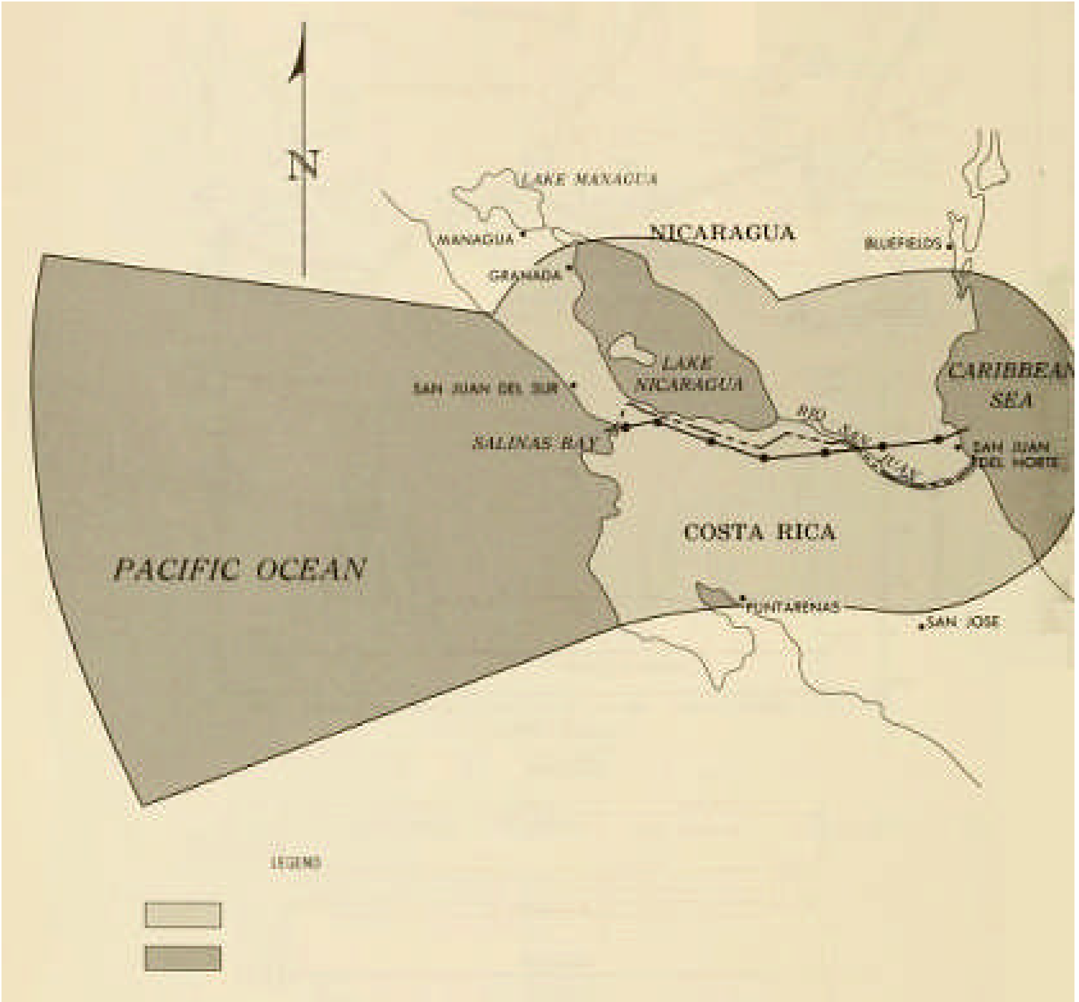
CHARACTERISTICS OF ROUTE 8 NUCLEAR[a]

Canal dimensions	1,000 x 75 feet (minimum)
Length of land cut	133 miles
Length of approaches	7 miles
Design vessel	250,000 dwt
Capacity	200,000 transits/yr (20 hrs average TICW)
Construction time	12 years
Excavation cost	$ 850,000,000
Other facilities[b]	$3,350,000,000
Contingencies	$ 630,000,000
EDS&A[c]	$ 340,000,000
TOTAL CONSTRUCTION COST	$5,170,000,000
Operation and maintenance:	
Fixed costs	$50,000,000/year
Variable costs	$1,100/transit

[a]Based on nuclear excavation throughout the length of the route, except for the ocean approaches which would be 1400 by 85 feet.

[b]Includes evacuation costs.

[c]Engineering, design, supervision and administration.



ROUTE 8 NUCLEAR EXCLUSION AREA

The Big Bang Theory

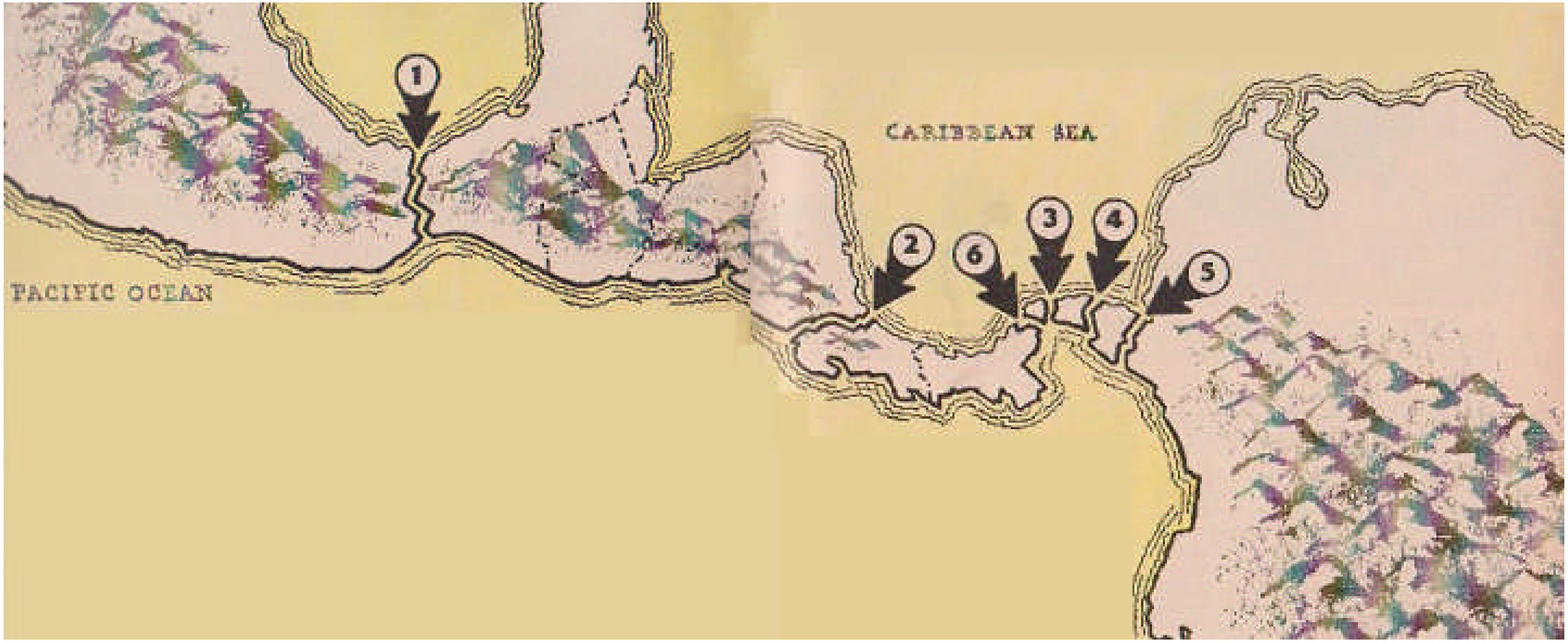
"For a quarter of a century, dreamers and hardheaded businessmen as well have been conjuring up new schemes to jockey huge ships across the aggravatingly skinny, but mountainous, strip of land connecting North and South America…the fondest dream of all has been a colossal sea-level ditch. Today, that idea is no longer a dream. It may happen – and soon. It can be done without squadrons of earth-moving monsters – at one-third the cost they would involve – and will result in an ocean-to-ocean river four times wider and twice as deep as the present canal; a 'ditch' big enough to take the world's largest tankers and carriers – something the present canal won't do…"

Popular Mechanics, **June 1964**

Where, When and How?

“…The question no longer ‘Can it be done?’ It is ‘Where, when and how can we dig it?’ Scientists and engineers working with the U.S. Government’s Panama Canal Company, the Atomic Energy Commission and the Army’s Corps of Engineers already have most of the answers. Where? Near the Panama-Columbia border. When? Within five or six years. How? By means of thermonuclear excavation based on new techniques...”

***Popular Mechanics,* June 1964**

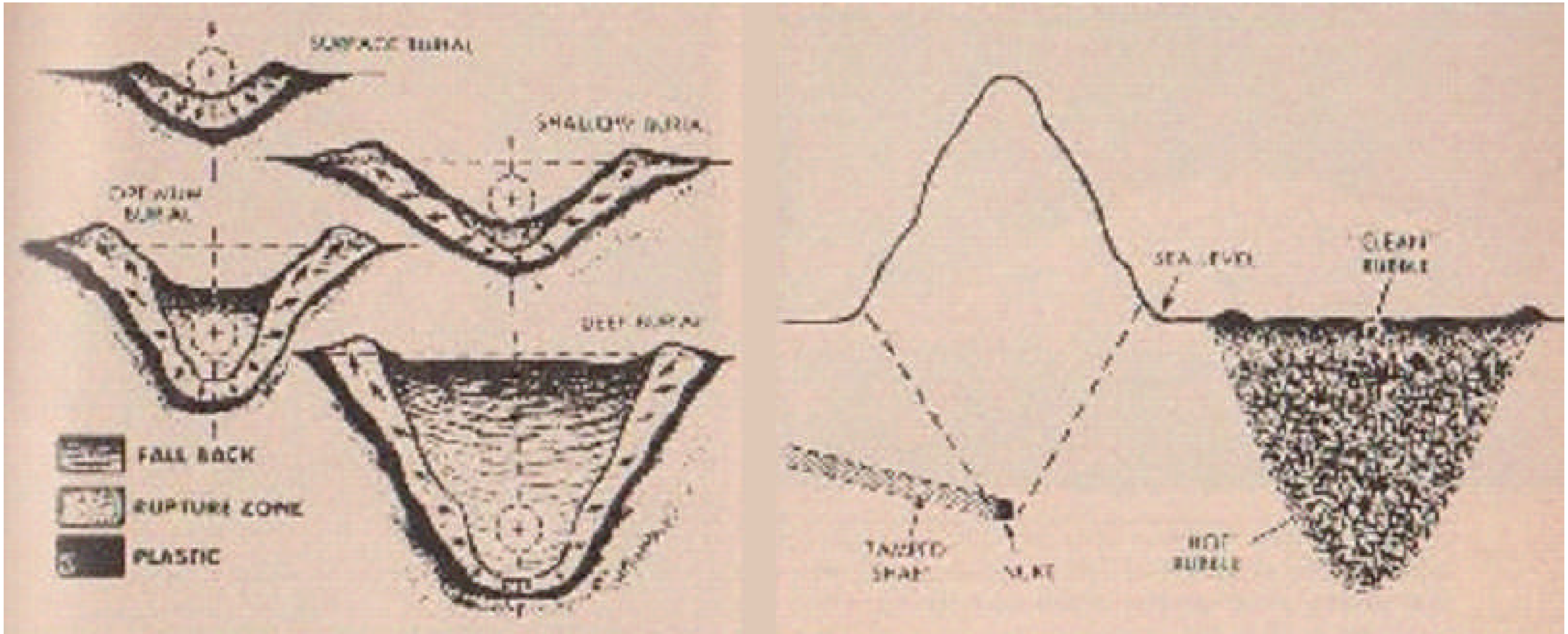


"…The best route, from an engineering standpoint, lies along the Sasardi and Morti Rivers in Panama (see map), some 110 miles east of the present canal. If Panama is ruled out, the canal will be cut farther east, in Columbia, following the Atrato and Truando Rivers…Actually, some 30 routes across Central America were studied by the Canal Company. These were narrowed to five by the A.E.C…"

<u>Above</u>: caption: "Five possible routes for a new canal have been selected from 30 alternates. They include: 1. Tehuantepec, through Mexico; 2. Greytown–Salinas Bay, across Nicaragua; 3. San Blas, through Panama; 4. Sasardi–Morti, through Panama; 5. Atrato-Truando, via Panama and Columbia; 6. Present canal."

***Popular Mechanics,* June 1964**

Nuclear Cratering

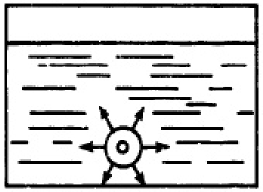


"…The new canal will be dug with clean 'nuclear explosives' – basically hydrogen bombs. They will be used in a 'row charge' blasting technique that digs sharply defined chasms with little need for earth moving equipment. Atomic energy scientists want the record straight on 'nuclear cratering.' Their unique 'row-charges' will not just loosen earth and rock for removal by power shovels and trucks. They will make a canal! This is the key to the trick. The A.E.C. developed the method in a series of Nevada tests. Eight more blasts, spread over four years, will be sufficient to refine the system…"

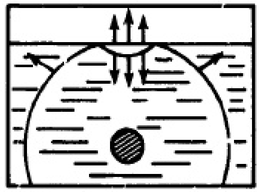
***Popular Mechanics,* June 1964**

Left: caption: "Crater profiles show how shape of ditch can be determined by depth at which explosive charge is planted. In these sketches, (+) indicates charge."

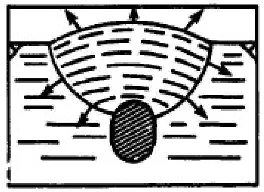
Right: caption: "Single charge, if buried deeply enough, as shown above, will not only level an entire mountain, but will throw rubble so that it falls back, filling the ditch"



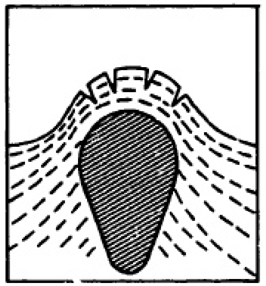
(a) The explosive detonates, generating a shock wave which vaporizes and melts the immediately surrounding material.



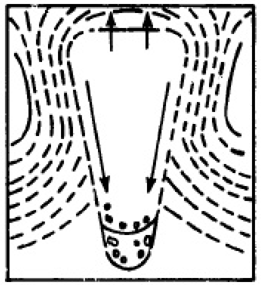
(b) The shock wave reaches and is reflected from the surface, causing it to spall, as the cavity grows spherically.



(c) The reflected tensile wave reaches the cavity, causing accelerated growth toward the surface.

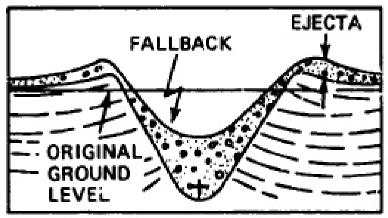


(d) A mound grows and then begins to dissociate, allowing vapor to filter through the broken material.



(e) The mound reaches its maximum development as major venting occurs; crater sides begin to slump.

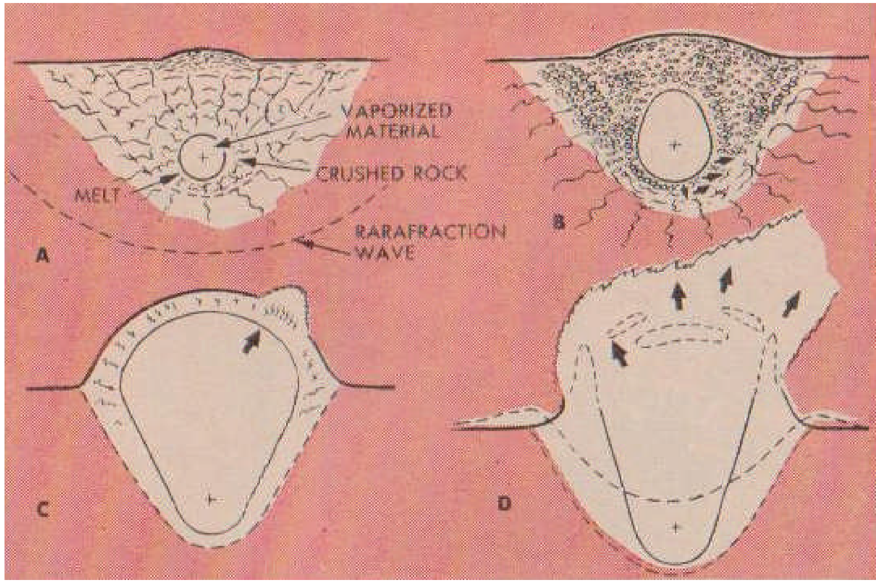
(f) The mound completely dissociates into fallback and ejecta, which are deposited to form the apparent crater and its lip.

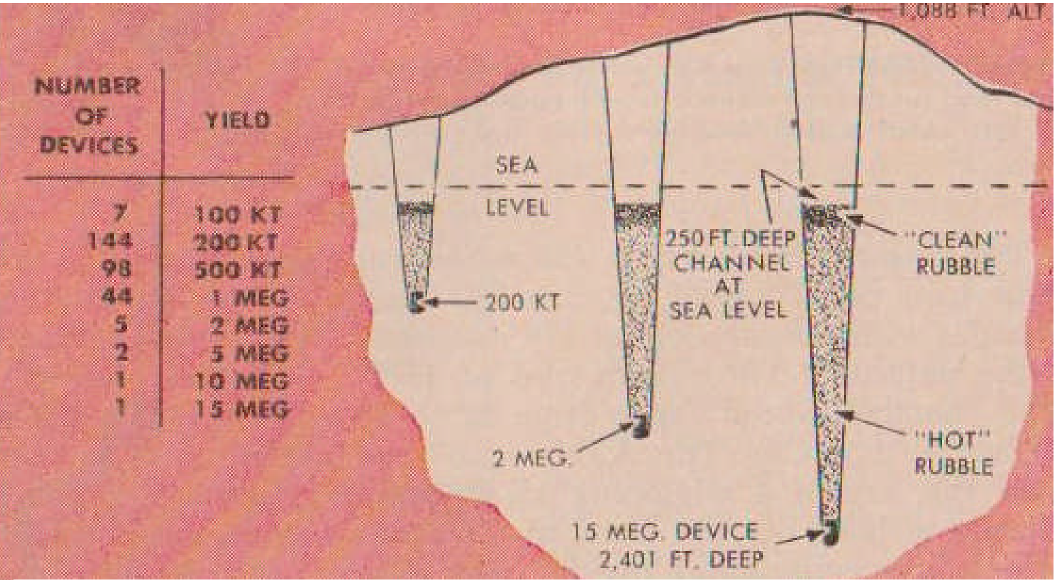


(g) Final configuration of a typical row charge excavation.

NUCLEAR CRATER FORMATION

Diffusion Blasting





"…The real secret of the new technique is called 'diffusion blasting,' first developed with conventional explosives and more recently applied to nuclear devices. Engineers have worked out formulas that tell them what size charge to use, and how deep to bury it in order to blast out a particular size and shape of hole. They can produce ready-made railway cuts, steep walled craters, or even remove mountains. They can so arrange their blast that the debris will fall into a gorge and form a precisely located dam of specific dimensions…"

***Popular Mechanics,* June 1964**

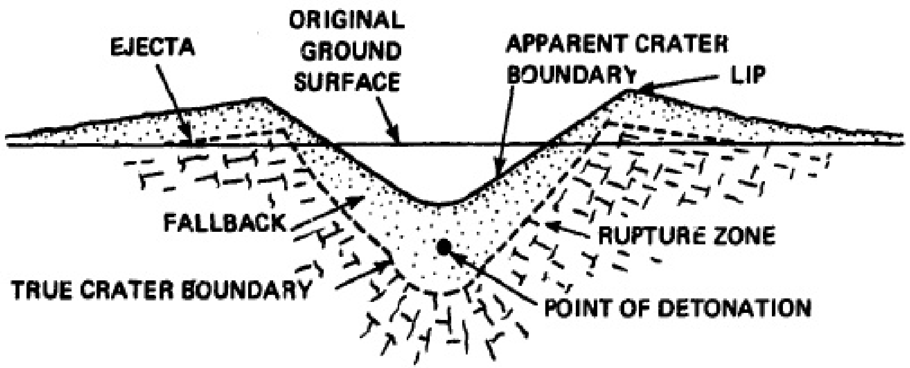
<u>Left</u>: caption: "Bubble development in an underground nuclear blast progresses as shown in sketches above in this four-stage alphabetic sequence. Blow occurs via the tamped hole where the charge was inserted; it appears here in stage C"

<u>Right</u>: caption: "Sasardi-Morti canal route would call for 302 nuclear devices with a total yield of 170 megatons equal to 170 million tons of TNT. To cut a sea-level ditch in simultaneous explosion, bomb depths would vary as shown here."

How Does it Work?

"…How does it work? Charges are placed so that the distance between them is little more than the radius of a single crater. When the charges detonate simultaneously, there is a 'doubling effect' at the points where the impact of one charge meets the punch of its neighbor. Not only does this remove 20 percent more material, but it forms a long, smooth walled trench instead of a line of craters. Even more astounding is the odd fact that row-charge excavating throws the dirt neatly to the sides of the trench; none goes out the ends. Experts suspect that a vacuum forms along the sides of the long row of explosives…It's hard to imagine a row of explosives producing a straight, smooth-sided, clean-bottomed trench with the dirt and rock piled neatly along the sides and none thrown out the ends. But that's what happens in a 'row-charge'…"

Popular Mechanics, **June 1964**



Apparent Crater - That portion of the visible crater which is below the original ground surface.

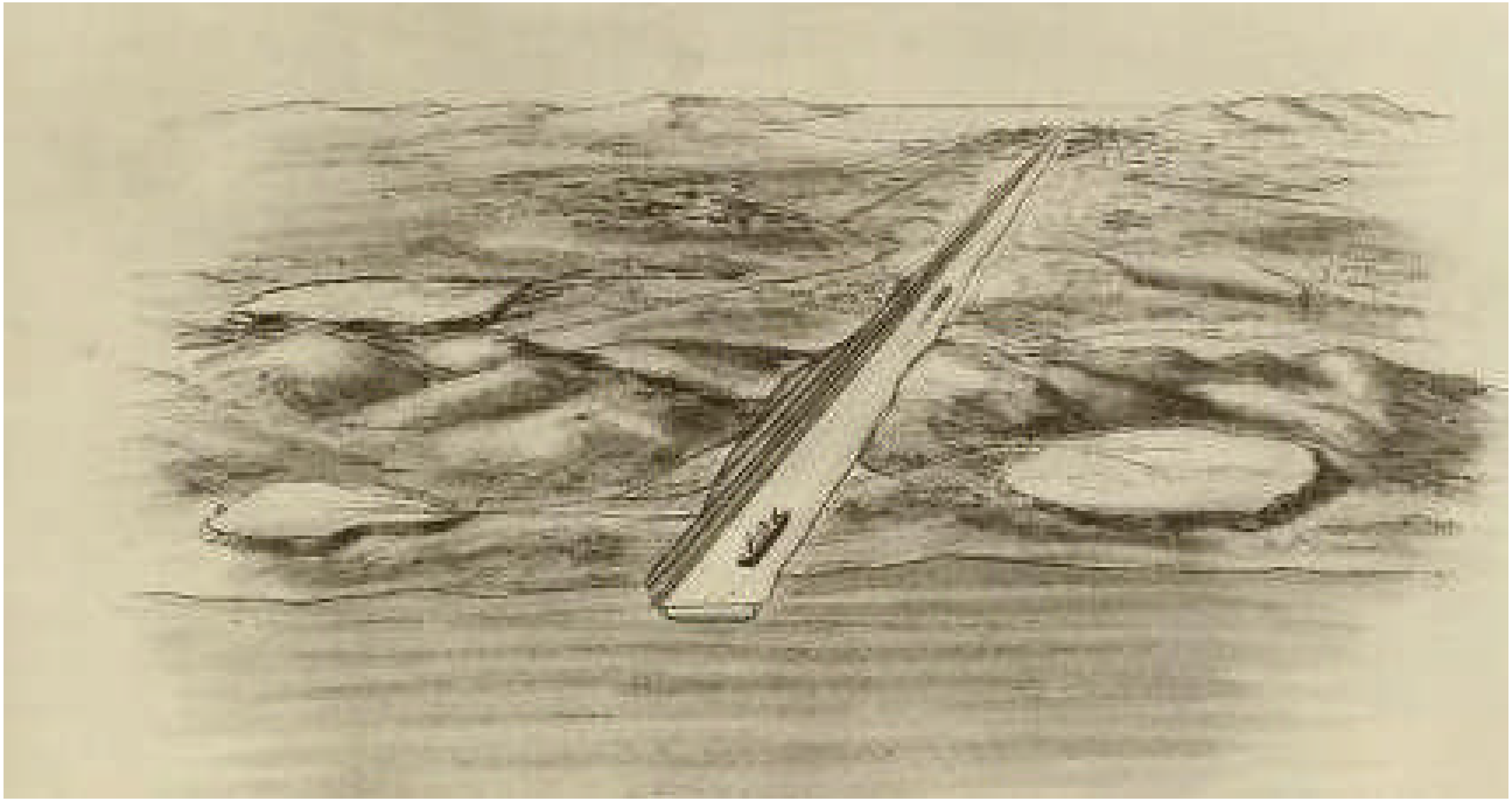
True Crater - The entire void initially created by the explosion including both the apparent crater and the broken and disarranged fallback material.

Fallback - Material thrown into the air by the explosion, which does not have sufficient horizontal velocity to escape the crater area and thus falls back into the void initially created by the explosion (true crater).

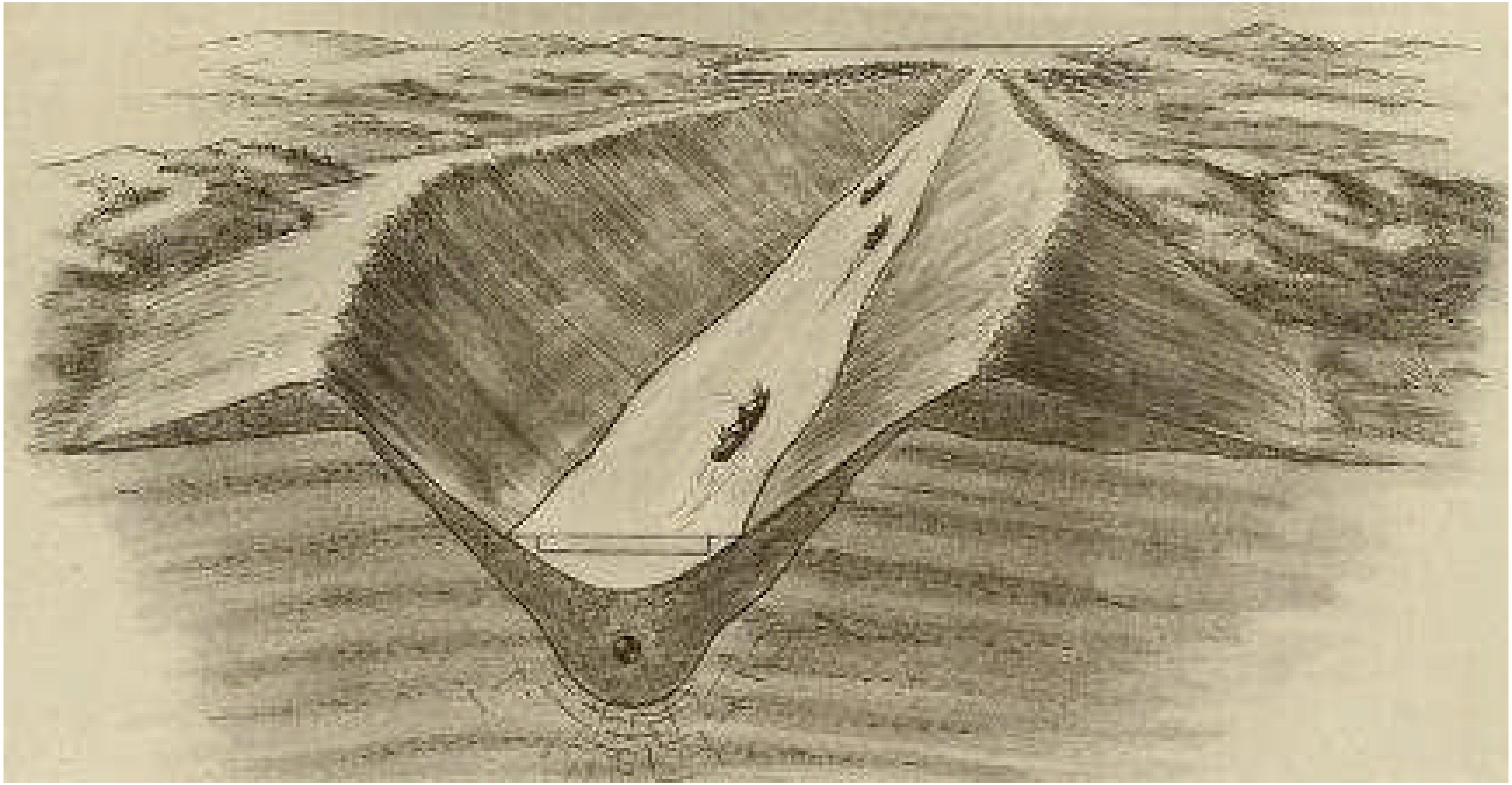
Ejecta - Material thrown into the air by the explosion with sufficient horizontal velocity to escape the crater area. Ejecta landing just outside the void created by the explosion forms part of the crater lip.

Rupture Zone - The region bounding the true crater in which material has been sufficiently stressed to cause fracturing, crushing, and some slight local displacement.

CROSS SECTION OF A ROW CRATER

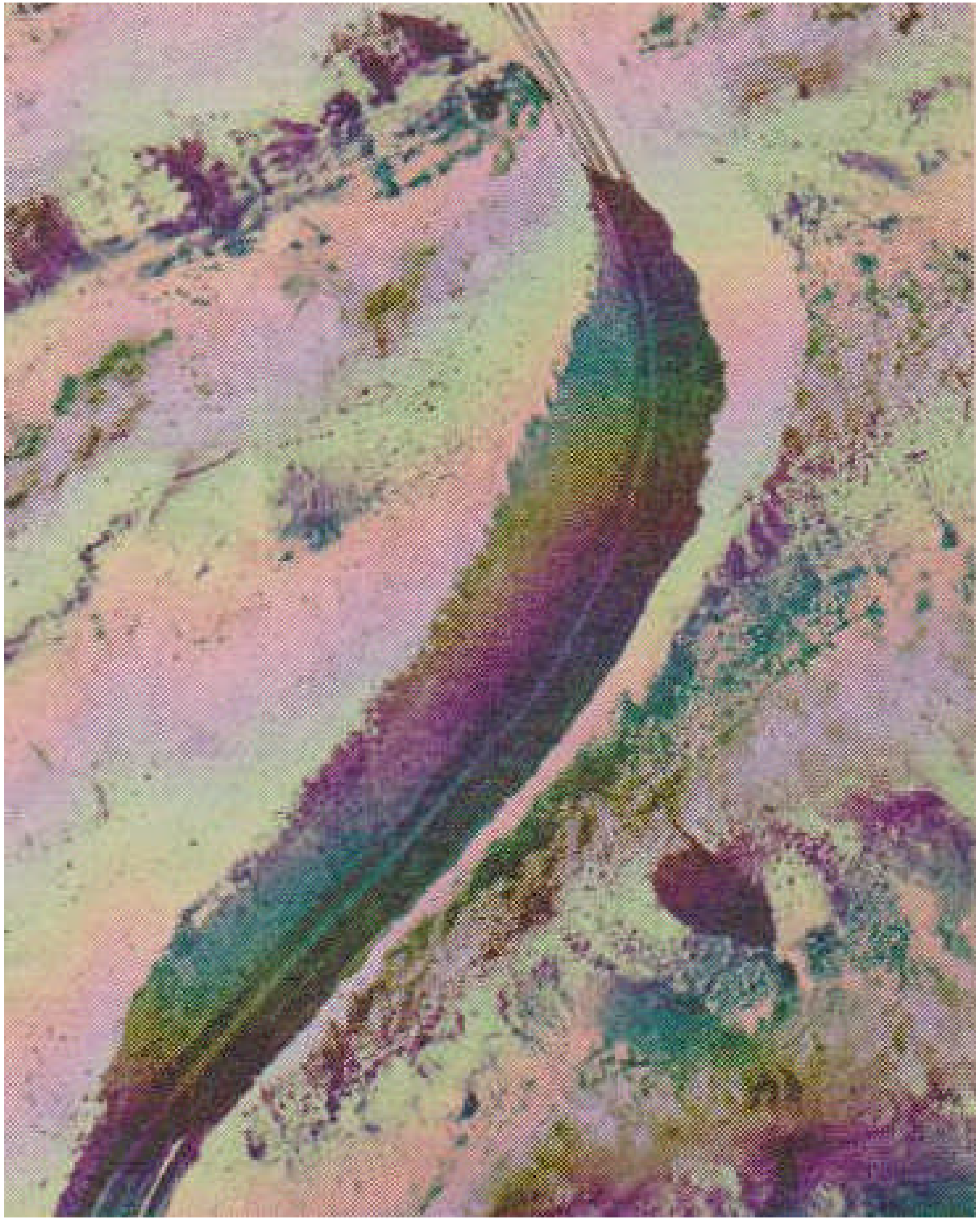


<u>Above</u>: caption: "Ship passing through a single-lane conventionally dug canal, showing the navigation prism. Maximum ground elevation shown is 300-feet. The navigation prism is 550 by 75-feet."



Above: caption: “Ship passing through a two-lane canal excavated by nuclear means, showing the navigation prism. Maximum ground elevation shown is 1,000-feet. The navigation prism is 1,000 by 75-feet.”

Project Carry-All

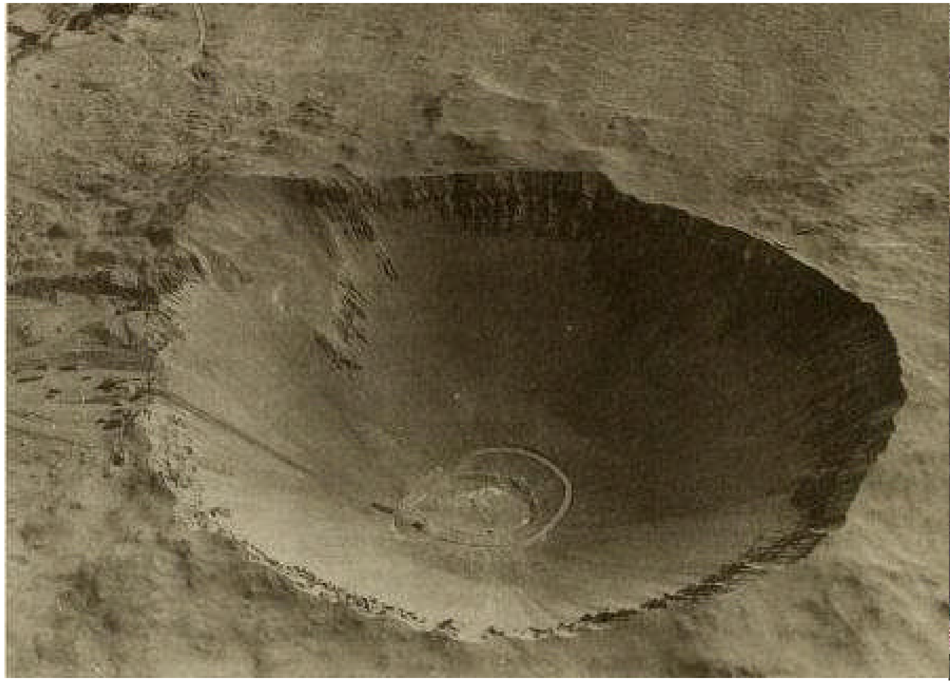


"…One such experiment is 'Project Carry-All,' a plan to cut a railroad and highway pass two miles long through California's Bristol Mountains. It calls for 22 nuclear explosives adding up to 1,730 kilotons. If Carry-All is undertaken, it will give the world a good look at nuclear earth moving…"

Popular Mechanics, **June 1964**

Left: caption: "Project 'Carry-All' in California proposes a road and rail cut through mountains with nuclear charges to test canal project feasibility. This is a model."

What About Radioactivity?



"…What about radioactivity? Five days after the Sedan blast, engineers began working at the crater lip. Six months later, an A.E.C. photographer tramped a zigzag course through the knee-deep, powdery fall-back down to the crater's floor and photographed a four-man team. The radiation level was so low that they did not need protective clothing. Within five years, the A.E.C. contends, radiation will be 100 time <u>less</u> than the Sedan count. This cannot be called a health hazard. But, it can be measured, and the limited nuclear test ban treaty specifies that underground blasts may nor result in any radioactivity outside the national boundaries. Hence, diplomatic agreements must be forged before work can start…"

***Popular Mechanics,* June 1964**

<u>Left</u>: caption: "Sedan, July 6, 1962, 100 Kiloton – the thermonuclear explosion occurred 635 feet below surface and excavated a crater 1,200 feet in diameter and about 320 feet deep with a volume of about 6.5 million cubic yards

<u>Right</u>: caption: "Engineers and scientists conduct a post-shot examination of the rubble at the lip of the Sedan crater in order to determine radiation and make-up of debris"

What Would it Cost?

"…What would a nuclear-dug canal through the Isthmus cost? The Sasardi-Morti route is now estimated at $500 million – far less than the $5 billion estimate for doing it conventionally and one-third less than an estimate made four years ago, thanks to new developments in handling our newest earth mover – the atom."

***Popular Mechanics,* June 1964**

Serving the Future

"For fifty years the Panama Canal has carried ships of all nations between the two great oceans – on terms of entire equality and at no profit to this country. The canal has also served the cause of peace and freedom in two world wars. It has brought great economic contributions to Panama. For the rest of its life the canal will continue to serve trade, and peace, and the people of Panama. But that life is now limited. The Canal is growing old, and so are the treaties for its management, which go back to 1903. So I think it is time to plan in earnest for a sea-level canal. Such a canal will be more modern, more commercial, and will be far easier to defend. It will be free of complex, costly, vulnerable locks and sea-ways. It will serve the future as the Panama Canal we know has served the past and the present."

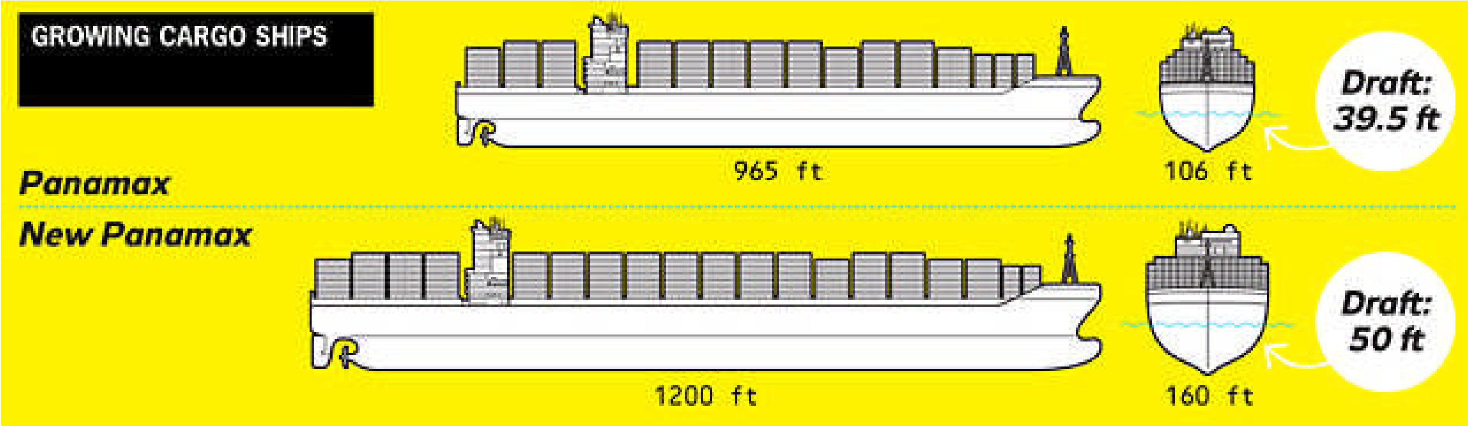
***Lyndon Baines Johnson,* POTUS**

RE: on December 18th 1964, President Johnson announced the willingness of the *United States* to negotiate with the *Republic of Panama* a new treaty to replace the treaty of 1903. At the same time, he stated that the U.S. would request rights to conduct on-site investigations of potential sea-level canal routes not only in *Panama*, but also in *Columbia, Nicaragua* and *Costa Rica*. When *Richard Nixon* became POTUS in January 1969, he retained the original presidential commission and requested it to continue its investigations until completion.

"…While the design was far ahead of its time, ship traffic and technology have been catching up, especially in the last two decades. The number of ships using the canal more than doubled between 1950 and 1970, and the cargo carried through it increased by nearly 400 percent. Despite the fact that the waterway has been lighted its entire length and put on a 24-hour schedule, it will reach the saturation point – 26,800 ships annually – sometime between 1989 and 2000…"

Popular Mechanics, **February 1978**

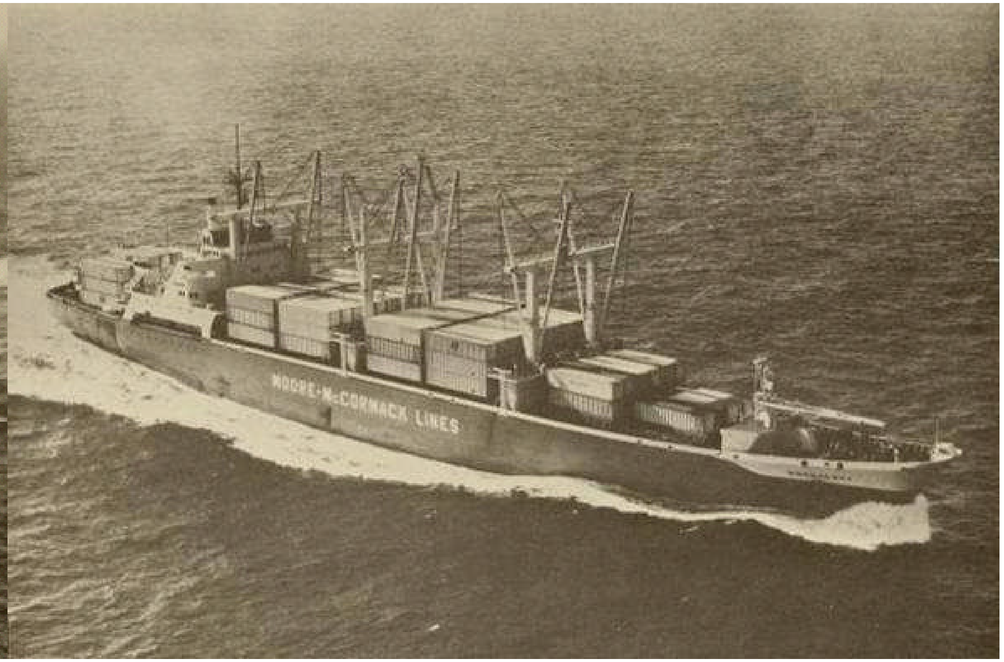
RE: in 1970, a survey revealed that 1,300 ships were too wide to fit thru the Panama Canal's locks. Added to this figure were all of the U.S. Navy's fleet of "super-carriers." Because their capacity exceeded the deadweight tonnage (DWT) limit of 65K-DWT, another 1,750 vessels were unable to use the canal fully loaded. Estimates in the 1970s predicted that fully 50% of the world's tankers would be too large for the *Panama Canal* by the year 2000.



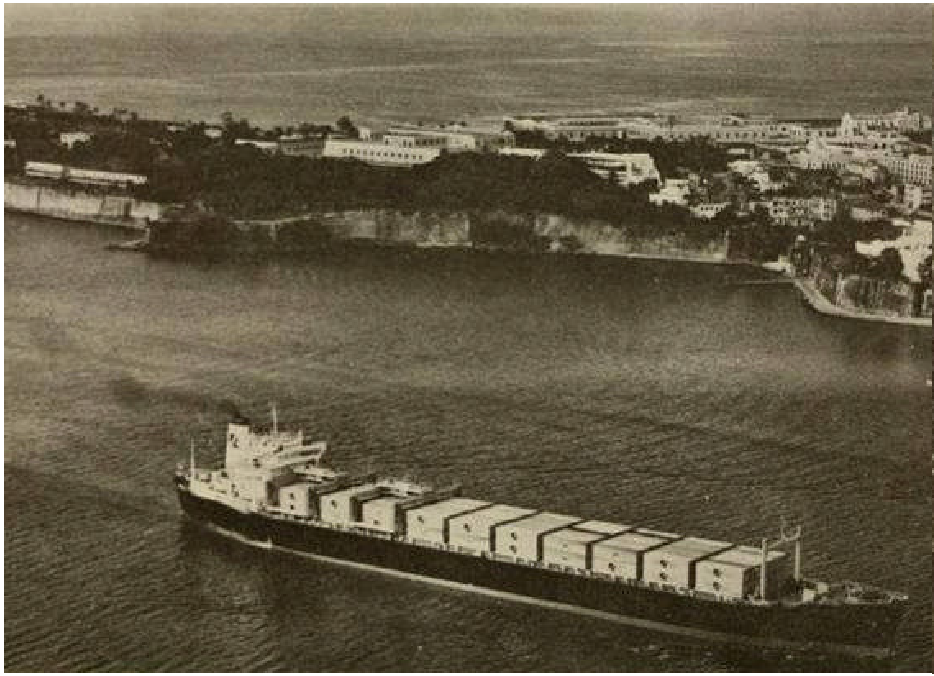
GROWTH OF THE MERCHANT FLEETS OF THE WORLD (1949-1968)
OCEANGOING STEAM AND MOTOR SHIPS OF 1,000 GROSS TONS AND OVER
(Tonnage in Thousands)

Year	Total			Freighters[1]			Bulk Carriers			Tankers (Including Whaling Tankers)		
	Number	Gross Tons	Dead-Weight Tons	Number	Gross Tons	Dead-Weight Tons	Number	Gross Tons	Dead-Weight Tons	Number	Gross Tons	Dead-Weight Tons
1949	12,868	73,640	103,461	10,287	56,031	76,370	559	1,764	2,829	2,022	15,845	24,263
1950	13,282	75,718	107,461	10,583	56,921	78,123	561	1,702	2,776	2,138	17,095	26,318
1951	13,646	78,821	110,655	10,809	58,509	79,414	572	1,782	2,832	3,365	18,530	28,409
1952	14,019	81,924	114,946	11,034	59,804	80,945	576	1,851	2,912	2,409	20,269	31,089
1953	14,370	85,102	119,427	11,226	60,724	82,125	593	1,988	3,107	2,551	22,390	34,195
1954	14,793	89,258	124,754	11,483	62,240	83,476	614	2,214	3,455	2,696	24,804	37,823
1955	15,148	92,944	129,975	11,736	63,931	85,715	653	2,628	4,081	2,759	26,385	40,179
1956	15,615	97,665	136,880	12,077	66,232	88,822	704	3,246	5,122	2,834	28,187	42,936
1957	16,293	104,770	147,316	12,512	69,176	92,826	763	3,880	6,111	3,018	31,714	48,379
1958	16,966	112,314	158,047	12,869	71,551	95,603	868	4,997	7,764	3,229	35,766	54,680
1959	17,185	117,640	166,014	12,802	71,420	95,105	1,016	6,661	10,269	3,367	39,559	60,640
1960	17,317	122,027	171,890	12,766	71,988	95,159	1,185	8,461	12,984	3,366	41,578	63,747
1961	17,426	125,851	177,290	12,705	72,075	94,947	1,349	10,476	15,971	3,372	43,300	66,372
1962	17,861	132,064	185,843	12,861	73,474	96,065	1,592	13,171	19,907	3,408	45,419	69,871
1963	18,033	137,657	194,274	12,871	74,014	96,352	1,726	15,750	23,832	3,436	47,893	74,090
1964	18,115	143,675	204,154	12,810	73,935	96,058	1,822	17,337	26,354	3,483	52,403	81,742
1965	18,329	151,868	217,229	12,776	74,140	95,975	1,971	20,696	31,531	3,582	57,032	89,723
1966	18,423	161,006	232,197	12,666	74,480	95,993	2,103	24,618	37,970	3,654	61,908	98,234
1967	18,800	171,522	250,403	12,692	74,074	95,223	2,368	31,644	49,638	3,740	65,804	105,542
1968	19,361	184,242	273,210	12,857	75,005	96,149	2,609	37,596	59,926	3,895	71,641	117,135

Notes: Excludes ships operating exclusively on the Great Lakes and inland waterways and special types such as channel ships, icebreakers, cable ships, etc., and merchant ships owned by any military force.
[1]Includes following categories: freighters, combination passenger and cargo, combination passenger and cargo refrigerated, and freighters refrigerated.
SOURCE: U.S. Department of Commerce, Maritime Administration



Left: caption: “The S.S. Alaskan Mail, a freighter of the general cargo type”
Right: caption: “The S.S. Mormacsky, a feighter designed for the carriage of containers and roll-on roll-off equipment”



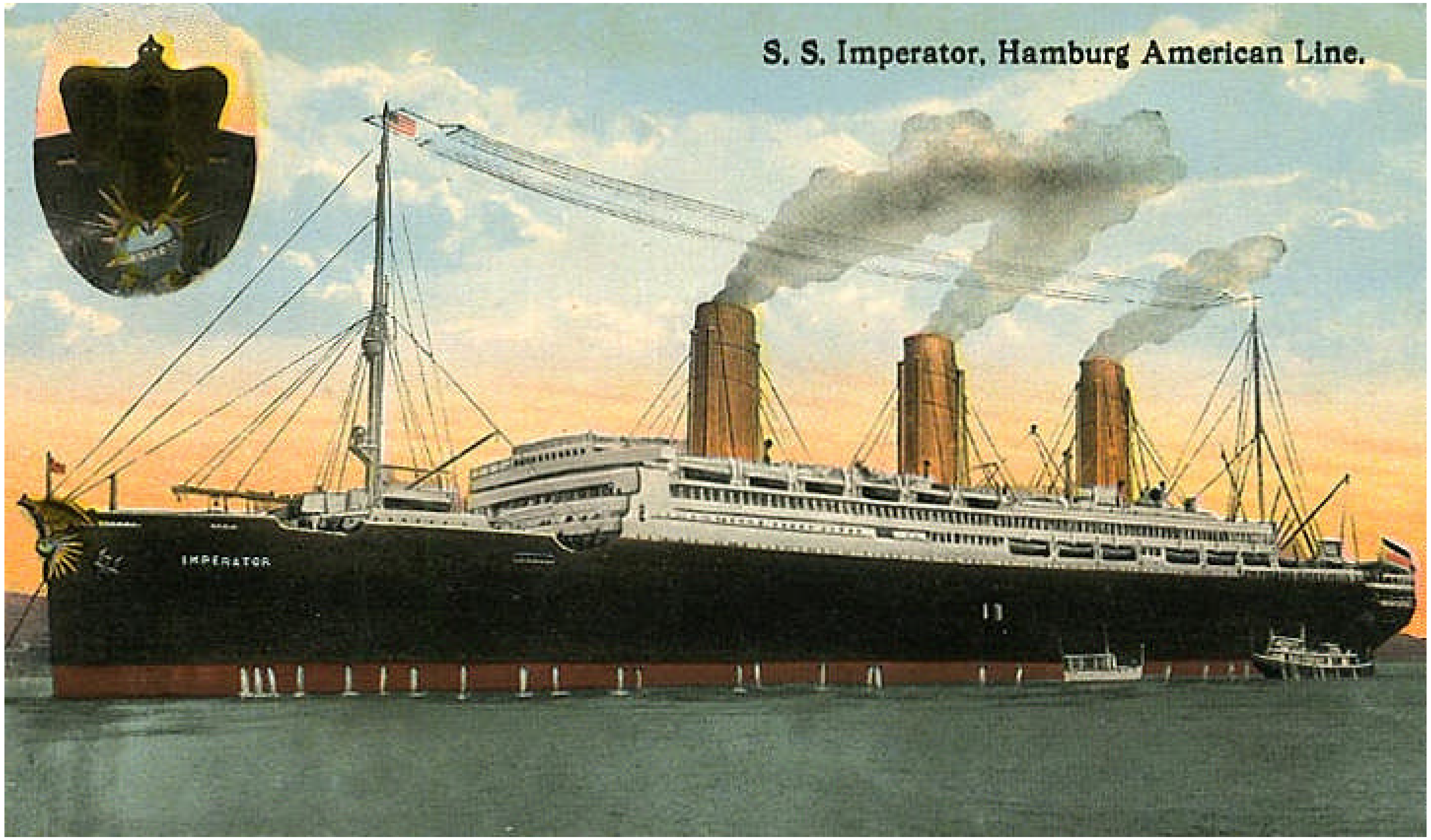
Left: caption: “A containership of the SEALAND fleet used for the carriage of containers exclusively”
Right: caption: “The S.S. Cedros, one of the world’s largest bulk carriers with a capacity of 170,418 DWT”

MAJOR TRADE ROUTES
PANAMA CANAL COMMERCIAL OCEAN TRAFFIC
SELECTED FISCAL YEAR 1947 - 1969
(000 Long Tons of Cargo)

Trade Route	1947	1950	1955	1960	1965	1966	1967	1968	1969
East Coast USA - Japan	532	2,079	5,450	10,719	17,457	20,396	24,145	29,089	32,918
East Coast USA - Asia (less Japan)	2,182	2,130	2,870	3,341	5,083	5,507	6,133	6,920	7,863
Europe - West Coast USA/[1] Canada	4,619	2,828	5,125	6,792	6,921	7,374	6,907	7,483	7,605
East Coast USA - West Coast South America	3,475	4,615	5,970	10,147	7,824	7,629	7,809	6,677	7,334
Europe - West Coast South America	1,314	1,545	2,527	4,584	7,153	6,645	5,694	5,740	5,570
South American Intercoastal	74	116	518	1,115	1,983	2,798	3,248	3,650	3,971
USA Intercoastal[1]	3,401	8,315	6,833	7,364	5,823	5,787	5,153	4,713	3,851
Europe - Asia	20	71	74	245	215	251	676	4,118	3,185
West Indies - West Coast USA[1]	247	349	964	797	2,055	2,145	2,866	2,968	2,883
West Indies - Asia	47	85	463	696	1,586	1,848	2,190	2,854	2,795
Europe - Oceania	1,148	1,718	2,329	2,082	2,379	2,255	2,085	2,682	2,635
East Coast South America - West Coast USA[1]	257	210	431	2,624	2,982	2,968	2,653	2,340	2,502
East Coast USA - Oceania	885	780	1,014	1,057	2,435	2,938	3,004	2,404	2,415
All Other routes	3,470	4,031	6,078	7,695	12,677	13,173	13,630	14,912	15,864
TOTAL	21,671	28,872	40,646	59,258	76,573	81,704	86,193	96,550	101,391

[1] Includes Alaska and Hawaii

SOURCE: Panama Canal Company Annual Reports



"…Although the canal could handle the biggest ship afloat in 1914 – the 52,000-ton, 5,500-passenger 'Imperator,' larger than the 'Titanic' – vessels have begun to crowd the 110-by-1,000-foot locks. The reason: ore and grain, container ships and oil tankers have grown to sizes that would have been beyond comprehension as recent as a dozen years ago…"

***Popular Mechanics,* February 1978**

THE WORLD'S MERCHANT FLEET
HISTORY OF SHIPS 100,000 DWT AND OVER

SUMMARY OF ALL SHIPS

Year	100,000 to 124,999	125,000 to 149,999	150,000 to 199,999	200,000 to 249,999	250,000 to 299,999	300,000 to 349,999	350,000 and Over	TOTAL
Put in operation								
1959	2	–	–	–	–	–	–	2
1960	1	–	–	–	–	–	–	1
1961	–	–	–	–	–	–	–	–
1962	1	1	–	–	–	–	–	2
1963	1	–	–	–	–	–	–	1
1964	3	–	–	–	–	–	–	3
1965	9	–	–	–	–	–	–	9
1966	16	5	1	1	–	–	–	23
1967	20	2	4	1	–	–	–	27
1968	23	5	12	15	–	2	–	57
	76	13	17	17	–	2	–	125
On order as of 12/31/68	29	34	37	124	43	4	1	272
TOTALS	105	47	54	141	43	6	1	397

THE WORLD'S MERCHANT FLEET
HISTORY OF SHIPS 100,000 DWT AND OVER (Cont'd.)
By Ship Type

Ship Type	100,000 to 124,999	125,000 to 149,999	150,000 to 199,999	200,000 to 249,999	250,000 to 299,999	300,000 to 349,999	350,000 and Over	TOTAL
Tankers								
Put in operation 1959-1968	69	12	17	17	–	2	–	117
On order 12/31/68	17	12	24	124	43	4	1	225
TOTALS	86	24	41	141	43	6	1	342
Dry Bulk Carriers								
Put in operation 1959-1968	7	1	–	–	–	–	–	8
On order 12/31/68	12	22	13	–	–	–	–	47
TOTALS	19	23	13	–	–	–	–	55
TOTALS	105	47	54	141	43	6	1	397

FORECAST PROPORTIONS OF SUPER SHIPS IN THE WORLD FLEET

Class	Year	Size Equaled or Exceeded – DWT		
		100,000	150,000	200,000
Freighters	2000	None	None	None
	2020	None	None	None
	2040	None	None	None
Bulkers	2000	3%	2%	1%
	2020	6%	3%	2%
	2040	10%	3%	2%
Tankers	2000	16%	5%	2%
	2020	28%	10%	3%
	2040	44%	18%	8%

CAPACITY OF SOME MAJOR EUROPEAN PORTS

Port	Ship Capacity in DWT	
	Present	Ultimate
Trieste (Muggia Bay)	160,000 DWT	Dredging for 200,000 DWT under consideration
Genoa	100,000 DWT in 1968	–
Naples	–	250,000 DWT
Marseilles	120,000 DWT	200,000 DWT
Bilbao, Spain	–	500,000 DWT (potential)
LeHavre	120,000 DWT	–
Dunkirk	100,000 DWT	125,000 DWT by 1970 250,000 DWT later
Rotterdam (Europort)	200,000 DWT	250,000 DWT in 1969 500,000 DWT ultimate
London	90,000 DWT	–
Milford Haven	100,000 DWT	175,000 DWT
Liverpool	100,000 DWT	Dredging for 150,000 DWT
Southhampton	100,000 DWT	–
Immingham	100,000 DWT	–
Glasgow	100,000 DWT	200,000 DWT in 1969 500,000 DWT possible
Antwerp	60,000 DWT	–
Hamburg	65,000 DWT	Plans for 82' depth
Gothenburg	100,000 DWT	200,000 DWT in 1969

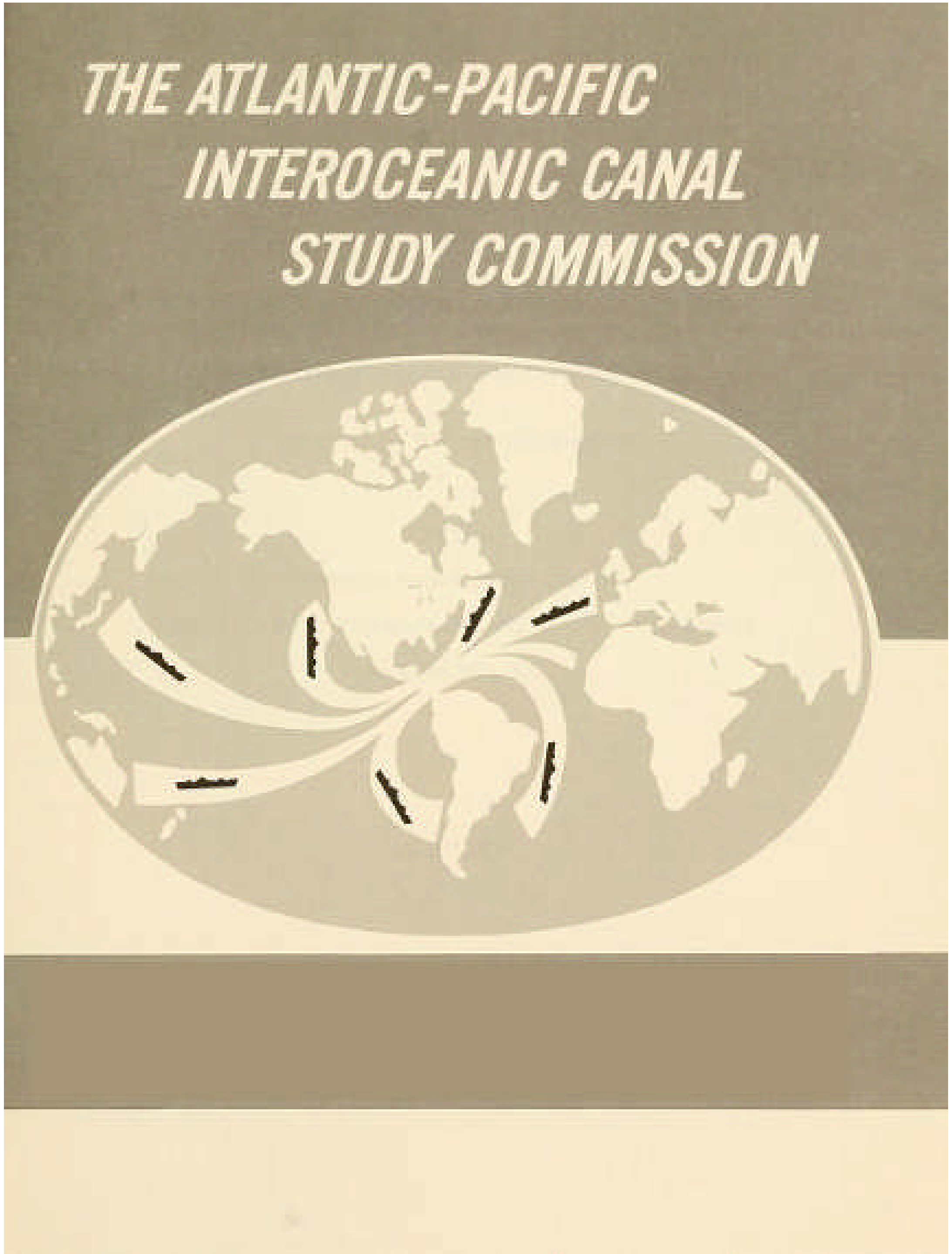
Highlighting the Problem

"…The problem is highlighted by North Slope oil bound for the lower 48 states. Just last August a tanker of 265,000 deadweight tons arrived off Panama. It was the 'S.S. New York' with the first oil from Port Valdez, Alaska. The only way to get crude through the canal is to use a seagoing 'petroleum depot' and a fleet of smaller tankers. Serving as the depot is the super-tanker 'M.V. British Resolution' which will remain anchored 65 miles from the canal until a land-based oil-terminal can be built. It took on 1.8 million barrels of oil from the 'New York' and pumped it into smaller shuttle tankers bound for the Gulf Coast via the canal…"

***Popular Mechanics,* February 1978**


APERTURA DEL CANAL DE PANAMA
CONSTRUYENDO EL FUTURO
75 Años
60
PANAMA
Honramos el Pasado 1914-1989
CARTOR

The Interoceanic Study Commission



"…To answer these questions, Congress established in 1964 an Atlantic-Pacific Interoceanic Canal Study Commission to gather data, evaluate possible routes and report on nuclear and other excavation techniques. The Commission's report, produced in 1970, still stands as a landmark. While postwar surveys have identified some 30 potential canal routes crisscrossing Central America from Mexico all the way down to Columbia, the Commission settled on just eight, later eliminating half of them…"

***Popular Mechanics,* February 1978**

ATLANTIC-PACIFIC INTEROCEANIC CANAL STUDY COMMISSION
726 JACKSON PLACE, N.W.
WASHINGTON, D.C. 20506

December 1, 1970

The President
The White House
Washington, D. C.

Dear Mr. President:

We have the honor to submit herewith the final report of the Atlantic-Pacific Interoceanic Canal Study Commission as required by Public Law 88-609, 88th Congress, as amended.

One provision of the law required us to determine the practicability of nuclear canal excavation. Unfortunately, neither the technical feasibility nor the international acceptability of such an application of nuclear excavation technology has been established at this date. It is not possible to foresee the future progress of the technology or to determine when international agreements can be effectuated that would permit its use in the construction of an interoceanic canal. Hence, although we are confident that someday nuclear explosions will be used in a wide variety of massive earth-moving projects, no current decision on United States canal policy should be made in the expectation that nuclear excavation technology will be available for canal construction.

The construction of a sea-level canal by conventional means is physically feasible. The most suitable site for such a canal is on Route 10 in the Republic of Panama. Its construction cost would be approximately $2.88 billion at 1970 price levels. Amortization of this cost from toll revenues may or may not be possible, depending on the growth in traffic, the time when the canal becomes operative, the interest rate on the indebtedness, and payments to the host country. We believe that the potential national defense and foreign policy benefits to the United States justify acceptance of a substantial financial risk.

As a first step, we urge that the United States negotiate with Panama a treaty that provides for a unified canal system, comprising both the existing canal and a sea-level canal on Route 10, to be operated and defended under the effective control of the United States with participation by Panama.

If suitable treaty arrangements are negotiated and ratified and if the requisite funds can then be made available, we recommend that construction of a sea-level canal be initiated on Route 10 no later than 15 years in advance of the probable date when traffic through the present canal will reach its transit capacity. Current trends indicate that this will be near the end of this century; the specific year can be projected with increasing confidence as it draws nearer.

We recognize, however, that the President of the United States and the Congress will continue to face many serious funding problems and must establish the relative priorities of the requirements for defense, welfare, pollution, civil rights, crime, and other problems in social undertakings then existing.

We specifically recommend that, when the rights and obligations of the United States under new treaties with Panama are determined, the President reevaluate the need and desirability for additional canal capacity in the light of canal traffic and other developments subsequent to 1970, and take such further steps in planning the construction of a sea-level canal on Route 10 as are then deemed appropriate.

Respectfully,

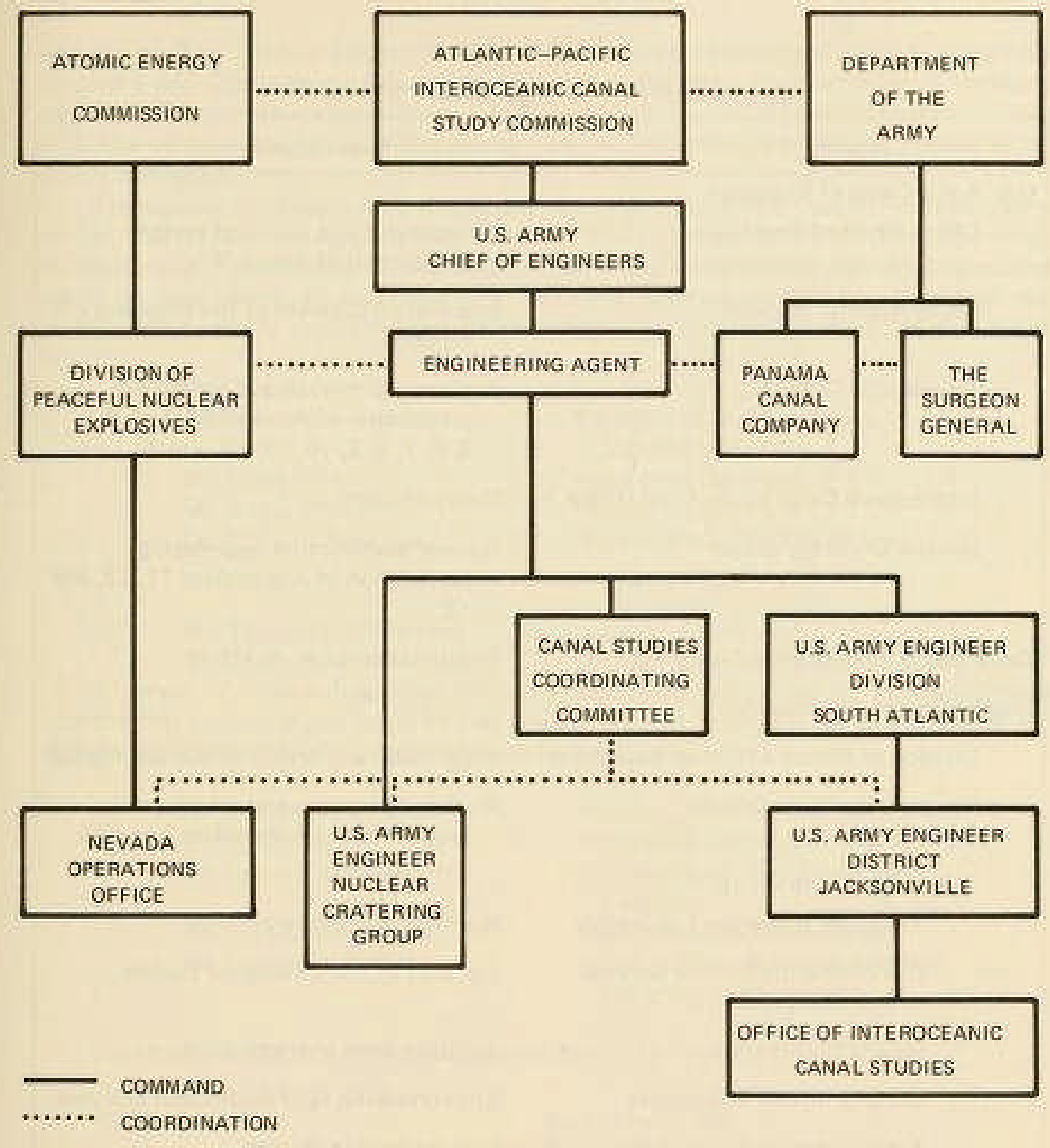
Robert G. Storey

Milton S. Eisenhower

Kenneth E. Fields

Raymond A. Hill

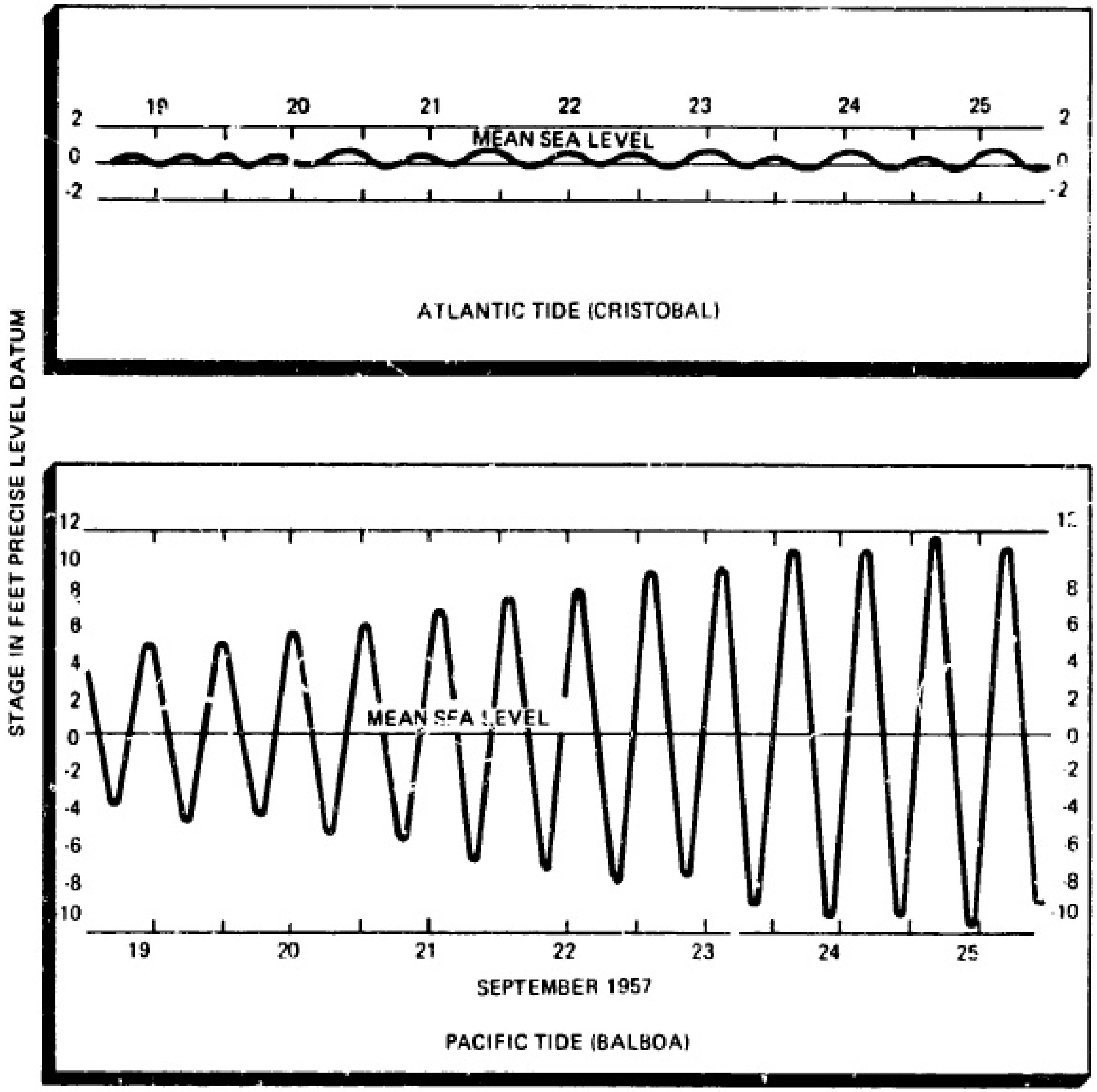
Robert B. Anderson, Chairman



ORGANIZATION OF THE
STUDY EFFORT

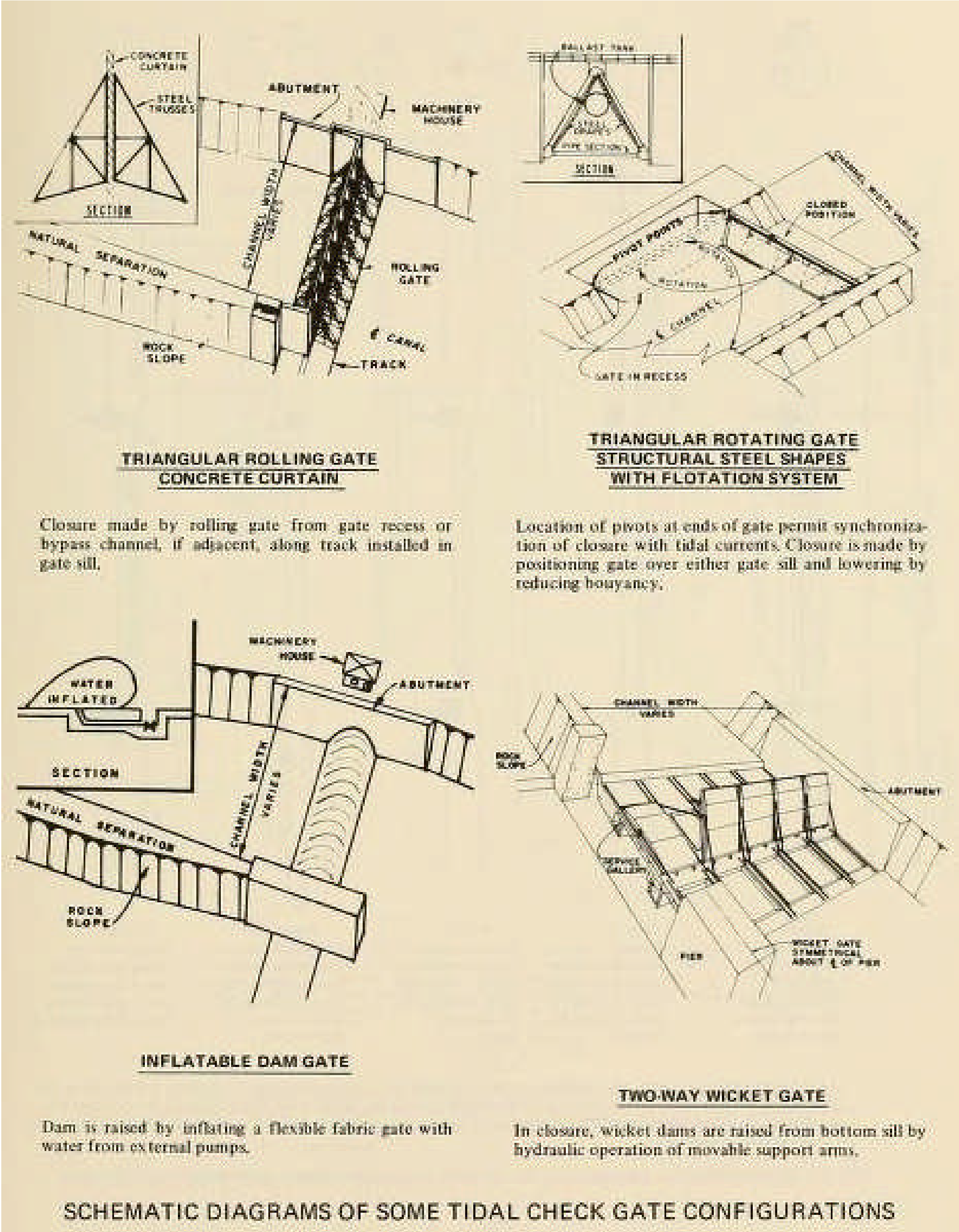
"…The vision of joining the oceans at sea-level persisted after the French suffered their disastrous failure. Theodore Roosevelt was dissuaded from it only after engineer John Stevens pointed out in 1906 that the idea would take billions more dollars and a decade longer than a lock canal. While a wide sea-level canal could handle super-tankers and other large ships, how would a channel containing six or more times the amount of earth removed for the present canal be excavated? What about the problem of joining the oceans, the Pacific with tides up to 11 feet above sea-level and as much as 10 feet below? Wouldn't it be better to consider a new or enlarged lock canal instead?..."

Popular Mechanics, **February 1978**

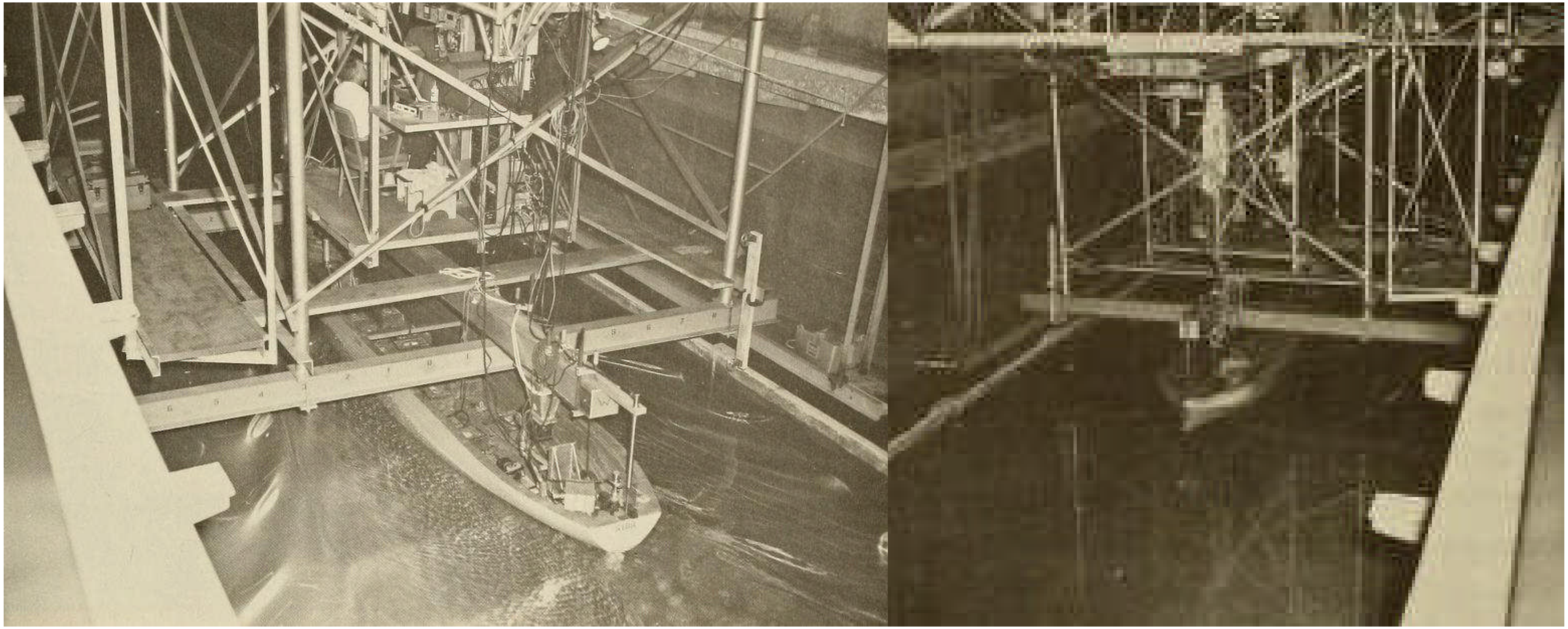


<u>Above</u>: caption: "Seven Day Tide Record"

Tidal Checks



"…What hazards would canal currents present to large ships negotiating a narrow passage?...With tidal currents estimated as ranging between 3.7 and 5.1 knots on Route 10, navigation would be possible even without control measures. For safety, however, devices known as tidal checks would be installed to keep currents below 2 knots. These would simply be large barriers that would be rolled or floated across a sea-level canal as tides change, moving back out of the way of oncoming ships traveling in convoys…"
Popular Mechanics, **February 1978**

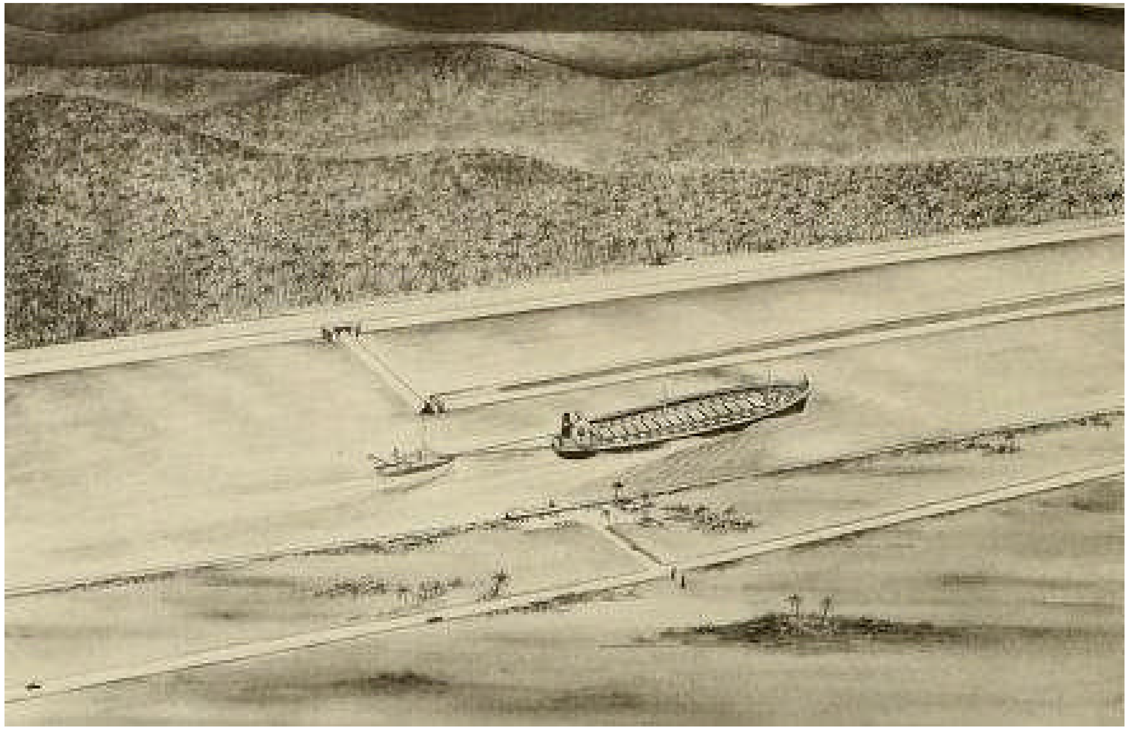


"…the U.S. Navy has set up a miniature canal at Carderock, Maryland for experimentation with channel currents, locks, and ship operations…"

***The Rotarian,* March 1949**

<u>Left</u>: caption: "Scale model of a 250,000 DWT tanker undergoing tests in the Naval Ship Research and Development Center to determine the controllability of large ships in a sea-level canal."

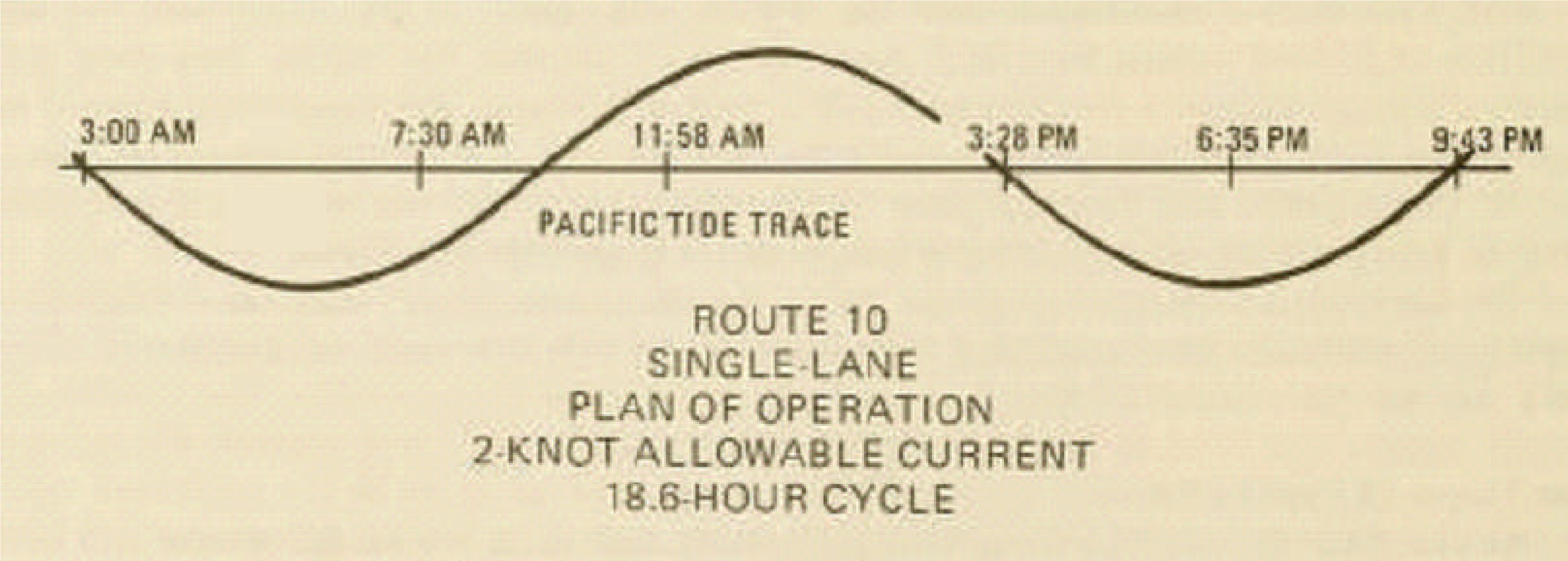
<u>Right</u>: caption: "Model of 250,000 DWT ship undergoing tests to determine its handling characteristics in confined waters. Since there was only limited information available on this subject the Commission was forced to research the question."



"…The uncertainty of safety of navigation under all tidal conditions led to consideration of a new concept: the installation of a tidal control structure at each end of a long restricted reach to limit the velocities of flow in a sea-level canal. It is contemplated that one structure and gate would be located close to the Pacific entrance and another 24 to 25 miles north thereof. The check gates would be moved alternately into position across or out of the channel at intervals of 6.2 hours or some multiple thereof when the Pacific is at the same level as the Atlantic. Under these conditions, the maximum velocity of flow would be approximately 2 knots at the Pacific entrance and less elsewhere. It is also contemplated that structures for gates would be built close to the Atlantic entrance where, if a gate were installed and employed alternately with the Pacific gate, the maximum velocity could be held to approximately 3 knots…"

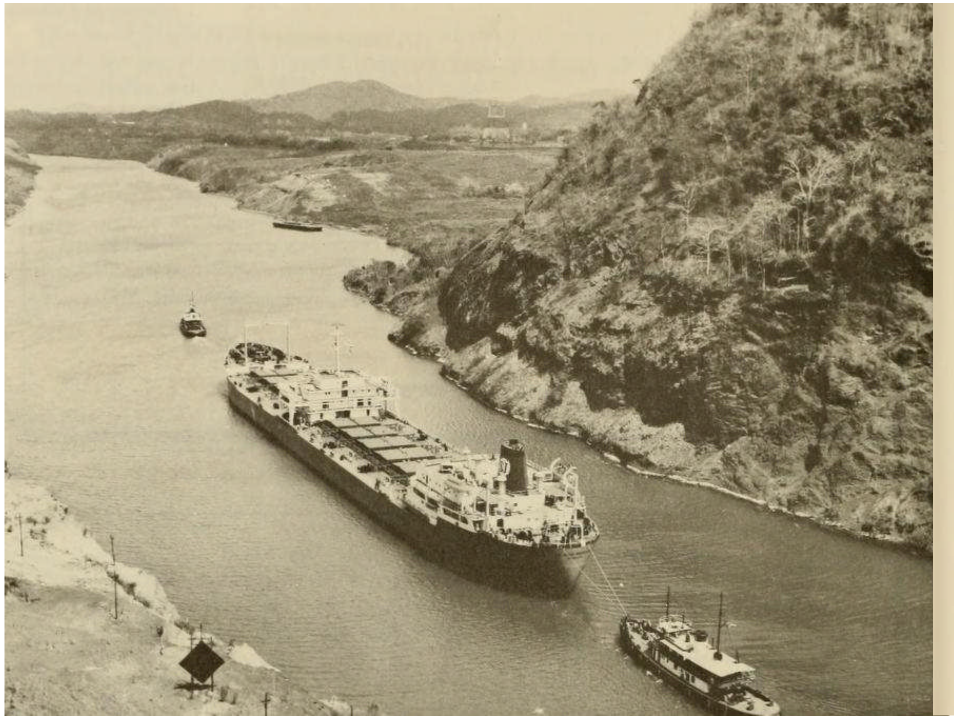
RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

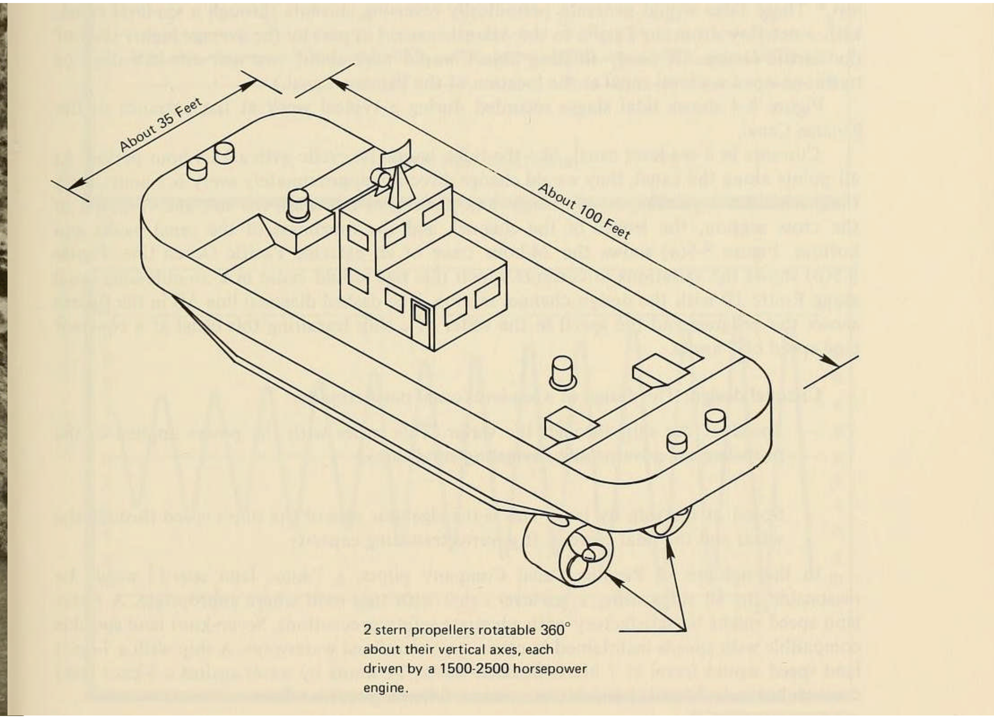
<u>Above</u>: caption: "Artist's sketch of a Tidal Check at the entrance to a Bypass Channel"



"…While Atlantic tides along the Isthmus are gentle and irregular (about 1.3 feet above and below mean sea-level), the Pacific rises from 5 to 11 feet and falls from 4 to 10 feet twice a day. As a result, the mean level of the Pacific is slightly higher; it's 8 inches higher at Balboa, for example, than the Atlantic is at Cristobal. A sea-level canal would thus produce a gentle sloshing back and forth, but the ultimate result would be the movement of some water from the Pacific to the Atlantic. If a completely unobstructed canal was built at Route 10, for example, the maximum flow of water would be about 45,000 cubic feet per second, some 10,000 less than the Missouri flowing past Kansas City…"

***Popular Mechanics,* February 1978**





Left: caption: “Tug assistance is required for all large ships in the present canal and is expected to be similarly required in a sea-level canal”
Right: caption: “Conceptual design of a sea-level canal tug”

Biotic Interchange

"…While tidal checks operating in synchronization with the tides would reduce the net flow of water to almost nothing, a sea-level canal could speed biotic interchange. Would the result be possible disaster as predicted by some marine biologists, or could it lead to beneficial changes as some maintain? Although our knowledge of the various species of fish and other organisms that inhabit the coastal regions of the Isthmus is too limited to make predictions, biotic interchange might be prevented simply by heating the canal water at some point or reducing its salt content. The hot condenser water from a power-plant would provide the heating, and the rivers along Route 10 could dilute salty ocean water. An effective fresh water barrier already exists at the present Panama Canal, for ships emerge from Gatun Lake with their hulls cleansed of barnacles and other organisms. Finally, other examples of biotic interchange are somewhat reassuring. No ill effects have been traced to the limited migration that has been taking place since the present canal opened, this in the variety of small plants and animals carried in ship ballast water from one ocean to another. The result of connecting the Red Sea and Mediterranean through the Suez Canal over 100 years ago has been the migration of 24 Red Sea species. While no harmful effects have been noted to date, 11 of the 24 types are now commercially important to Mediterranean fishermen…"

***Popular Mechanics,* February 1978**

Route 10

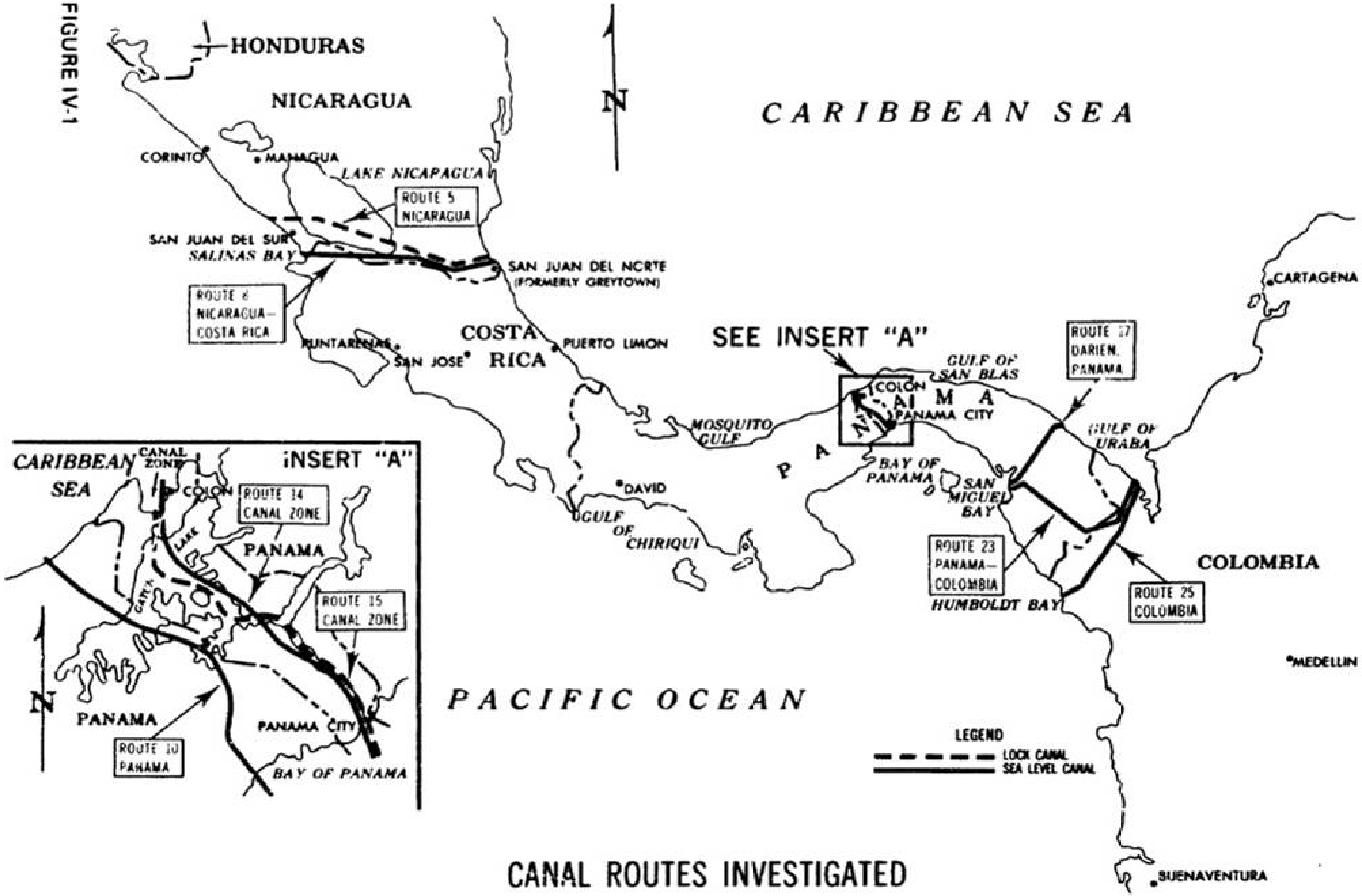
CANAL ROUTES SELECTED FOR COMMISSION INVESTIGATION

Route No.	Route Name	Country	Type of Canal/ Excavation Method	Basis of Evaluation
5	San Juan del Norte-Brito	Nicaragua and Costa Rica	Lock/Conventional	Available data
8	San Juan del Norte-Salinas Bay	Nicaragua and Costa Rica	Sea-Level/Conventional or Nuclear	Available data
10	Chorrera-Lagarto	Panama	Sea-Level/Conventional	Available data augmented by geological investigations
14-Combined	Panama Canal Sea-Level Conversion	Canal Zone	Sea-Level/Conventional	Available data augmented by geological investigations
14-Separate	Panama Canal Sea-Level Conversion	Canal Zone	Sea-Level/Conventional	Available data augmented by geological investigations
15	Panama Canal	Canal Zone	Lock/Conventional	Available data
17	Sasardi-Morti	Panama	Sea-Level/Conventional and Nuclear Combination	Comprehensive on-site survey
23	Atrato-Tuira	Colombia and Panama	Sea-Level/Conventional or partially Nuclear	Available data augmented by data from surveys on Routes 17 and 25.
25	Atrato-Truando	Colombia	Sea-Level/Conventional and Nuclear Combination	Comprehensive on-site survey

"…Route 10, a brand-new sea-level canal 10 miles west of the present Panama Canal, received strong endorsement in 1970 and may still be the best choice. Running between Lagarto on the Caribbean and La Chorrera and Puerto Calmito on the Pacific, the route passes through an underdeveloped area with only a few farms breaking into the jungle…"

***Popular Mechanics,* February 1978**

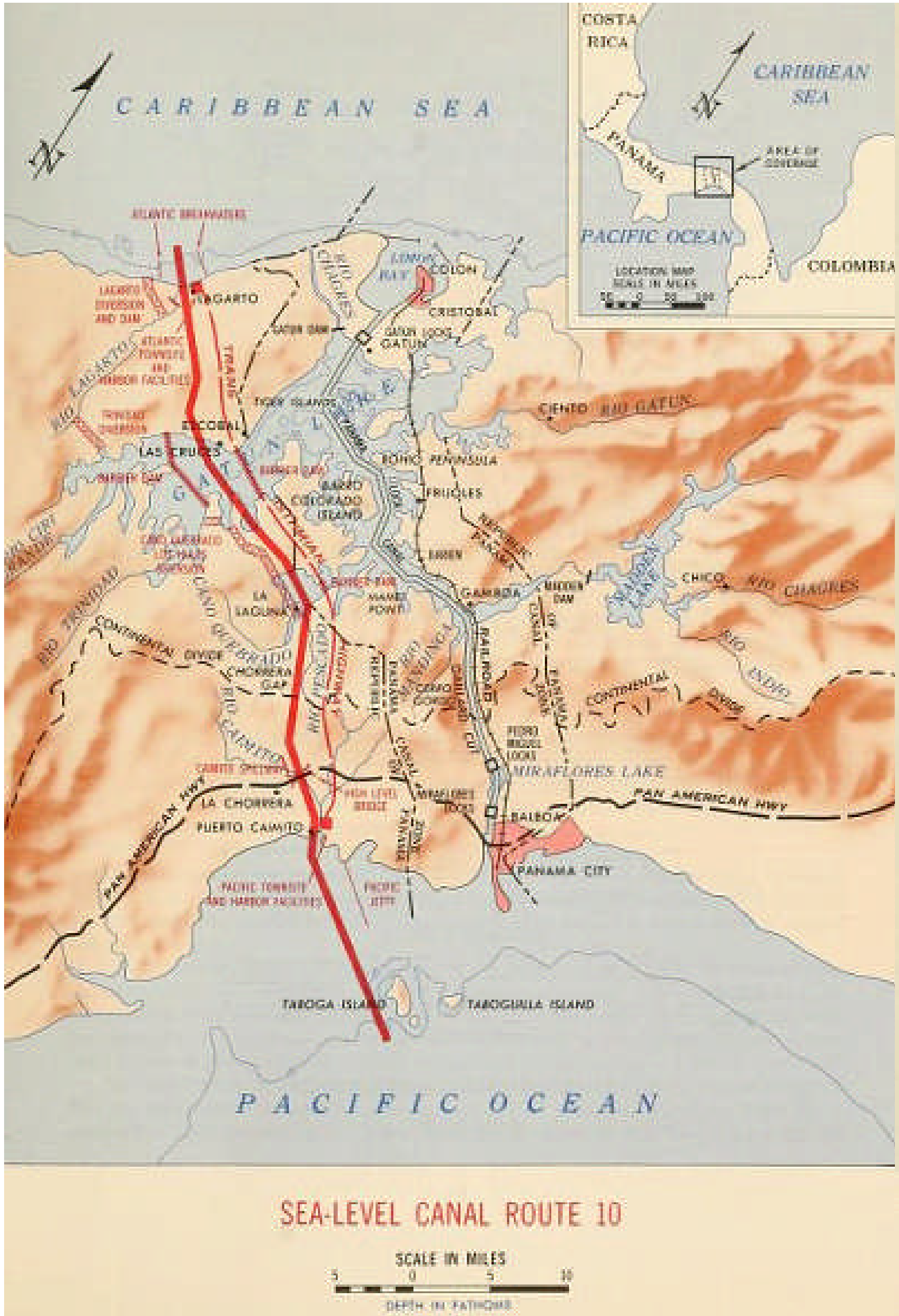
FIGURE IV-1

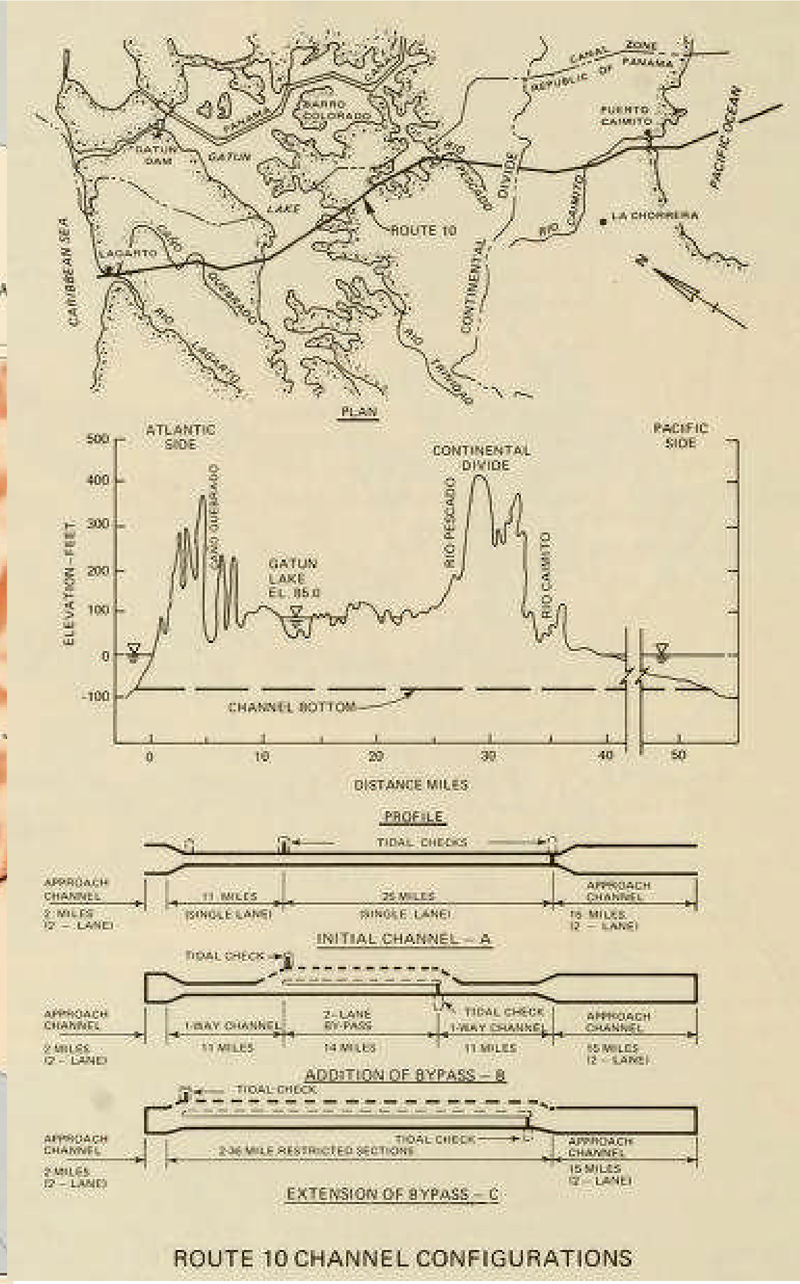


CANAL ROUTES INVESTIGATED

"…Route 10 is approximately 10 miles to the west of the existing Panama Canal. With the exception of two short reaches across arms of Gatun Lake, the route lies outside the present Canal Zone. The area is undeveloped except for a few small farms and grazing lands interspersed with jungle. The proximity of the Canal Zone would permit use of existing Panama Canal facilities in support of canal operations…Past negotiations indicate that a sea-level canal on Route 10 should be acceptable to Panama under reasonable treaty conditions. The precise treaty conditions can be determined only by further negotiations, but the objective of the United States and Panama in any canal on Panamanian territory do not appear to be irreconcilable. Construction of a canal on Route 10 would not bring about any shift of canal operations from near Panama's metropolitan centers. The avoidance of interference with traffic during the construction phase and the preservation intact of the existing canal after a new canal is opened would have distinct advantages for Panama. Construction of a canal on Route 10 would permit future operation of the existing canal in combination with the sea-level canal and leave Route 14 available for construction of a second sea-level canal if one were ever needed…

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970


CARIBBEAN SEA
PACIFIC OCEAN
COSTA RICA
PANAMA
COLOMBIA
LIMON BAY
COLON
CRISTOBAL
GATUN
LAGARTO
ESCOBAL
LAS CRUCES
BARRO COLORADO ISLAND
FRIJOLES
GAMBOA
LA LAGUNA
LA CHORRERA
PUERTO CAMITO
BALBOA
PANAMA CITY
MIRAFLORES LAKE
PAN AMERICAN HWY
TABOGA ISLAND
TABOGUILLA ISLAND
RIO GATUN
RIO CHAGRES
CONTINENTAL DIVIDE
SEA-LEVEL CANAL ROUTE 10
SCALE IN MILES


PLAN
PROFILE
ATLANTIC SIDE
PACIFIC SIDE
CONTINENTAL DIVIDE
GATUN LAKE EL. 85.0
ELEVATION–FEET
CHANNEL BOTTOM
DISTANCE MILES
INITIAL CHANNEL – A
ADDITION OF BYPASS – B
EXTENSION OF BYPASS – C
ROUTE 10 CHANNEL CONFIGURATIONS

Route 10

Total construction cost	$2,880,000,000
Channel excavation volume	1,870,000,000 cubic yards
Channel excavation cost	$2,030,000,000
Construction time	14 years (includes 2 years for preconstruction design)
Operation and maintenance cost	$57,000,000/year (for 35,000 transits)

These data are based on construction and operation of a sea-level canal with a 36-mile single-lane land cut and 17 miles of two-lane approach channels. Ships up to 150,000 DWT could be accommodated under all conditions; larger ships up to 250,000 DWT could be accommodated under controlled conditions. Tidal gates would be installed and used continuously to limit current to no more than 2 knots.

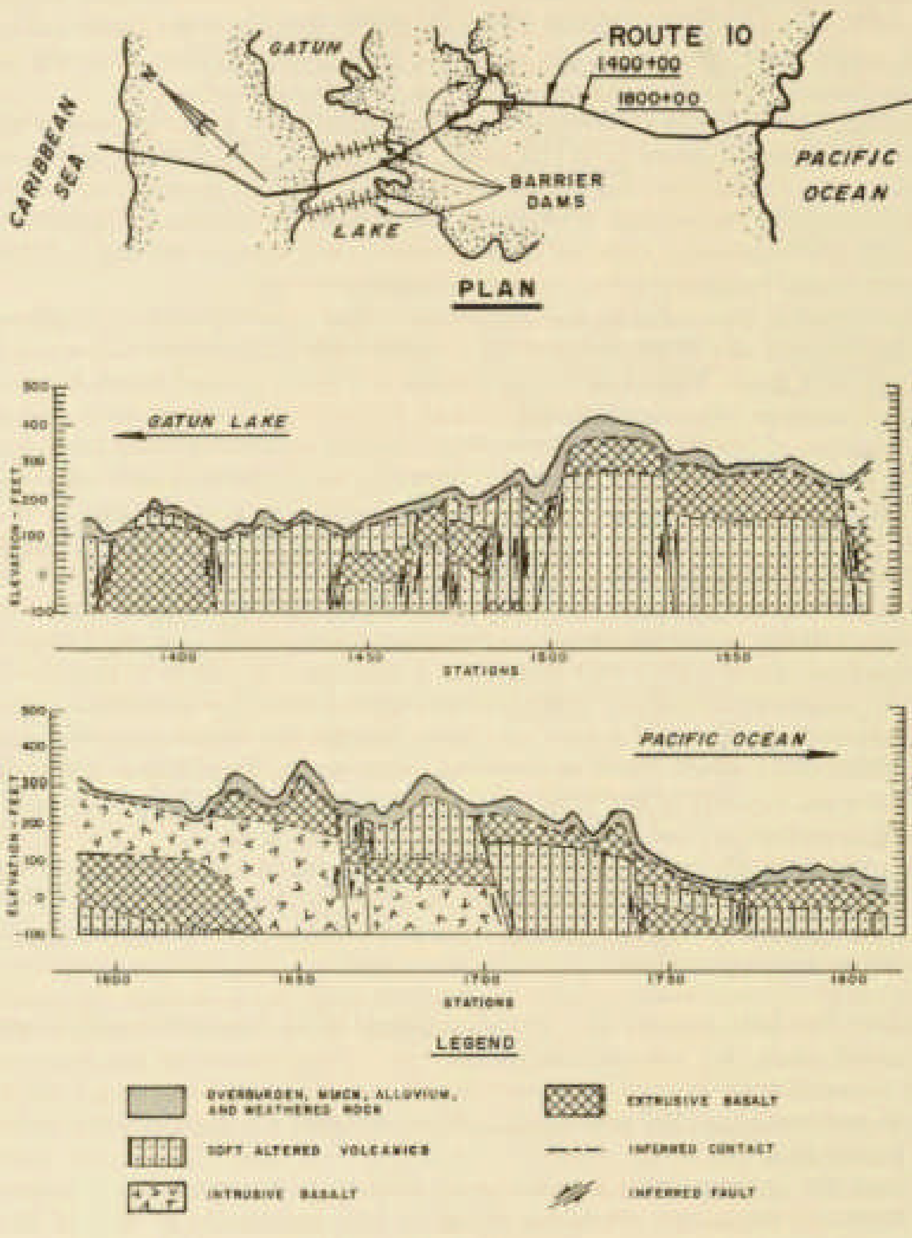
This configuration would have an effective capacity of 38,000 transits/year. At this capacity, the time lost by a ship in slowing down, forming into a convoy, passing through the canal, and regaining open ocean speed would be comparable to time lost by a ship passing through the Panama Canal in 1970. At lower traffic levels, time lost would be significantly less.

If experience showed that additional capacity would be required on this route, a 14-mile bypass would be constructed for about $460,000,000. It would have an effective capacity of 56,000 transits/year and, at all levels of capacity, would allow less time in transit than a single-lane canal.

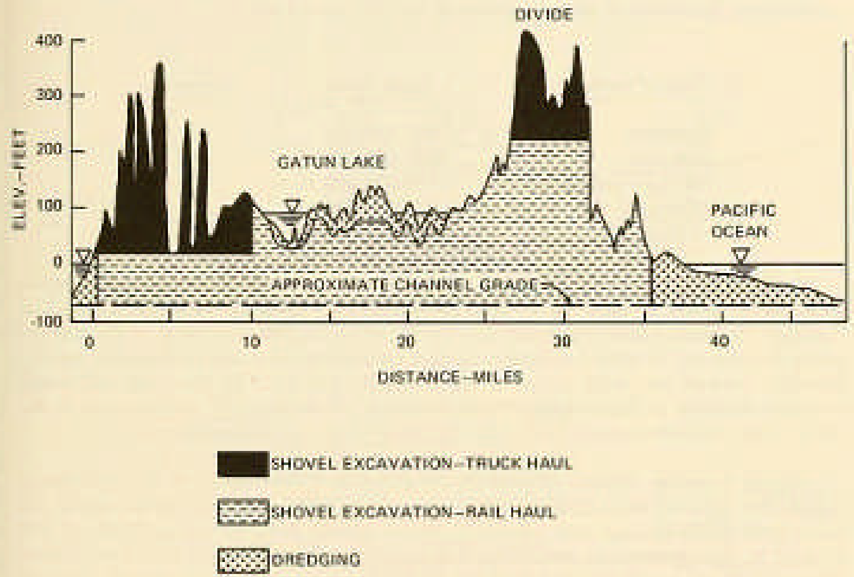
<u>Above</u>: caption: "Route 10 Data Estimates"

"…The mammoth construction job, a 14-year, $3 billion project, would use barrier dams to isolate the work from Lake Gatun. An awesome 1.9 billion cubic yards of rock and dirt – six times the amount removed to build the original canal – would be excavated to dig a 36-mile single channel and 17 miles of two-lane approach channels. While the channel would be different, the digging methods would be reminders of the past – power shovels and endless dirt trains to move the spoil. The present canal would remain in use and be operated in combination with the new route to increase the capacity of both…"

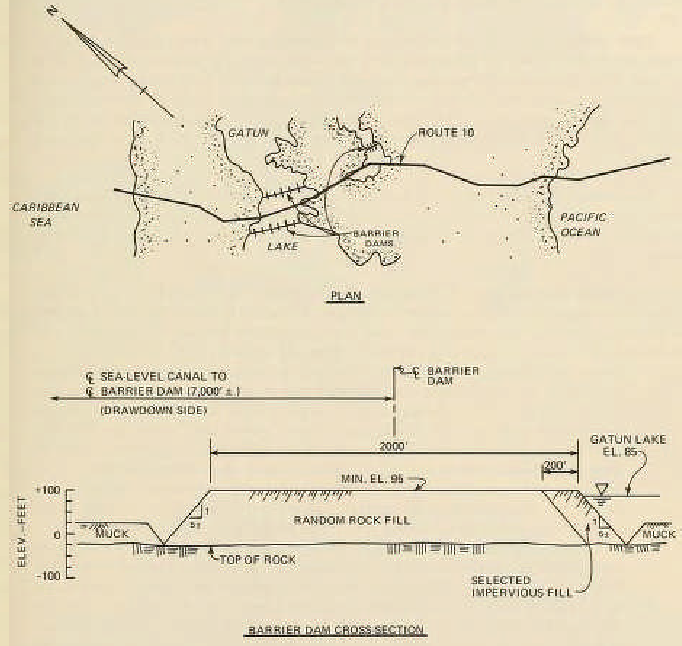
Popular Mechanics, **February 1978**



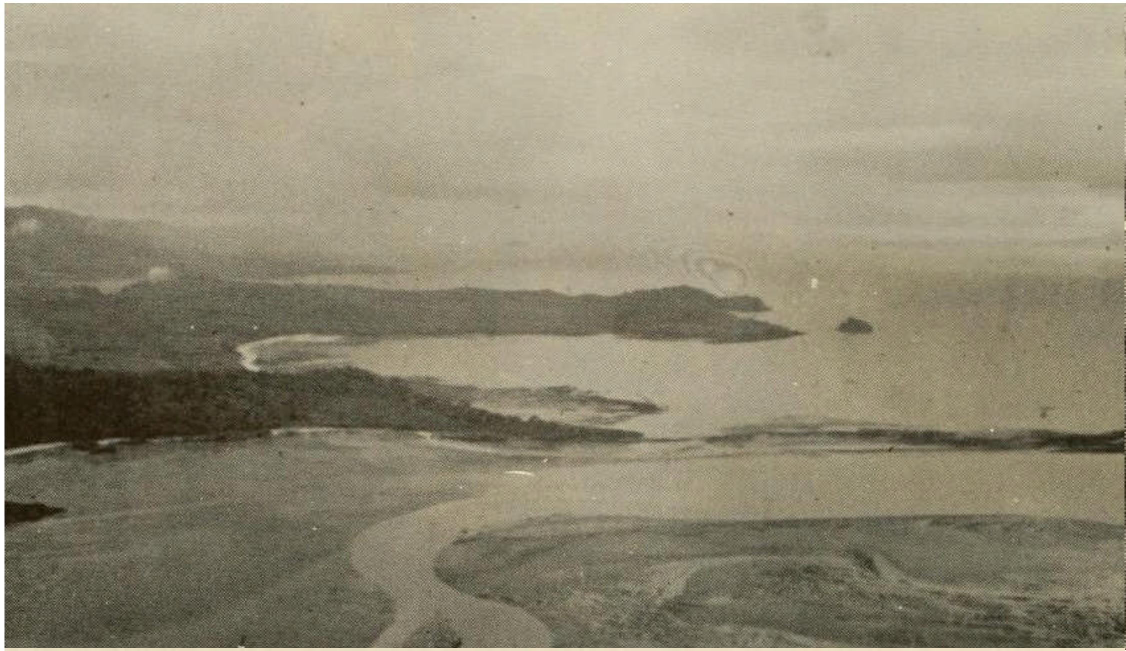
GEOLOGIC PROFILE
CONTINENTAL DIVIDE
ROUTE 10

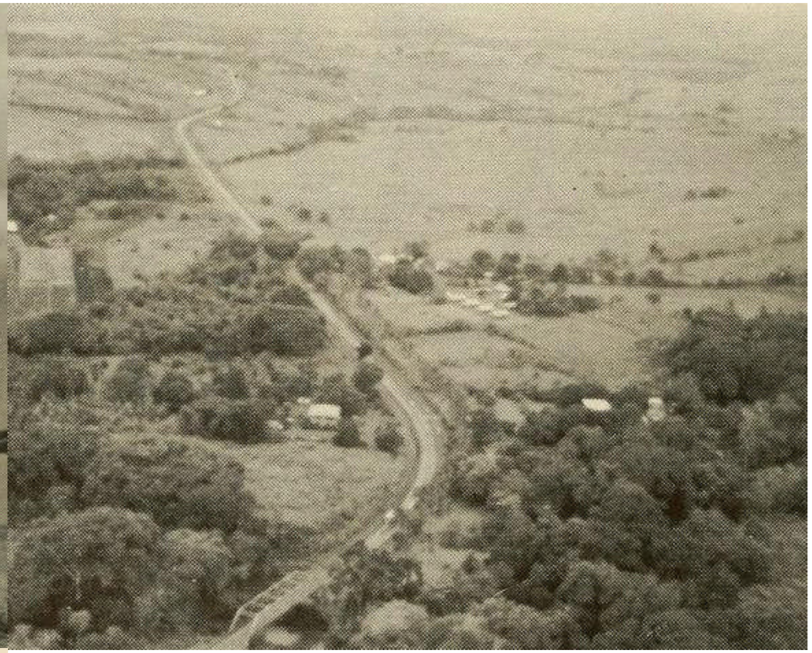


Generalized Excavation Methods
Route 10



ROUTE 10 – BARRIER DAMS





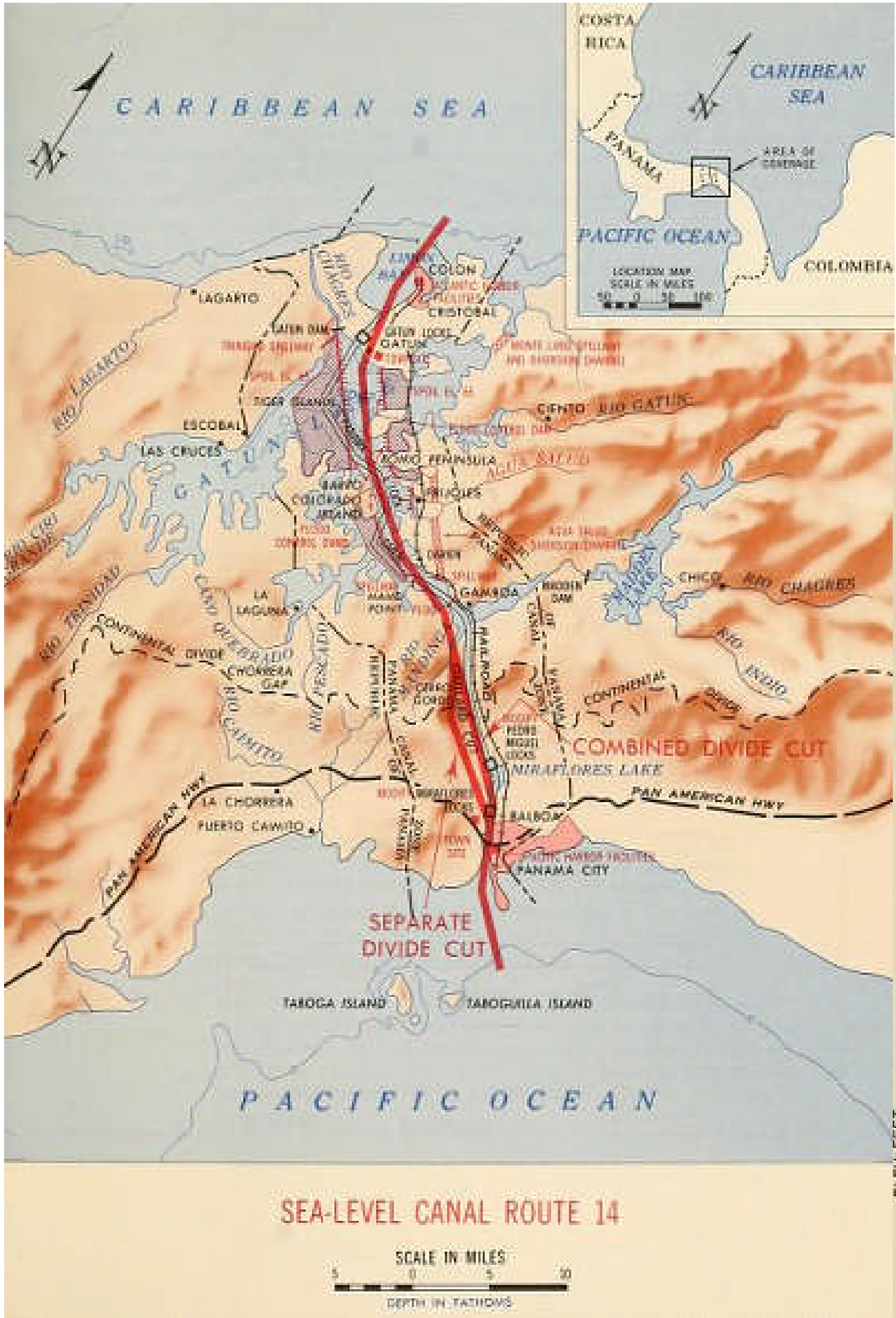
<u>Top Left</u>: caption: "The Caimito River and Pacific coastline, looking southeast from the proposed Route 10 terminus"

<u>Top Right</u>: caption: "Looking northeast along the Pan American Highway from the vicinity of the alignment. The bridge in the foreground crosses the Caimito River"

<u>Left</u>: caption: "The alignment immediately north of the Continental Divide, looking northeast"

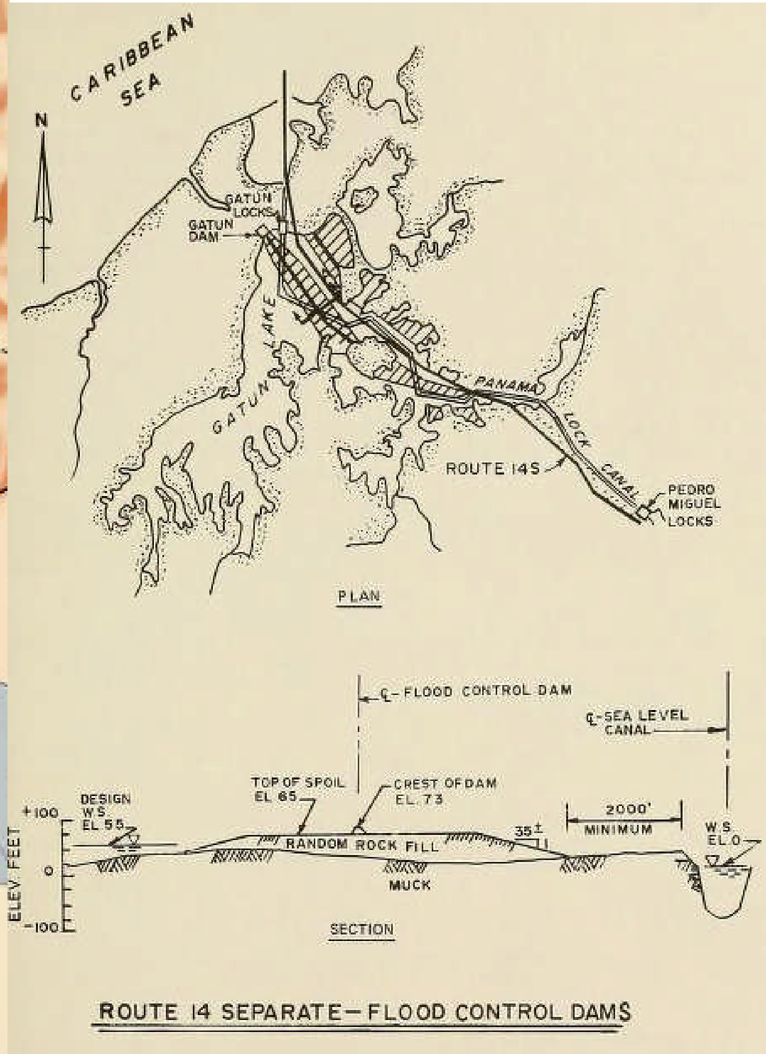
"…Defense of a sea-level canal on Route 10 would require only limited expenditures…Not only would a sea-level canal on Route 10 be far less vulnerable than a lock canal, but also it would be somewhat less vulnerable than one on Route 14 with its more extensive barrier dams needed to preserve Gatun Lake…The major military advantages of Route 10 over Route 14 are that construction on Route 10 would avoid the long period of vulnerability of the existing canal during construction of a sea-level canal adjacent to it on Route 14, and the additional capacity and safety offered by the continued availability of the old canal after a new one is opened on Route 10…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970



Route 14 Conventionally Excavated Sea-Level Canal

The two alinements of Route 14 that were evaluated are identical except through the Continental Divide (see Figure 37). Both follow the trace of the present Panama Canal without its many angularities. Route 14 Combined (14C) would involve deepening and widening of the present Gaillard Cut; Route 14 Separate (14S) would require a new cut through the Divide about one mile to the southwest of the present cut. Both alinements pass under the existing bridge at the Pacific end of the present canal and utilize excavation already accomplished for the unfinished third locks project.



Route 10: In its basic single-lane configuration, Route 10 would have a transiting capability slightly greater than the Commission's initial capacity requirement (38,000 vs. 35,000 transits per year), even if operations were limited to currents not exceeding 2 knots. The design capacity of 35,000 transits per year could be attained with a TICW of about 12 hours. Acceptance of higher tidal current velocities would increase capacities substantially, with operations at 4 knots allowing 66,000 annual transits, 6,000 more than the requirement for the year 2040.

If current velocities greater than 2 knots were to prove unacceptable, transit capacity could be increased, if necessary, by the construction of a bypass, permitting 56,000 transits annually, closely approximating the year 2040 requirement. The capacity of Route 10 could be further expanded by enlarging it to a full 2 lanes.

Construction of Route 10 would provide a relatively short passageway between oceans, thus facilitating migrations of biota unless tidal checks are used. Other significant long-term ecological effects are not anticipated from this project, although there might be short-term disruptions from excavation and spoil disposal.

Route 10 has the following advantages: (a) it could be constructed and placed in operation without hazard to or interferences with the existing lock canal which could be maintained on a standby basis. A slide during construction or in the first few years of operation, while undesirable, would not result in complete blockage of trans-isthmus ship passages as it would on Route 14C or 14S. (b) A large part of Gatun Lake could be maintained permanently at its present elevation by barrier dams, which would not be particularly difficult to construct where Route 10 crosses the lake. (c) By virtue of its separation from the existing canal and Gatun Lake, a large part of the excavation could be accomplished in the dry by well-established construction methods. (d) Large portions of the tremendous volume of excavation spoil could be transported to the Pacific and Atlantic Oceans for useful construction of breakwaters and for disposal with the least effect on the environment. (e) The terrain lends itself well to economical construction of a ship by-pass channel near the middle third of the length, if increases in traffic should make this necessary. This is not possible on Route 14.

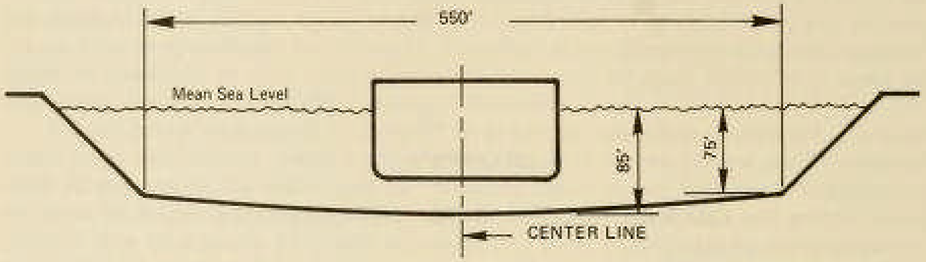
RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970 (summary regarding *Route 10*)

"…The chief advantages of a sea-level canal would be the removal of the present locks with a consequent reduction of accidents and saving of time at these points. Opponents of the plan say these gains would be more than offset by new hazards to navigation. There would be, for example, an extension of hazardous channel from 7.69 miles (Gaillard Cut) to 31.18 miles; an increase in the number of turns in hazardous channels; a considerable increase in total curvature in restricted channels; and a probable extension of the channel length subject to fog. A sea-level canal would require ship mooring stations in narrow channels; extend the collision, grounding, and steering-gear failure areas; and reduce pilots' vision by lowering ships in a cut for long distances…Advocates of the sea-level plan, on the other hand, have been less informative about what would happen to a sea-level canal if bombs breached the extensive system of dams proposed to hold back and divert the torrential Chagres River. Besides, no one knows what an atom bomb would do in Gaillard Cut in any case…"

***The Rotarian,* March 1949**

"…The present canal would continue in operation during the construction of any sea-level canal. When the sea-level canal is opened, the existing canal would be needed to provide an emergency alternative until the new canal has been operated for a period of years, its capabilities proved, and there was reasonable certainty that it would not be seriously affected by slides. The Commission has been advised by its Technical Associates for Geology, Slope Stability, and Foundations that 10 years is a minimum period for this purpose. It would be desirable also to maintain it on a standby basis for an extended period thereafter…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970



The design channel at mean tide, showing a 150,000 dwt ship. Channel side slopes vary, depending on the slope stability criteria. At extreme low low tide, the water level at the Pacific entrance of a canal could be 10 feet lower.

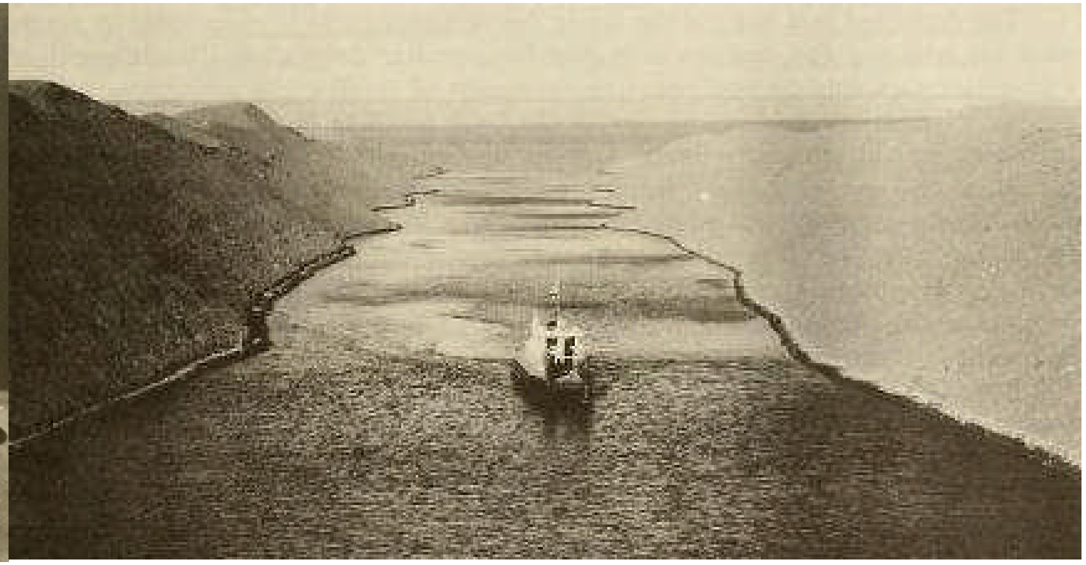
RECOMMENDED SIDE SLOPES OF EXCAVATIONS FOR DIFFERENT MATERIALS AND HEIGHTS

Nature of Material	Side Slopes of Cut Horizontal ÷ Vertical				
High Quality Rock	0.375 Overall Including Construction Benches				
Intermediate Quality Rock	0.625 Overall Including Construction Benches				
Low Quality Rock Such as Clay Shale	Height of Cut in Feet				
	100	200	300	400	500
Condition A	1.0	4.1	6.0	7.5	8.6
Condition B	1.0	5.3	7.8	9.5	10.7
Condition C	1.0	6.4	9.2	11.4	13.0

Condition A: For locations where the canal would be remote from the existing canal. (The existing canal would be available for use during a proving period.)

Condition B: For locations where the canal would be separate from the existing canal but in close proximity. (Excavation would be performed in the dry and gradual drainage would be possible during construction. An observational period would be available prior to the canal becoming operational.)

Condition C: Locations where the canal would be adjacent to the existing canal in an area with a history of slides. (The area would have undergone long-term creep, and the slopes would be subject to rapid drawdown. The maintenance of traffic on the Panama Canal during construction is considered.)

"…A growing body of knowledge and experience indicates that high slopes in clay shales, as in the Chucunaque Valley, or in more competent rocks underlaid by clay shales, as in parts of the existing canal, may have to be very flat for long-term stability and to avoid the danger of massive slides in the first few years after excavation. Some attempts have been made to produce such flat slopes by elaborate explosive techniques, such as over-excavation in anticipation of slides, multiple row charges, and successive series of explosions or 'nibbling' techniques for application to problems such as construction of a sea-level canal across the Chucunaque Valley. The Technical Associates believe this to be a highly unpromising line of investigation with minimal chances of developing procedures that could be used with assurance in the foreseeable future…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

Left: caption: "Channel at Fort Peck Reservoir, Montana, created in an experiment demonstrating the feasibility of creating a navigation channel by explosive means. This channel was excavated with 18 chemical explosive charges ranging from 5 to 40 tons. It is 1,300 feet long, 130 feet wide, and has an average depth of 17 feet."

Right: caption: "Tugboat in Fort Peck channel (Tugboat length is 47 feet: beam 11ft.: draft 5 feet 7 inches)"

Nuclear Excavation

NUCLEAR EXCAVATION

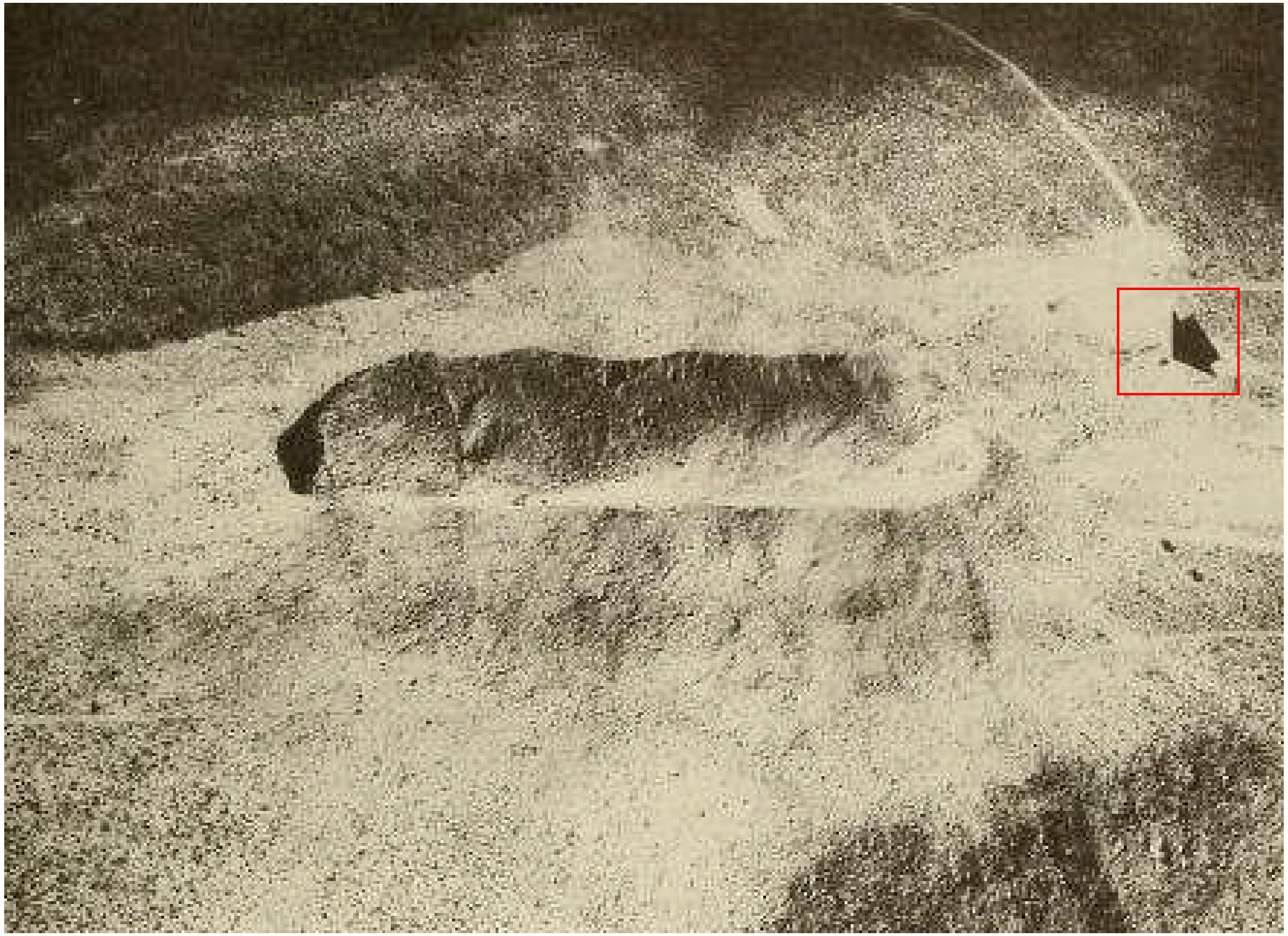
The prestige the United States would derive from having constructed a sea-level canal would be enhanced if it were to prove feasible to employ nuclear excavation. The USSR is moving ahead with a series of projects which give that nation an opportunity to demonstrate its own advances in the field of peaceful uses of atomic energy. The excavation of a sea-level canal by nuclear means would provide the United States a unique opportunity to demonstrate progress on its part in this field on a massive scale.

Nuclear excavation would, however, raise fears regarding physical harm to individuals and the disruption of their lives. Residents of the area chosen would have to be relocated during construction. Evacuation would affect over 3,000 square miles and involve perhaps 10,000 people on the best route for nuclear excavation. The psychological and sociological implications present problems that could prove formidable.

The restrictions of the Limited Test Ban Treaty on the use of nuclear explosives pose another problem. It is not possible to determine whether or when international agreement can be reached that would permit the use of nuclear explosives in Isthmian canal construction.

The technical feasibility of nuclear canal excavation has not been established. Determination of technical feasibility and removal of international treaty obstacles to nuclear excavation would still leave great political and economic objections to a sea-level canal remote from Panama's metropolitan centers.

We conclude that, based on information currently available, nuclear canal excavation is not now possible.



<u>Above</u>: caption: "The Buggy I crater approximately 860 feet long, 250 feet wide, and 65 feet deep produced by the simultaneous detonation of five nuclear explosives of approximately 1 Kiloton each on March 12, 1968. The explosives were buried 135 feet deep and spaced 150 feet apart in hard rock on the U.S. Atomic Energy Commission's Nevada test site. The arrow points to a pickup truck."

"…In a letter (Enclosure 3) to the Canal Study Commission near the end of the sea-level canal studies, the Chairman of the Atomic Energy Commission reported that any decision to construct a sea-level canal in the near future must be made without reliance upon the availability of nuclear excavation. He expressed the AEC's view that, given funds and authorization, the technical problems of nuclear excavation could be solved within a relatively short time: that each step which has been taken in developing nuclear excavation technology has resulted in lowering the potential risk involved: that increased understanding of the cratering mechanism has increased belief in the potential benefit of this undertaking for mankind: and that, if for any reason a decision to construct an interoceanic canal is delayed beyond the next several years, nuclear excavation technology might be available for canal construction. It is clear that the technical feasibility of using nuclear explosives for Isthmian canal construction has not been established and that any conclusion as to its technical feasibility in the future for this purpose would be a speculative judgment of the potential of nuclear excavation for the most sophisticated task that could be asked of it. It is equally clear that the United States could not propose such excavation until the reliability of the technology for such an application has been proved unconditionally. Although mindful of, and in essential agreement with the AEC's prognosis of eventual availability of a nuclear excavation technology, the Canal Commission believes that many experiments will be required in combination with practical applications in smaller projects before the necessary degree of confidence can be assured. Although there is a considerable body of scientific and engineering opinions that the technology has already been sufficiently developed for application to projects of moderate size, such as harbors and highway cuts, it is the view of the Commission that its perfection for use in canal excavation on Route 17 or 25 is many years away…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

July 7, 1970

Mr. Robert B. Anderson, Chairman
Atlantic-Pacific Interoceanic Canal Study Commission
Room 6217
726 Jackson Place, N.W.
Washington, D.C. 20506

Dear Chairman Anderson:

We were most pleased to have a report on the last meeting of the Atlantic-Pacific Interoceanic Canal Study Commission (CSC). With the tenure of CSC drawing to a close, we believe this is an appropriate time for the Atomic Energy Commission to provide the CSC with a brief status report concerning the work our laboratories have been doing in relation to nuclear excavation and our current estimate concerning what can be accomplished with further investigations.

Since the establishment of the CSC we have oriented our nuclear excavation experimental program so as to support the CSC studies and investigations. To date, we have not been able to do all the experiments which would be required to make a determination of the feasibility or infeasibility of using nuclear explosions for the excavation of the canals under study by the CSC. It is thus clear that any decision made to construct a sea-level canal in the near future must be made without being able to rely on nuclear excavation.

While we have not developed the technology sufficiently to make a specific determination of the feasibility of using nuclear explosions in the construction of a sea-level canal, our laboratories have made great progress in understanding the cratering processes and in designing explosives that minimize radioactivity. Some of their major technical achievements have been:

1. Development of a basic understanding of crater mechanisms. This understanding comes from theoretical studies, laboratory experimental work, and most importantly seven nuclear cratering experiments with yields ranging up to 100 KT. This understanding provides a greater degree of confidence in the calculations now used to design excavations, and also permits the specification of the important physical properties of rocks which must be determined so as to make these calculations.
2. The first nuclear row charge experiment had dimensions and other characteristics essentially as predicted.
3. Development of an understanding of seismic response through tests at the Nevada Test Site, which now has exceeded one megaton yields with no adverse effects.
4. Reduction of the radioactivity associated with excavation projects. An explosive specifically designed for excavation has been developed through a series of nine tests. The last one was the FLASK experiment executed in May 1970 in which a reduction of radioactivity, of a factor of five below our previous levels, was achieved. Although it is too late to incorporate the encouraging results from FLASK into the CSC studies, I believe that you will be pleased to know that if nuclear explosions were to be considered at some future date for canal construction the radioactivity would be an even smaller problem than is indicated in the reports presently being prepared for you.
5. Development of a predictive capability, through extensive measurements on nuclear cratering experiments, for the distribution of radioactivity in the fallback, ejecta, fallout, and long-range diffusion.

However, some technical problems still remain and require further work. While the understanding of cratering has been experimentally determined up to 100 KT, it is necessary to conduct experiments at yields up to a megaton. In addition, experiments are needed in rock of the same type as that expected along the routes of the canal, namely hard, water-saturated rock, and weak clay shales. Furthermore, additional experimentation is needed on nuclear row excavation to investigate close spacing concepts at high yields and to determine if there are any unknown practical problems associated with connection of rows. Additional work would also be useful in further reducing the radioactivity of excavation explosives.

The Lawrence Radiation Laboratory is working on a more detailed technical summary of the status of the excavation technology and the remaining questions. We will provide you a copy of the summary as soon as it is available.

The rate of development of the technology is not dictated so much by technical problems as by international considerations and public attitudes. The great current expression of public concern over the environment makes any experimental program such as this one difficult to accomplish. However, as the record clearly indicates, we have always proceeded in an extremely cautious manner in regard to environmental effects and we will continue to do so. Our large research effort to date in this area has led us to the conclusion that the risks associated with this application of nuclear energy can be kept to minimum acceptable levels while, at the same time, we can derive great benefits from its utilization. It is our opinion that, with the further improvements which we are confident can still be made and with greater public understanding of this technology, realistic environmental concerns can only diminish.

One of the factors we are faced with is the constraint of the limited test ban treaty. However, we have conducted our last five excavation experiments within these constraints and would, of course, conduct future experiments similarly.

As shown by the discussions which took place during the negotiation of the Nonproliferation Treaty, there is an awareness on the part of developing countries of the potential benefits under Article V of the Treaty. We also cannot ignore the excellent and aggressive program in nuclear excavation which has been described by the USSR, and particularly their stated plans for using this type of excavation on projects of a magnitude similar to the sea-level canal between the Atlantic and Pacific Oceans.

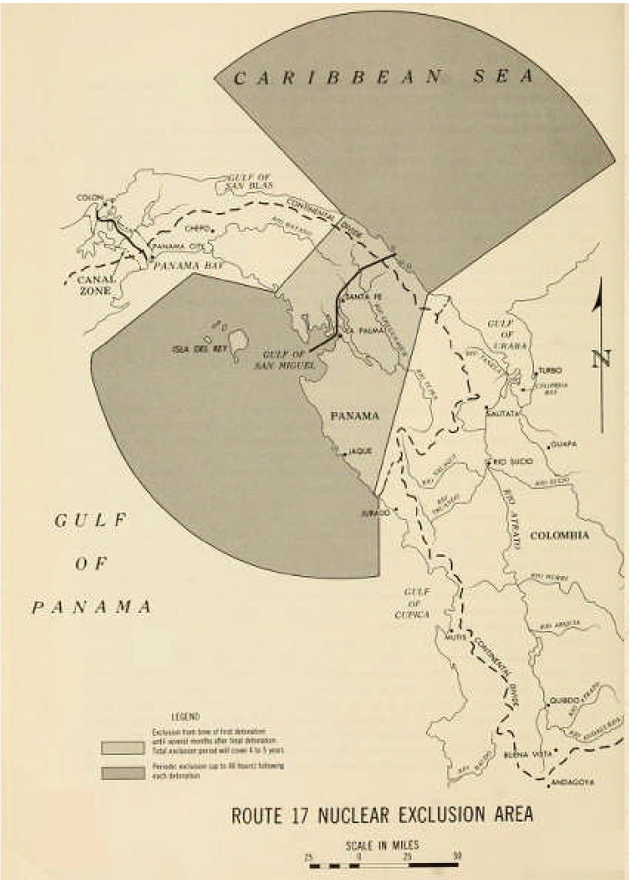
Our commitments, the interest on the part of the developing countries, and the USSR program not only establish a need for us to proceed with the development of nuclear excavation technology but also, we believe, will aid us in overcoming the political and emotional problems we currently face.

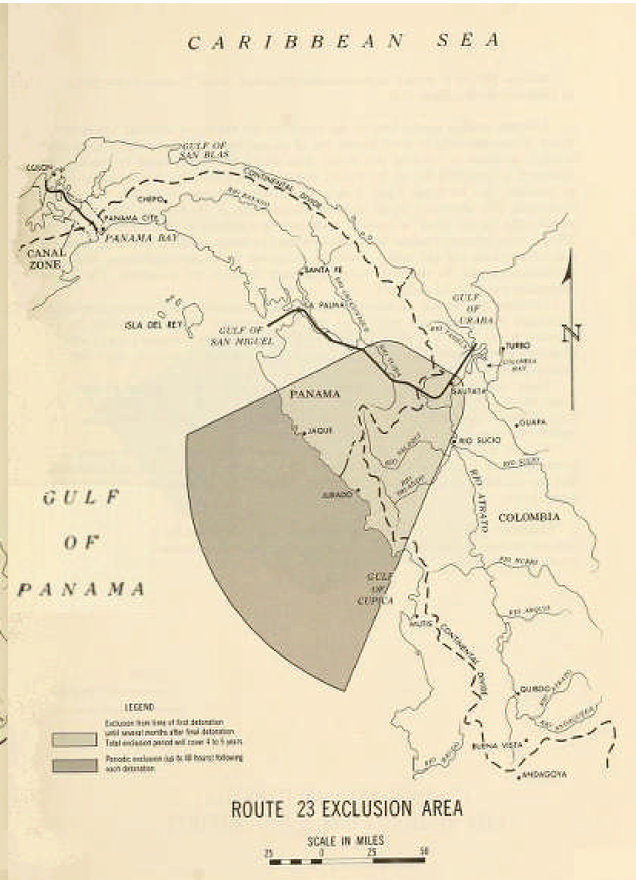
In summary, it is our view that, given the authorizations and funds, the problems regarding technical feasibility can be solved within a relatively short time. Each step we have taken in developing nuclear excavation technology has resulted in lowering the potential risk involved. At the same time, our increased understanding of the cratering mechanics has increased our belief in the potential benefit of this undertaking for mankind. Apparently the USSR has reached a similar conclusion concerning the benefits and risks and is proceeding accordingly. We believe that, if for any reason a decision to construct an interoceanic sea-level canal is delayed beyond the next several years, a nuclear excavation technology might be available and provide a realistic option in canal construction considerations at that time.

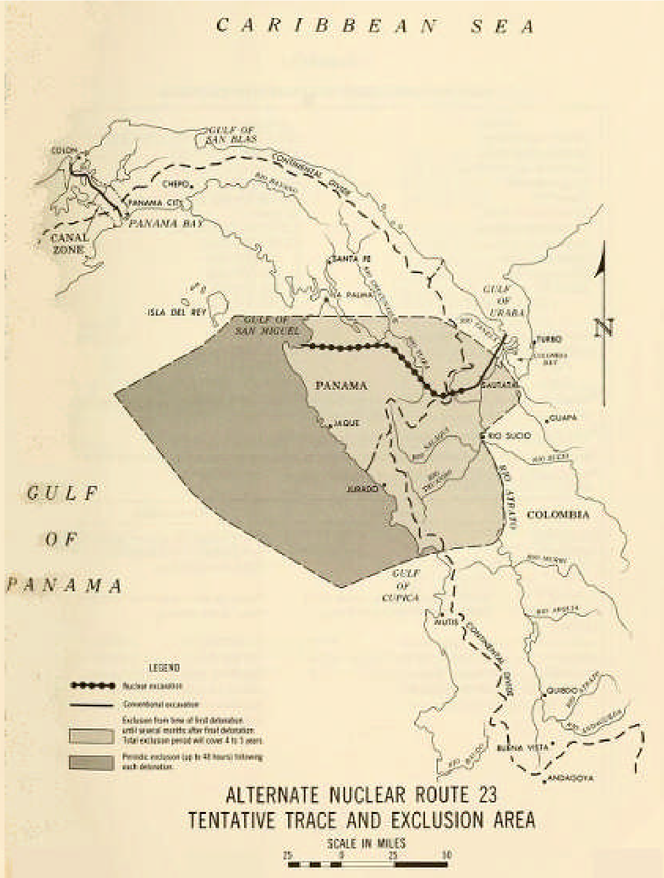
Sincerely,

Glenn T. Seaborg
Chairman

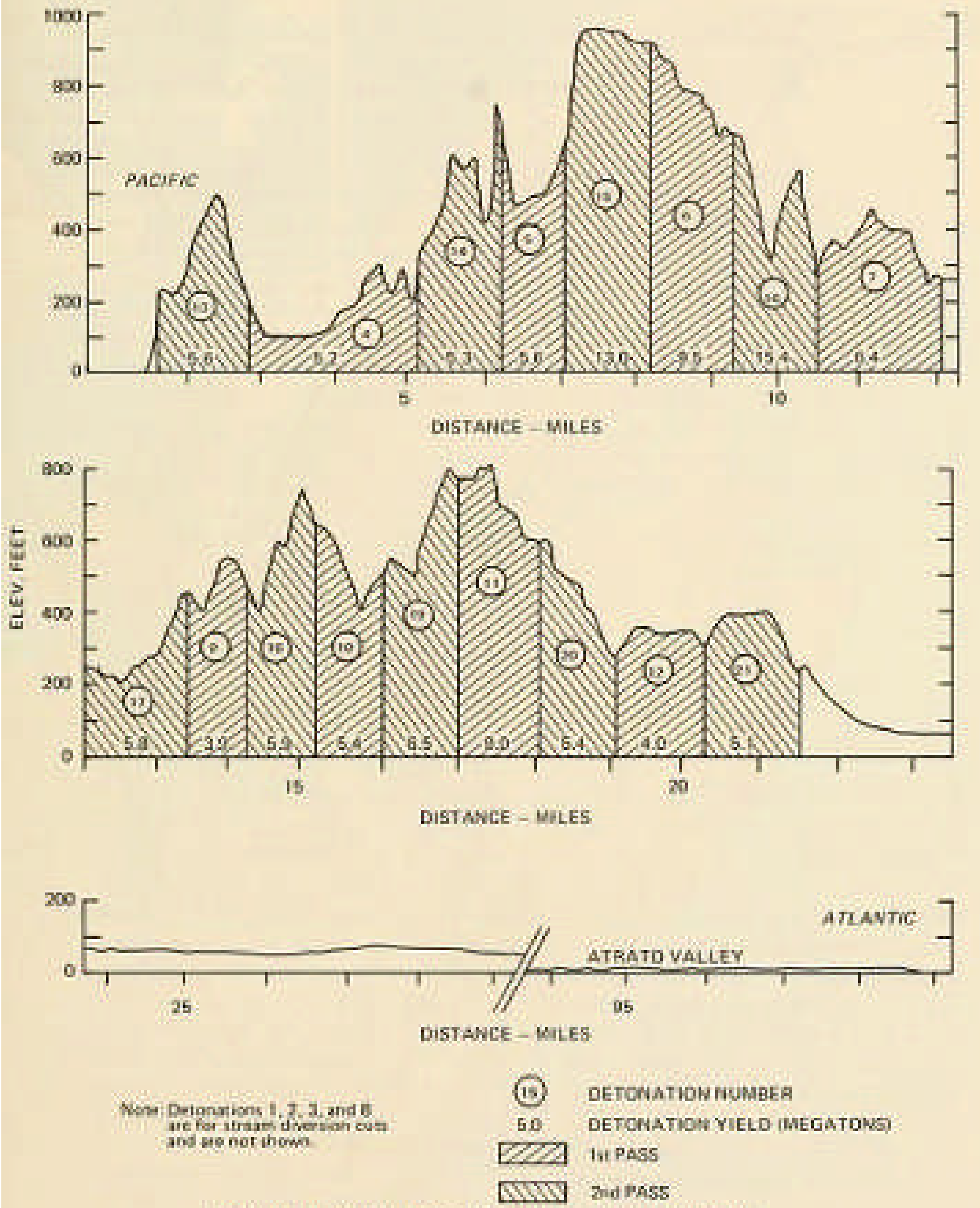
Above: caption: “Enclosure 3”







<u>Above</u>: Nuclear Exclusion Area/s for Route/s 17, 23 and 23 Alternate
<u>Left</u>: Nuclear Exclusion Areas for Route 25



ROUTE 25 NUCLEAR DETONATION SEQUENCE

The Limited Test Ban Treaty

"…The political constraints upon the use of nuclear explosives for canal excavation were recognized at the time the Commission's investigation was authorized by Congress…Although there have been encouraging developments in international treaties bearing upon nuclear excavation, the Limited Test Ban Treaty constraints remain in effect…The Limited Test Ban Treaty enjoins its signatories from conducting any nuclear explosion which causes radioactive debris to be present outside the territorial limits of the state under whose jurisdiction or control such explosion is conducted. The United States recognizes, because there seems to be no possibility of excavating an Isthmian canal with nuclear explosives without transport of some radioactive material across territorial boundaries, that the provision could prohibit nuclear excavation of a sea-level canal. It was also recognized by the United States and other signatories, including all canal-site countries, that nuclear excavation for peaceful purposes could later become practicable and mutually acceptable…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

Part 9

Something Must Be Done

The Plain Truth

"…Something must be done, for the plain truth is that 'Teddy' Roosevelt's 'Big Ditch,' finished in 1914, is outmoded. It's too small for the great liners 'Queen Mary' and 'Queen Elizabeth.' The 110-foot locks impose a 108-foot limit on ships, but the U.S. Navy ignored it to build three 'Midway'-class carriers with 113-foot beams – and now the 65,000-ton supercarrier CVA 58 is projected with a beam of 130 feet! These facts are known to many people…"

***The Rotarian,* March 1949**

Hazards to Navigation

"…Less known are the serious navigational hazards and the fact that besides the locks themselves their arrangement on the Pacific side limits traffic and invites accidents. Between January 13, 1922 and July 13, 1942, there were 1,036 accidents in the Canal serious enough to warrant investigation. Of these 393 were lock accidents caused by ships striking the sharp corners of lock wing walls or ramming them. The others included groundings, collisions, and mishaps resulting from steering-gear failure which tend to occur at certain danger spots…"

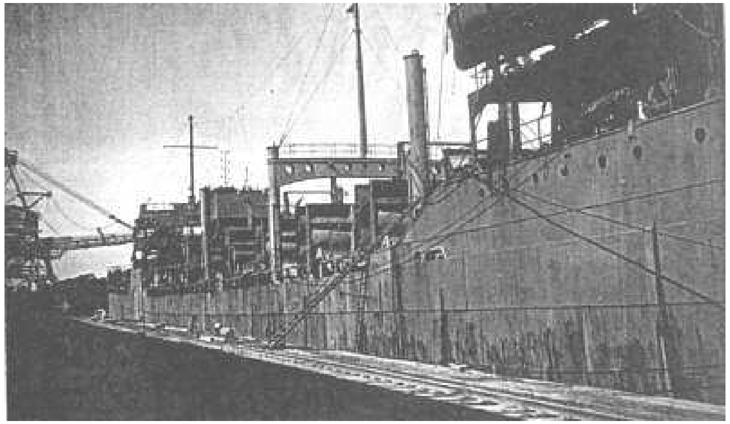
***The Rotarian,* March 1949**

Danger Spots

“…The danger spots are the locks, the narrow and rocky Gaillard Cut (formerly Culebra Cut), and wherever ships make short-radius turns in confined waters. Groundings in Gaillard Cut are greatly feared because a ship may strike the rocky bank and sink, blocking the channel. Five out of seven sinkings in the 24 years 1919 to 1942 occurred in the last six years. Of 50 collisions in the Canal channels during the same time, Gaillard Cut contributed 26. Fog is more common in the Cut than elsewhere along the Canal. In 1942 there were 223 fog reports from marine signal stations in Gaillard Cut during traffic hours. Fog in the cut not only closes the gorge, but also closes the Pacific locks even though visibility is usually good in that area…”

***The Rotarian,* March 1949**

Surge Currents



"…To these dangers must be added surge currents caused by the operation of Pedro Miguel Locks. The surge currents bring us to what is perhaps a fundamental error in the basic design of the present canal. When a Pedro Miguel lock chamber 1,000 feet long is filled, 103,000 tons of water are drawn for Gaillard Cut. The withdrawal causes a surge, sometimes called a 'seiche,' about three feet high. It rushes through the Cut at almost 25 miles an hour. The 36,000-ton ore carrier 'Steel Ore' sank in the cut when surge currents and bank suction caused the vessel to strike the bank and breach several forward plates on February 17, 1942. But the full force of the current was demonstrated <u>after</u> the ship had settled to the bottom and was made fast to the bank with heavy steel cables. Suddenly the 36,000-ton vessel rose, moved forward several feet, snapping the hawsers like fishing tackle, and once more settled on the bottom…"

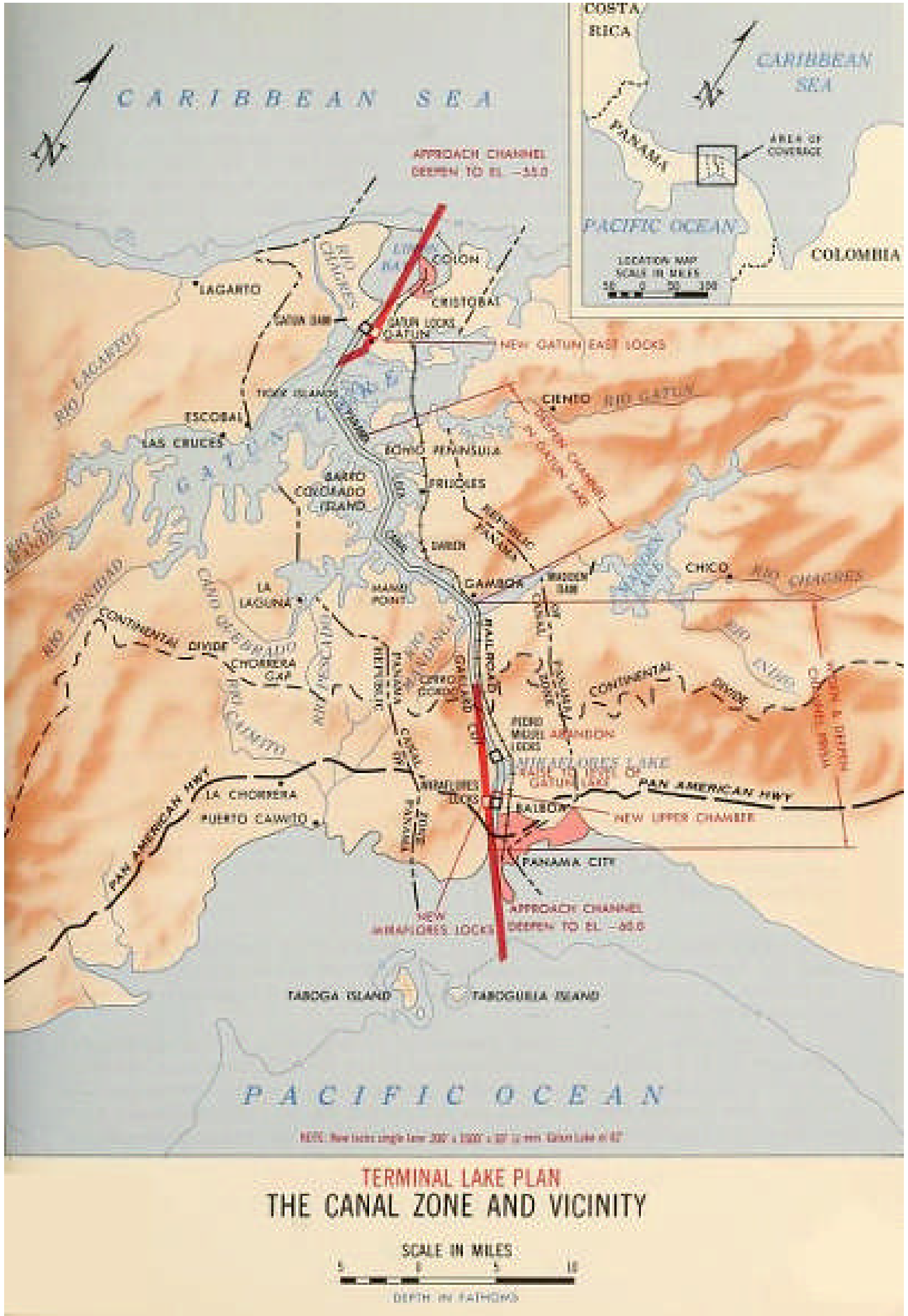
***The Rotarian*, March 1949**

<u>Above</u>: the 36K-ton *S.S. Steel Ore*

The Terminal Lake Plan

"…Terminal-Lake Plan. This calls for creation of a large artificial lake at the Pacific end of the Gaillard Cut comparable in purpose to Gatun Lake on the Atlantic side. A relatively small dam, at its highest point about 30 feet, across the area now occupied by the Miraflores Locks would raise Miraflores Lake to the 85-foot level and impound additional water in the surrounding hills. A total navigable area of 1.03 square miles would provide anchorage for 39 vessels safely removed from the main channel which would be widened to 600 feet. The new 'terminal-lake' would prevent lockage surges in Gaillard Cut and increase the total volume of water available for operating the locks. A new set of triple-lift locks three channels wide would be built near the old Miraflores Locks, which would be abandoned. The Pedro Miguel Locks would be removed. The new locks would probably be 150 feet wide to accommodate the largest vessels afloat and those which can reasonably be anticipated. The new Miraflores Locks, together with the terminal-lake, would make operation of the canal on the Pacific side as efficient as it is at Gatun. An enlarged series of three sets of triple-lift locks would also be built at Gatun, and certain of the more hazardous turns in the channel would be widened and straightened as a part of this plan. The cost of the terminal-lake is estimated at half a billion dollars, or one-fifth of the most optimistic figure for the sea-level project…"

***The Rotarian,* March 1949**



"…The Terminal Lake Plan would consolidate Miraflores and Pedro Miguel Locks on the Pacific side, raising Miraflores Lake to the level of Gatun Lake. In the process a third lane of locks would be added on both the Atlantic and Pacific sides. This plan has the advantage of providing an anchorage area above the Pacific locks which would eliminate navigation hazards now encountered in that area…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

"…The Terminal Lake Plan, considered first in the design of the existing canal, was proposed again in 1943. As described in 1947, it calls for abandoning Pedro Miguel Locks, raising Miraflores Locks, and constructing one lane of large locks at both Miraflores and Gatun, capable of handling 110,000-dwt ships. Execution of this plan would increase the annual transit capacity to about 35,000 ships. The added locks would be 200 by 1,500 by 50-feet. Raising Miraflores Lake would provide an anchorage area above the Miraflores locks, reducing navigation hazards at the Pacific end of the Gaillard Cut. Operational efficiency would be increased by consolidating the Pacific locks. The existing two-lane locks at Gatun and Miraflores would continue in operation, and Gatun Lake would remain at its present level…The 1964 Report estimated the cost of this plan to be $946 million ($1.1 billion at 1970 price levels)…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

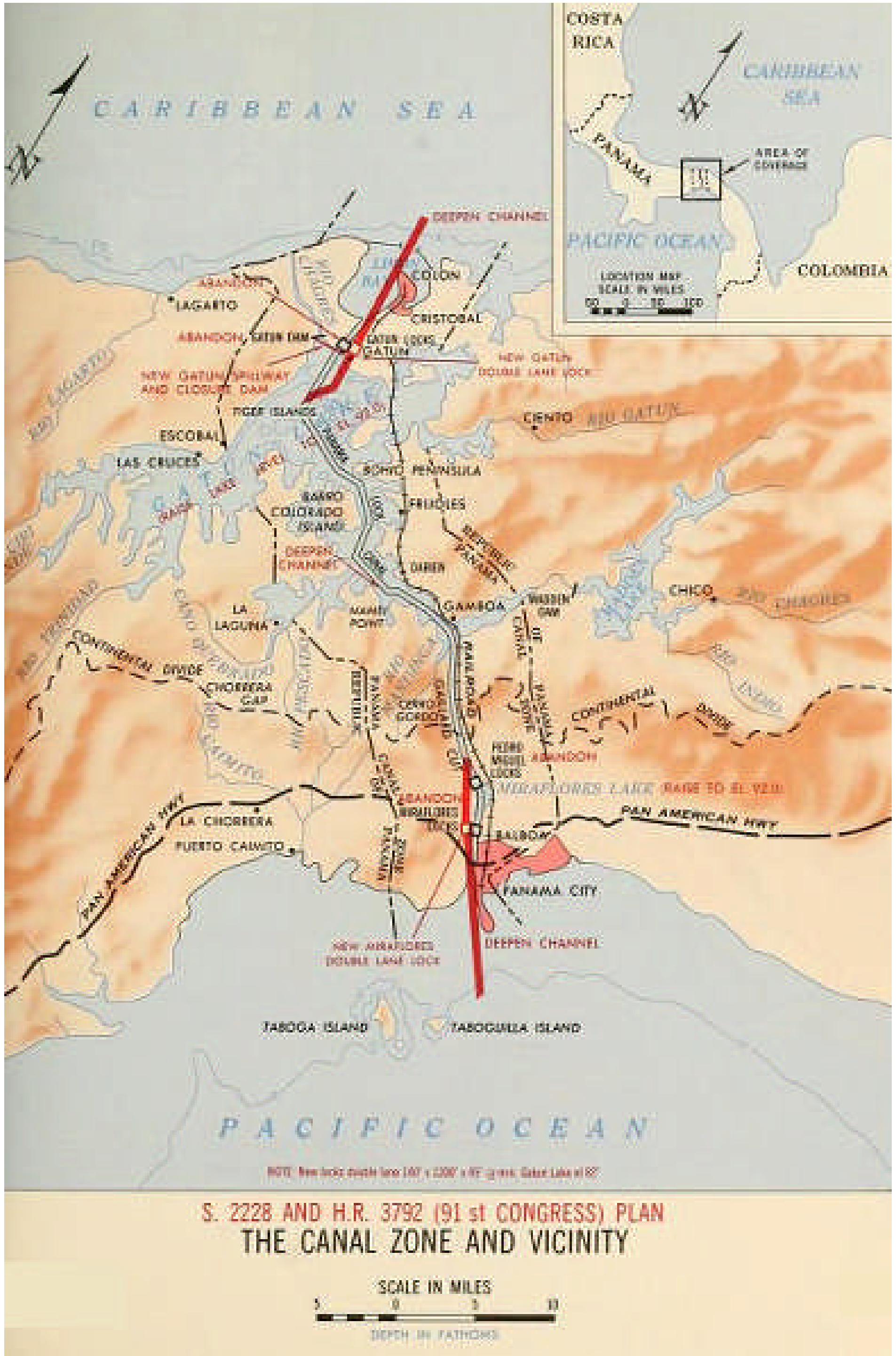
"…Modernizing the Panama Canal as proposed in the terminal-lake plan appears to resolve all the operating problems but one – the defense of the Canal against atom bombing. Proponents of the terminal-lake plan willingly grant that any lock-type canal can be put out of commission for a long period by destruction of the locks or the dams that impound water to operate the locks. They argue that any canal is vulnerable and that a true defense of the Canal depends on the military might of defending forces and the ability to stop an attack before it reaches the installations…"

The Rotarian, **March 1949**

The Terminal Lake Plan Variation

"…A number of variations in the Terminal Lake Plan have been proposed. Typical of such proposals is that described in H.R. 3792 and S. 2228, 91st Congress, Second Session. These bills call for abandoning the Pedro Miguel Locks and appear to require replacement of the locks at Gatun and Miraflores with two lanes of locks 140 feet wide and 1,200 feet long, having a minimum depth of 45 feet of water over the sills. They would accommodate ships of 80,000 to 110,000 dwt, depending on the level of Gatun Lake. The lake, now maintained between elevations 82 and 87 feet, would be regulated between 82 and 92 feet, requiring modification of the dam and spillway at Gatun. A terminal lake at Gatun Lake level would be formed above the new Miraflores Locks, improving conditions for navigation. Raising the level of the lakes would obviate the need for major excavation...Transit capacity would be approximately equal to that of the existing canal after planned improvements. The bills proposing these variations include $850 million for construction; however, if 3 lanes of new locks were provided at each end to increase annual transits to about 35,500, construction costs would be about $1.4 billion…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970



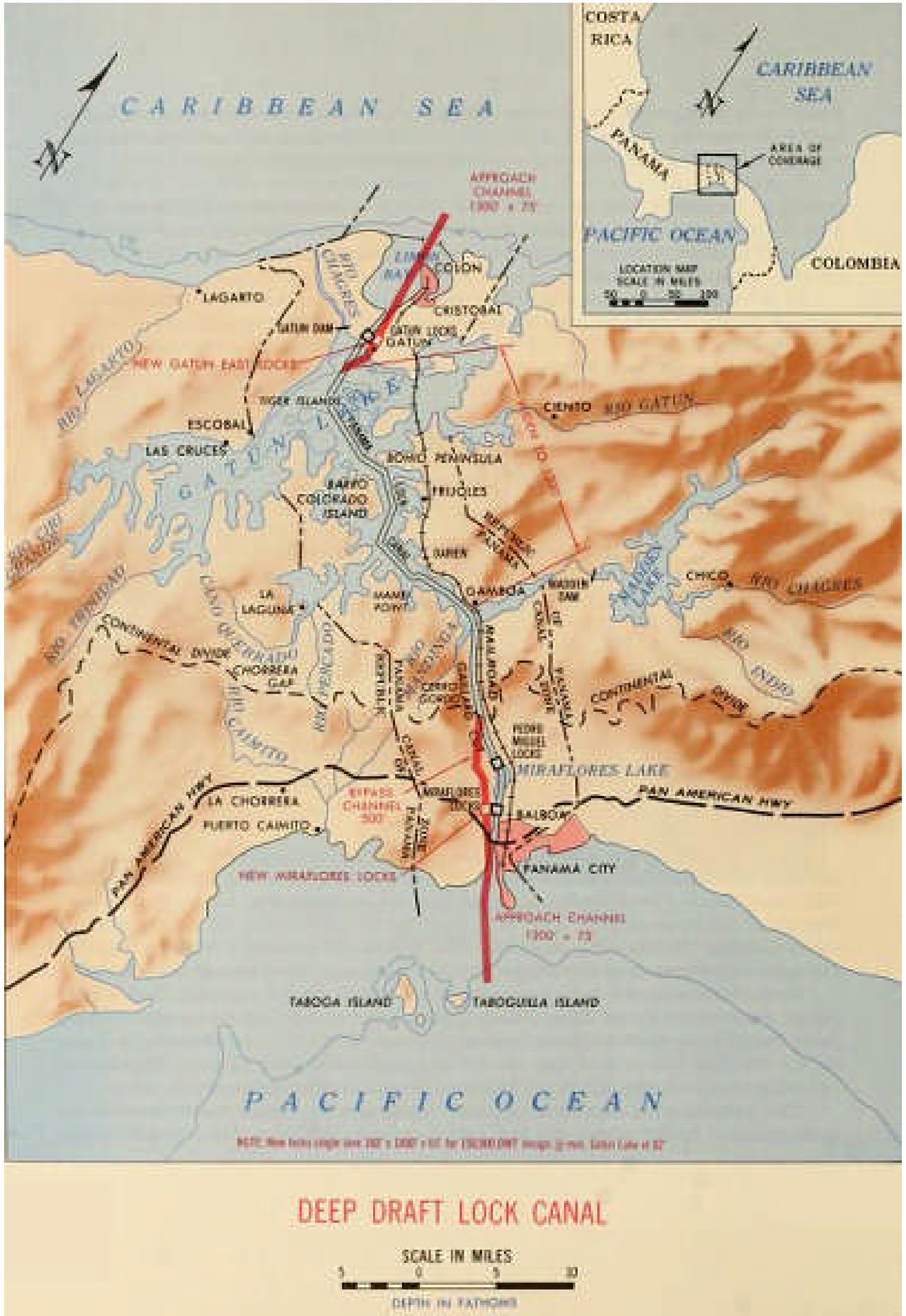
"…A variation of the Terminal Lake Plan, proposed by S.2228 and H.R. 3792, 91st Congress, provides for three lanes of locks, the largest being 140 feet wide, 1,200 feet long, and 45 feet deep. The Pedro Miguel Lock would be eliminated and the operating level of Gatun Lake would be raised 5 feet to a maximum of 92 feet above sea level…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

Deep Draft Lock Canal Plan

"…Deep Draft Lock Plan: A plan incorporating the most desirable features of previously proposed lock canal plans was developed during the current studies. To meet criteria applied in this study, the locks were designed to accommodate 150,000-dwt ships and flatter excavation slopes were assumed than those of earlier lock canal plans. The new plan calls for adding a lane of triple-lift locks to the existing two lanes at Gatun and constructing a separate lane of tripe-lift locks at Miraflores to raise 150,000-dwt ships into a bypass around Pedro Miguel at the level of Gatun Lake…It has the advantage of permitting continued operation of all existing locks throughout their useful lives. It would accommodate 35,000 transits per year. Its initial cost would be about $1.5 billion. Additional costs would be incurred when the existing locks could no longer be used economically and would have to be replaced. Replacement would be accomplished with some interference to traffic but would consolidate all three lifts on the Pacific side at Miraflores, raising Miraflores Lake to the level of Gatun Lake…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

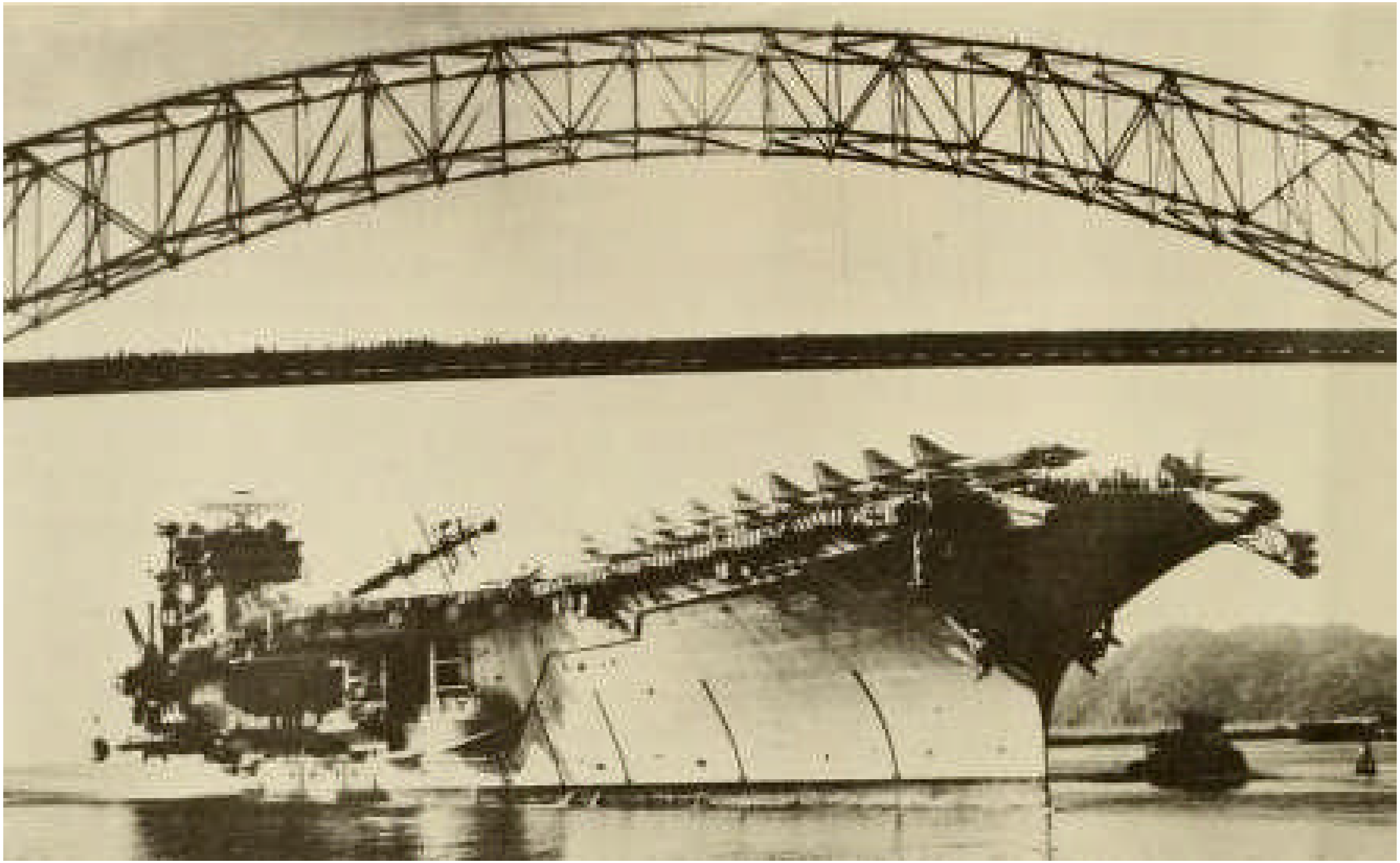


"…Construction effort involved in the Deep Draft Lock Canal Plan would be about evenly divided between lock construction and channel excavation. The new locks would take advantage of the Third locks excavation made in 1940-1942. Channel excavation would be accomplished mainly by dipper dredges and spoil would be removed in scows. Construction would take about 10 years…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

"…Except for the Deep Draft Lock Canal Plan, none of these plans meets present forecasts of traffic demands after the year 2000, with respect to both ship size and annual transits. As now conceived, the Deep Draft Lock Plan could not accommodate the larger attack aircraft carriers of the U.S. navy; the locks would be too narrow to hold angle decked ships. This limitation could be overcome by providing a lane of locks with very low lifts, but such an arrangement would add significantly to the transit time of all ships using that lane, and would increase construction and operating costs. A preferable solution might be to provide wider locks; however, this also would increase costs, especially those for lockage water supply. Construction costs of a lock canal which could accommodate large carriers are estimated to be approximately $2.3 billion. Annual operating costs for such a canal would be about $78 million at 35,000 transits per year…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

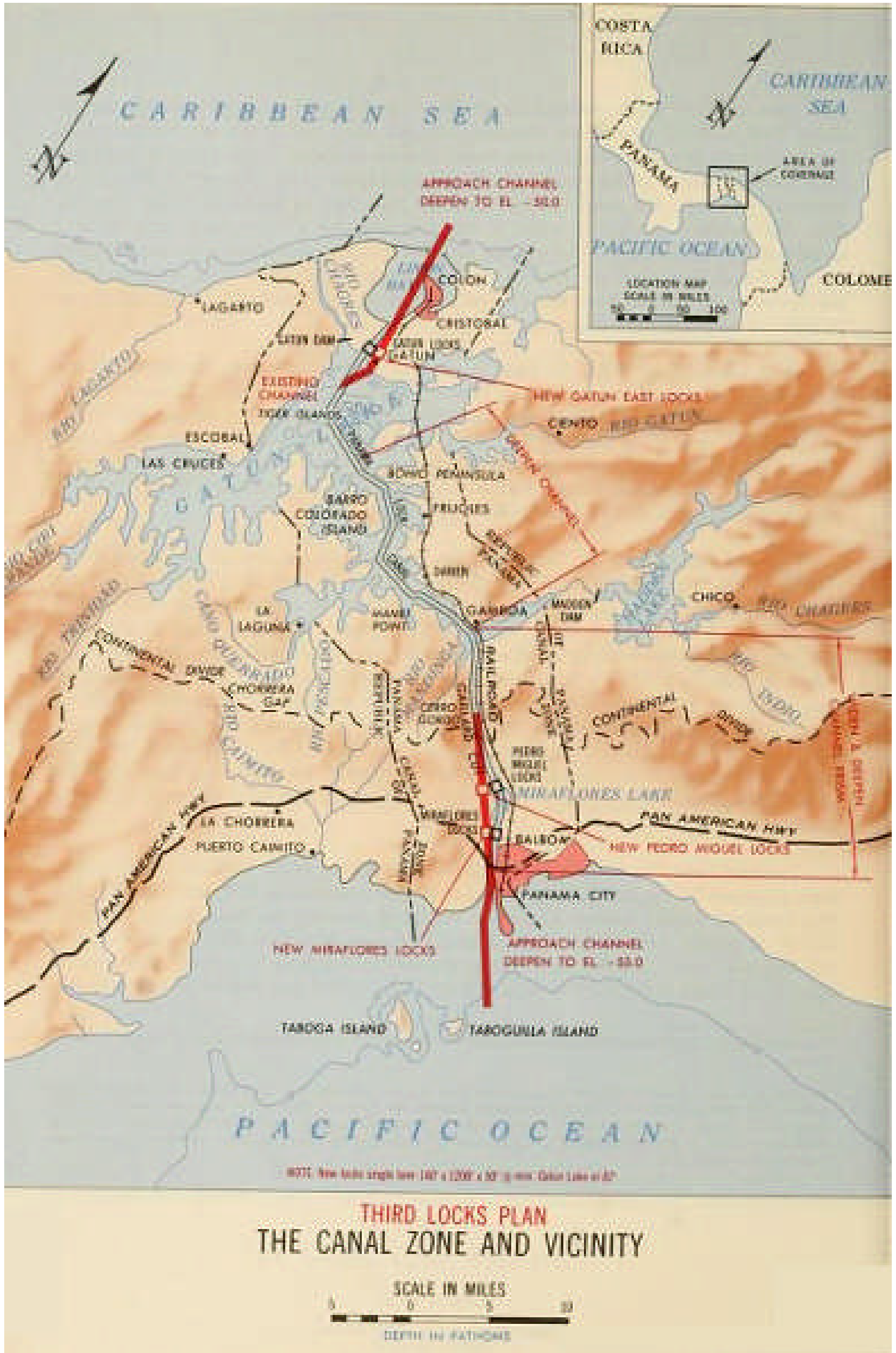


<u>Above</u>: caption: "The United States Navy carrier CONSTELLATION passing under the Thatcher-Ferry Bridge over the Panama Canal. This carrier, with a 250-foot wide flight deck, is too wide to pass through the 110-foot wide locks of the present canal."

The Third Locks Plan

"…The Third Locks Plan: In 1936 a joint resolution of Congress directed the Governor of the Panama Canal to investigate means of increasing capacity of the 'Panama Canal for future needs of interoceanic shipping and for other purposes.' The Governor's report recommended a third lane of locks and in August 1939, Congress authorized its construction. This measure was taken to improve the defensive posture of the Panama Canal and to increase its capacity. Excavation for the third locks at Gatun and Miraflores and design of structures and appurtenances were almost complete when the project was suspended in 1942 because of higher priority demands imposed by World War II. This work was not resumed when the war ended…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970



"…The 1938 Third Locks Plan, as subsequently modified, calls for one additional lane of 140 by 1,200 by 50-foot locks adjacent to each existing set. The new locks would pass 105,000-dwt vessels and would increase the canal's annual transit capacity to about 35,000 ships. The existing locks would continue in use and Gatun Lake would remain at an average elevation of 85 feet…The 1964 Report estimated the cost of the Third Locks Plan to be $635 million ($800 million at 1970 price levels)…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

"…There have been many proposals for increasing the capacity of the present canal by construction of additional locks. The most promising are variations of two basic plans: The Third Locks Plan and the Terminal Lake Plan. The former was actually initiated in 1939 and discontinued after expenditure of approximately $75 million on excavation for larger locks adjacent to existing ones. The new locks would have been 140 feet wide, 1,200 feet long, and 50 feet deep. Locks of this size would accommodate vessels of up to approximately 110,000 DWT…"

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970

By Mutual Consent

“…The United States has held that the provisions of the Treaty of 1903 permit the building of a third lane of locks. This may not be a practicable alternative because a controlling determinant of the long-term viability of any course of action in Panama is its acceptability to the government and people of Panama, the United States, and, hopefully, to Latin America generally. It seems obvious that major augmentation of the existing canal would not serve United States interests unless accomplished under a new treaty arrangement or major revision of the present treaty willingly entered into by Panama…”

RE: excerpt from the *Atlantic-Pacific Interoceanic Canal Study Commission* report, 1970


YANKEES GO HOME
ZONIANS OUT

HOME

Part 10

A Canal for the 21st Century

Unfinished Business

"…In 1939, based on the survey in Nicaragua and the findings of the Governor of the Panama Canal, Congress shelved the idea of a second canal and authorized instead a third set of locks at Panama. The cost of the project was not to exceed $277,000,000. Actual work was begun on July 1, 1940, but the outbreak of the war caused the project to be greatly modified. Work was continued, however, throughout the war, and a large part of the dredging and excavation operations has been completed…"

***Popular Mechanics,* June 1946**

“...the idea of expanding the canal has been around almost since its inception. In 1939, the United States began excavations to enable the canal to accommodate a new generation of warships, but the start of World War II cut the project short. The ACP reviewed dozens of options before deciding to complete the Depression-era U.S. work. ‘On the Atlantic side, all of the American excavations are usable. On the Pacific side, we can use part of the excavations,’ an ACP official stated…”

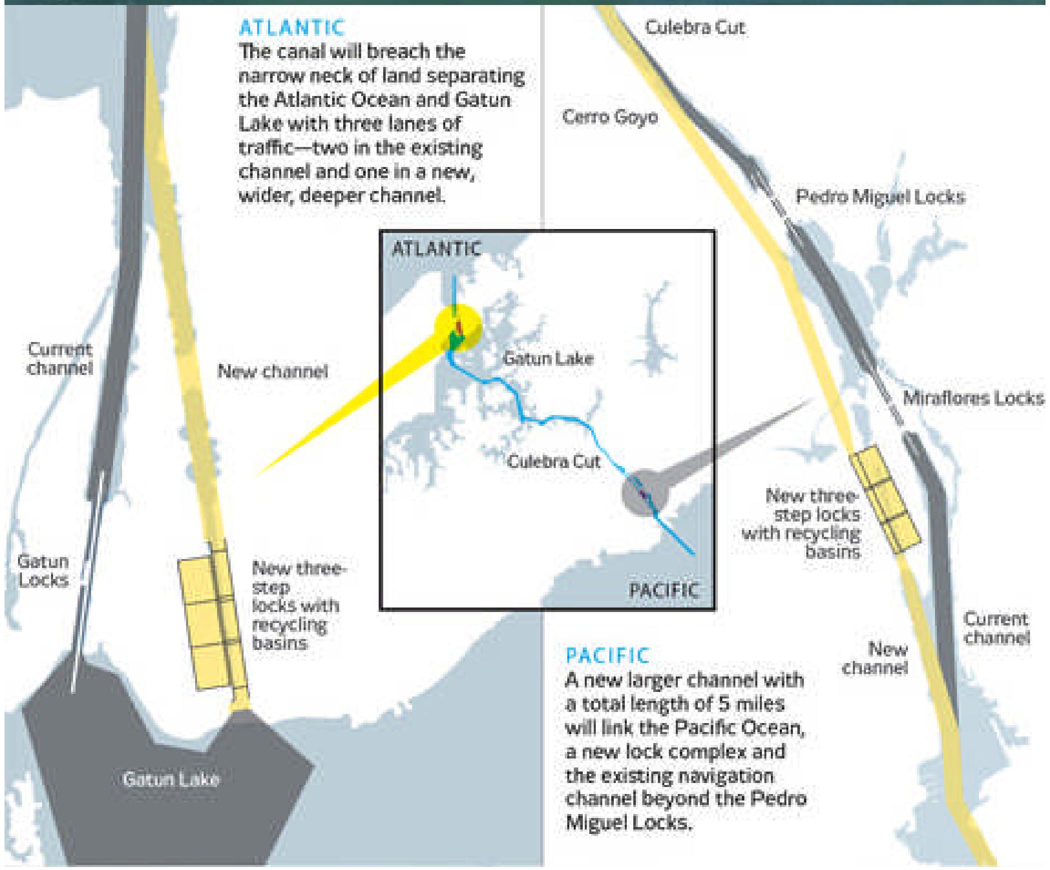
Popular Mechanics, **October 2009**

The People’s Choice

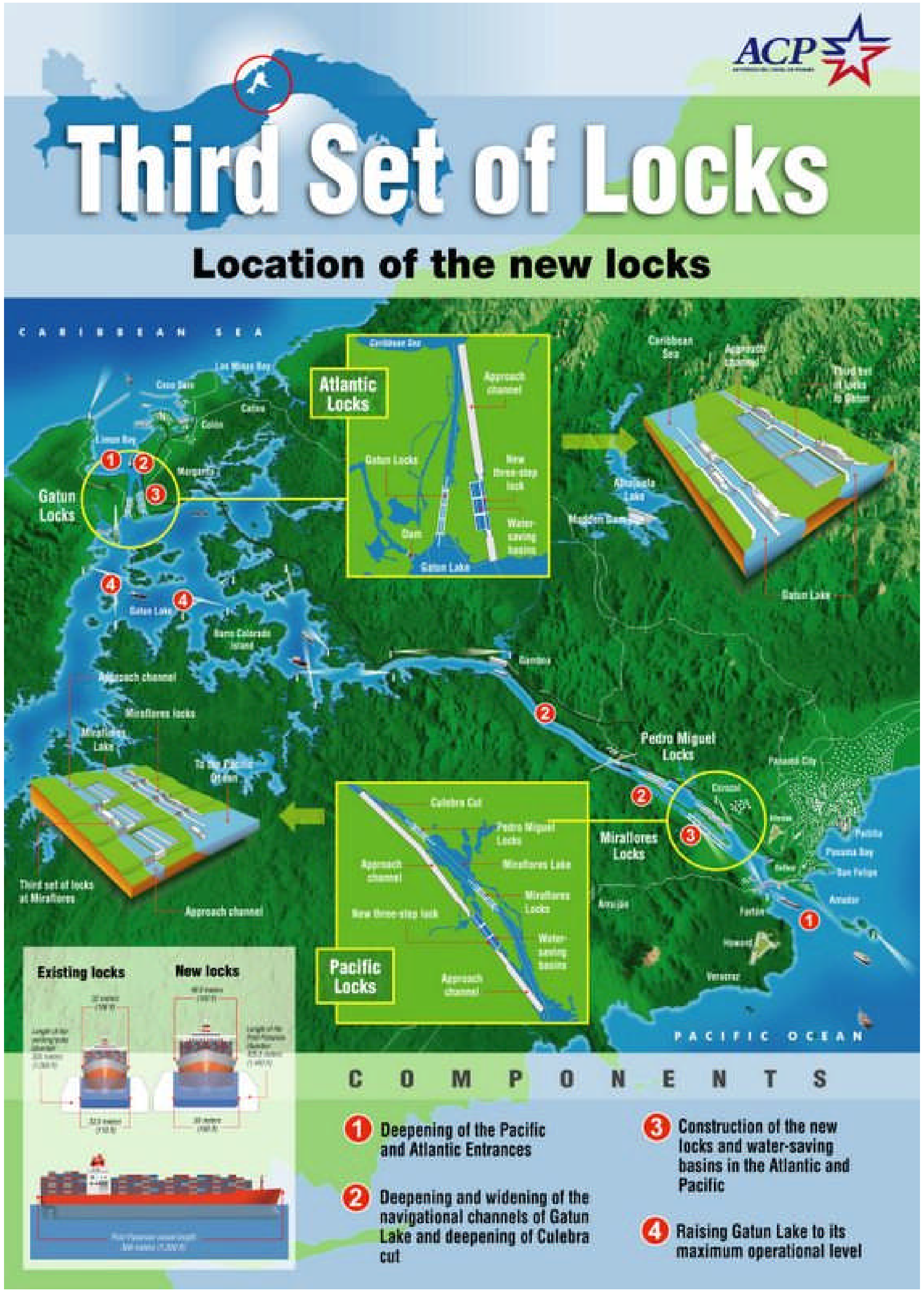
The decision to expand the canal was judged to be of such critical importance to Panama's future that it was the subject of a national referendum in 2006 when all citizens were invited to make their views known. At the time, President *Martín Torrijos Espino* said it was the most important decision his generation had to make. Public approval was readily evident when over 76% of voters declared they were in favor of the expansion. A year later, President Espino announced the Cabinet Council's authorization for the *Panama Canal Authority* (ACP) to negotiate the financial support package required. A group of multilateral and bilateral credit organizations, including the *European Investment Bank*, the *Japan Bank for International Cooperation*, the *Inter-American Development Bank*, *International Financial Corporation* and the *Andean Development Corporation* pledged a total of US$2.3 billion.

<u>Top Left</u>: *Jimmy Carter*, the POTUS who handed the canal back to *Panama* in 1977, attended the start of construction ceremony held on Monday, September 3rd 2007

<u>Top Right</u>: despite blistering heat and occasional storms, thousands of Panamanians lined the banks of the canal to celebrate the start of the *Canal Expansion Project*.


ATLANTIC
The canal will breach the narrow neck of land separating the Atlantic Ocean and Gatun Lake with three lanes of traffic—two in the existing channel and one in a new, wider, deeper channel.
Current channel
New channel
Gatun Locks
New three-step locks with recycling basins
Gatun Lake
ATLANTIC
Gatun Lake
Culebra Cut
PACIFIC
Culebra Cut
Cerro Goyo
Pedro Miguel Locks
Miraflores Locks
New three-step locks with recycling basins
Current channel
New channel
PACIFIC
A new larger channel with a total length of 5 miles will link the Pacific Ocean, a new lock complex and the existing navigation channel beyond the Pedro Miguel Locks.

On July 15th 2009, it was announced that *Grupo Unidos por el Canal SA* (GUPCSA) had been granted the job of designing and building the two new sets of locks that will join the *Panama Canal* to the *Atlantic Ocean* at one end and the *Pacific Ocean* at the other. *GUPCSA* is a consortium comprising *Sacyr Vallehermoso SA* of *Spain*, *Impregilo SpA* of *Italy*, dredging specialist *Jan De Nul NV* of the *Netherlands* and the Panamanian construction company *CUSA*. There was fierce competition for the project worth US$3.2 billion. Four international consortia were pre-qualified and, in the end, three bid for the project. ACP evaluated the proposals and judged that GUPCSA presented the best value proposition and had the resources to execute the locks project and bring it to completion by the scheduled date in late October 2014; the year of the centenary of the canal's opening. Meanwhile, *Dredging International* was awarded the contract for deepening and widening the *Pacific* entrance channel and Jan de Nul would undertake dredging of the *Atlantic* entrance channel. The expansion program also involves building a new channel; the *Pacific Access Channel*, that bypasses *Miraflores Lake* in parallel to the existing channel and locks. This new channel measures 6.1 kilometers and has been awarded via four distinct contracts. CUSA, a local contractor, won the initial excavation contract in 2007. Then a second dry excavation contract was undertaken by the Mexican-Panamanian consortium *Cilsa Panama-Minera Maria*. A third contract was awarded in 2008 to *Constructora Meco SA*, for a total of $36.6 million.



"By designing these projects in discrete elements, it meant we could do the entire excavation program in eight years. We would not have been able to do a full design for the entire length of the channel for another two years which would have meant two years of lost time. Another consideration was that we wanted to start with smaller projects to give local and regional contractors an opportunity to participate. They were able to come up with very good bid prices and as a result we have some components that were completed well under budget. Working closely with the contractors has also given us many opportunities for a shared approach to value engineering. For example, the completion of the first phase of the excavation work was achieved with a saving of $700,000 for ACP and the contractor improved its profit margin more than they anticipated by providing the ACP with a redesign of a portion of a road. It has been a similar success story with all three of the first dry excavation projects which have all come in under budget."

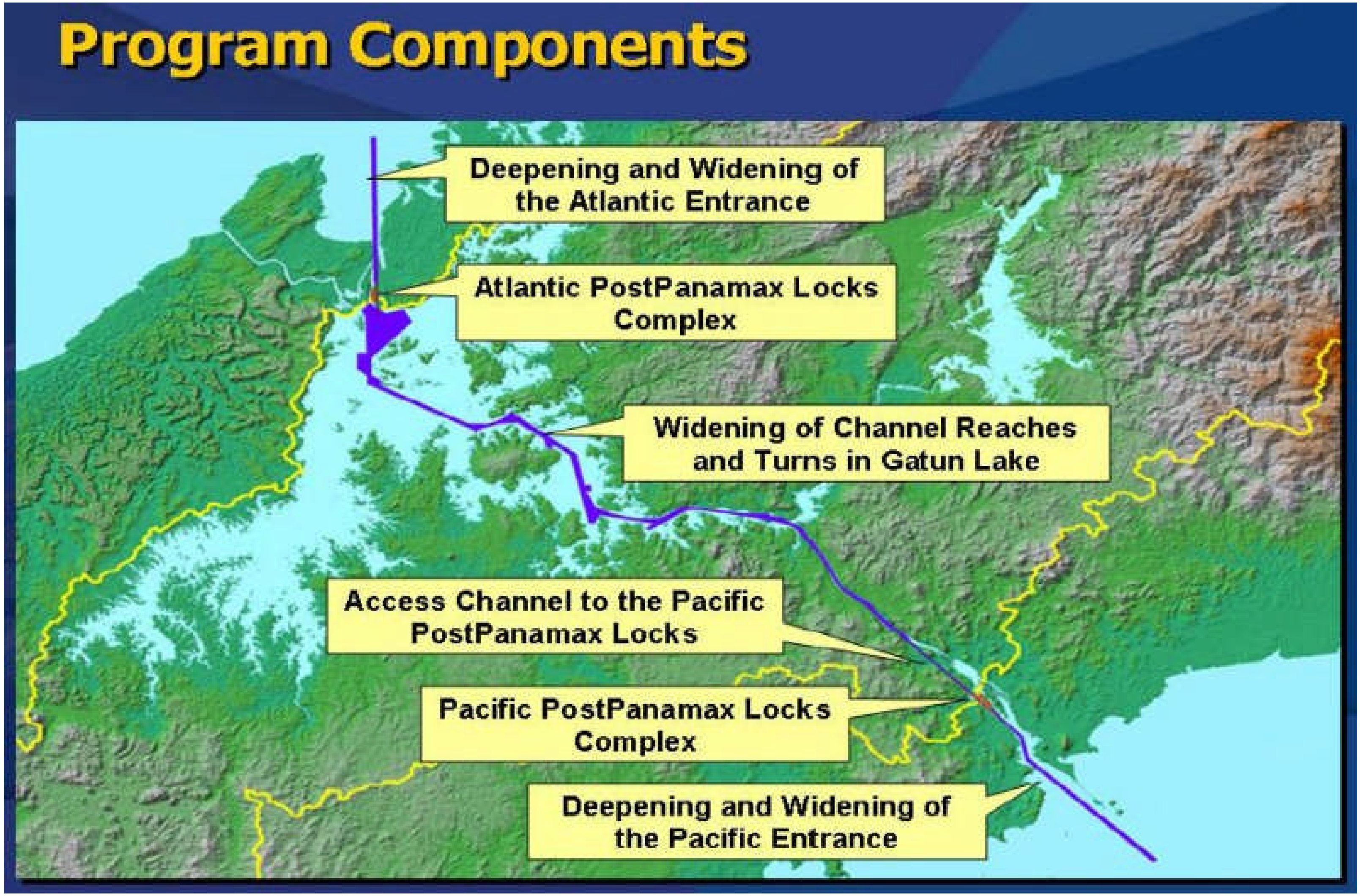
***Jorge Quijano*, ACP Executive Vice President of Engineering**

RE: his rationale for splitting the excavation of the 6.1 km channell into four contracts. At the mouth of the *Pacific Access Channel*, there is also another small but significant dredging project.

"…We have been studying ways to expand the Canal since 1997 and looking at alternatives and options. Then in 2002 and 2003, we invited other consultants to particularly contribute on the locks project to find a way to avoid building an additional reservoir…we did a great deal of legwork before we put these projects out to tender…We started with a large contingency fund containing over $1.5 billion dollars to account for inflation and all sorts of possible unknowns in the field. As projects were designed, bid and awarded at or under budget the remaining contingencies have been consolidated to complement the final components of the expansion if we see that they are needed…On the dry excavation side for example, we have been contracting work out for more than twenty years and each time it has been on the basis of presenting contractors with tenders that required excavations of unclassified material. We know the geology of the area very well by now…"

***Jorge Quijano*, ACP Executive Vice President of Engineering**

RE: all of the canal expansion work, with the exception of the locks, was designed in-house by ACP engineers and complemented with consultants for the dams. Design also entailed full responsibility for extensive preliminary geological investigations.


Program Components
Deepening and Widening of the Atlantic Entrance
Atlantic PostPanamax Locks Complex
Widening of Channel Reaches and Turns in Gatun Lake
Access Channel to the Pacific PostPanamax Locks
Pacific PostPanamax Locks Complex
Deepening and Widening of the Pacific Entrance

"…Here's how the upgrade will work. A post-Panamax freighter from Asia bound for, say, Norfolk, Va., will nose into the canal west of the existing Pacific entrance and head up a new mile-long channel to three-step locks (excavation crews will use 85 percent of an earlier dig that was halted by World War II). The lock will lift the vessel 85 feet to another new channel that parallels the current Miraflores and Pedro Miguel Locks. Beyond Pedro Miguel, old and new waterways will merge in a widened, deepened channel that will knife through the Continental Divide at the Culebra Cut. Five miles on, the supersize ship will enter man-made Gatun Lake, which it will cross in a 45-mile-long expanded navigation channel to reach a new three-step lock complex and water lane east of the existing Gatun Locks and channel (crews will use all of the World War II-era excavation here). Two miles later - and, depending on traffic, 8 to 10 hours after entering the canal - the freighter will reach the Atlantic, with Norfolk less than a week away to the north…"

***Popular Mechanics*, February 2010**

<u>Left</u>: caption: "At Cerro Goyo, northwest of the Pedro Miguel Locks on the Panama Canal, a 1400-hp hydraulic shovel claws 22 cubic yards per swipe. Part of a $5.25 billion expansion, this excavation will connect a new set of locks to the existing waterway."

<u>Right</u>: caption: "An Atlantic-bound Panamax container ship that has cleared the Pedro Miguel Locks eases past the Cerro Goyo excavation en route to Gatun Lake. Panamax refers to the current maximum size of a vessel that the canal can accommodate: 965 feet long, with a beam of 106 feet and a draft of 39 feet. Expansion will boost post-Panamax dimensions to 1200 feet, 160 feet and 50 feet."

"We decided that because transiting vessels in the lake move regularly past the equipment, the dredging work would be best left to our internal team which has 100 years of navigational dredging expertise in the area. Nonetheless the northern sections of the lake's channels are wider, with fewer safety and operational implications, so these have been contracted out."

***Jorge Quijano*, ACP Executive Vice President of Engineering**

RE: *Gatun Lake*, a particularly sensitive area, where traffic is most restricted. ACP made it a priority that the canal continue to operate as efficiently while expansion work was in progress.

Above: two images showing the progress of the *Panama Canal Expansion Project*. At left, from 2006 and at right, from June 2009. Note the hill in front of the *Centennial Bridge* in the photograph at left. In the photo at right, the hill has been completely removed. The first phase of the expansion project was the dry excavations of the 715-foot wide trench connecting the *Culebra Cut* with the *Pacific* coast; removing a total of 47 million cubic meters of earth and rock.

Left: caption: “Dynamite was used to blast away part of a hillside next to the canal. The project will involve the removal of 47 million cubic meters of earth and rock.”

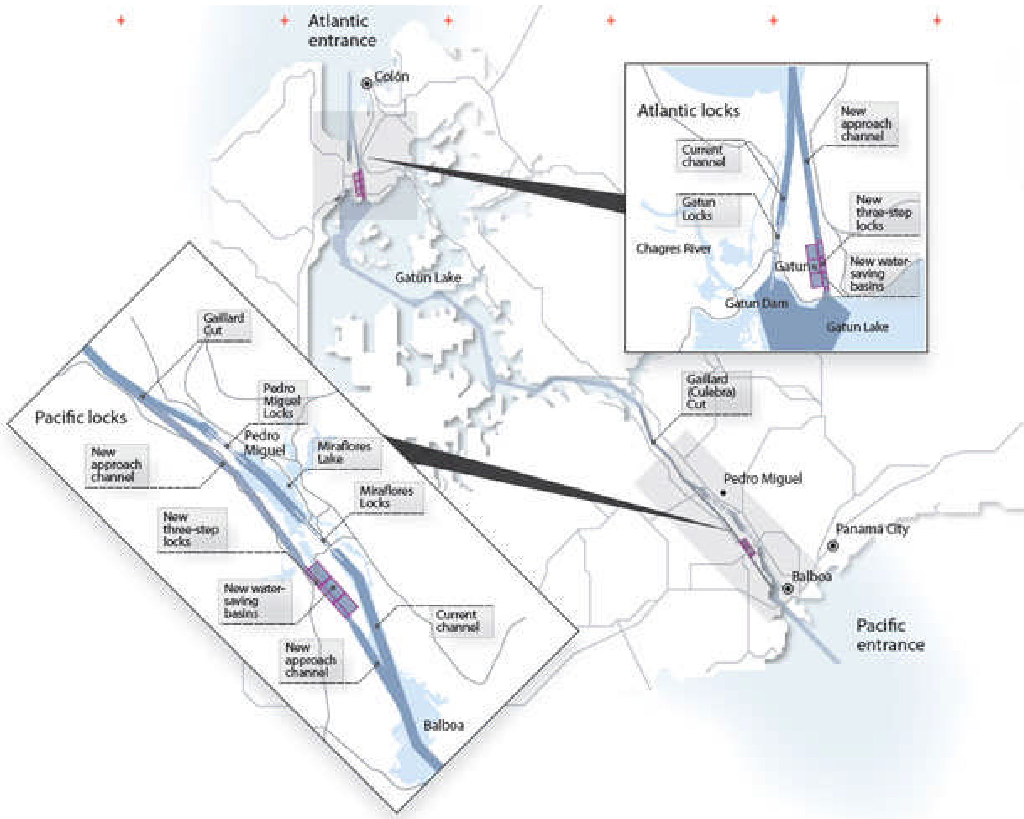
 

<u>Left</u>: caption: “Uncovered during excavations at Cerro Goyo, a dredge bucket and iron railroad wheels date from early-20th-century American excavations.”
<u>Right</u>: caption: “This vehicular bridge is part of a diversion project that now sends the Cocoli River down to the Pacific. The river used to flow through the site of a new access channel that will carry post-Panamax vessels between the ocean and new three-step locks near the existing Miraflores Locks.”

"This element we decided not to tackle ourselves. It was decided that it would be delivered through a design-build contract. As such the whole design risk has been effectively transferred to Montgomery Watson Harza who the consortium has chosen to be the designer of record for the locks. These locks are being built entirely according to their design and specifications, although of course we have reviewed the process closely."

***Jorge Quijano*, ACP Executive Vice President of Engineering**

RE: the design/construction of the core locks (which has a value of US$3.2 billion)



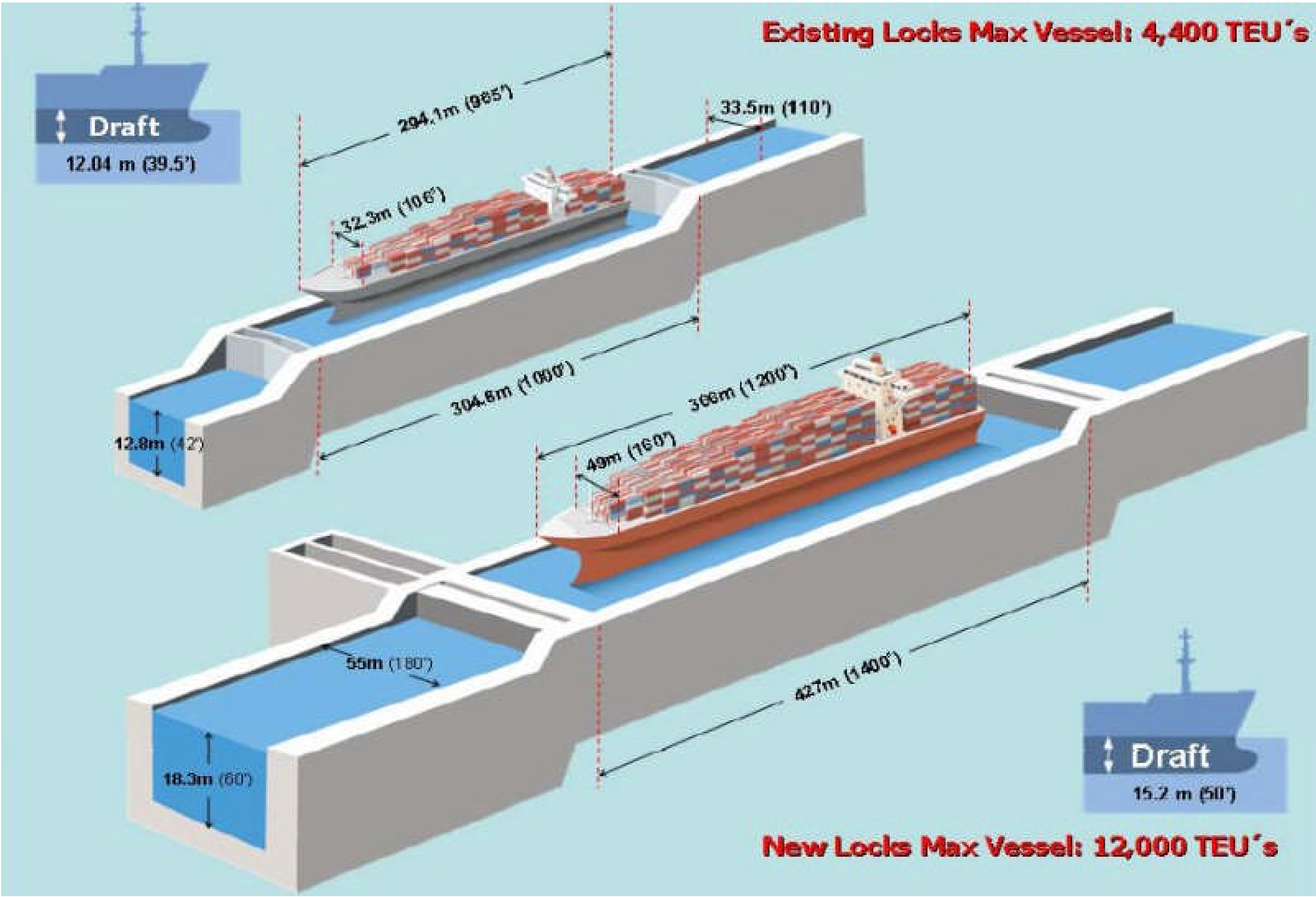
"…More than half the $5.25 billion budgeted for the expansion of the Panama Canal; $3.35 billion, will be spent on new single-lane, three-step locks at the Atlantic and Pacific entrances, as well as on new channels. The new locks will not replace but augment the existing locks and allow the canal to handle larger post-Panamax ships and tankers. To connect those locks to existing shipping lanes, nearly five miles of channels will be excavated. The current route through Gatun Lake will also be deepened by five feet and widened, from today's 500 foot minimum, to 920 feet on straightaways and 1200 feet in the turns. Gatun Lake will then be raised 1.5 feet, providing an extra 550 million gallons of water each day for the locks and alleviating concerns that canal expansion will tax water supplies. About 130 million tons will be excavated over the next seven or eight years, more than half the amount removed during thirty-four years of French and U.S. digging…."

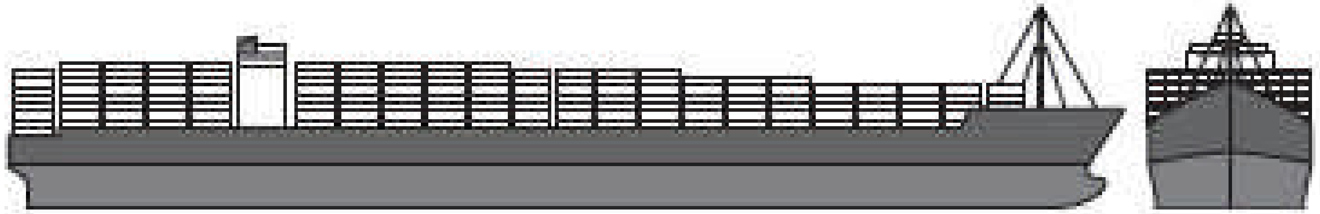
***Popular Mechanics*, October 2009**

"Most of their effort is concentrated on the locks, which is the most complex aspect of the expansion, but at a program management level many other projects feed into this overall objective and we looked for external support to get the integration we felt we needed. We did not want a turnkey approach to this project because we have many highly skilled and capable engineers within ACP. It was more a question of filling in the knowledge and experience gaps and now, after four years of working with CH2MHill, we are all perfectly aligned with objectives that are understood and shared across the program. I feel we have succeeded in mixing the best of local talent with the expertise of some of the finest international consultants to achieve an extraordinary feat of engineering,"

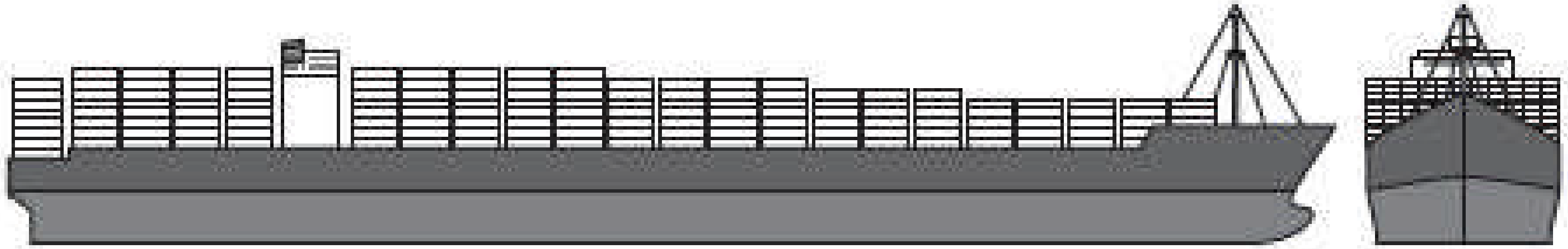
***Jorge Quijano*, ACP Executive Vice President of Engineering**

RE: in 2007, ACP contracted *CH2MHill*, known for their project management of the *London Olympics*, to support the expansion program for the duration of the canal expansion.


Existing Locks Max Vessel: 4,400 TEU´s
Draft
12.04 m (39.5')
294.1m (965')
33.5m (110')
32.3m (106')
304.8m (1000')
12.8m (42')
366m (1200')
49m (160')
55m (180')
427m (1400')
18.3m (60')
Draft
15.2 m (50')
New Locks Max Vessel: 12,000 TEU´s



Panamax: max. load 5000 containers



Post-Panamax: max. load 12,000 containers

"The new locks will accommodate 1200-ft.-long post-Panamax ships displacing 170,000 tons and hauling up to 12,000 Twenty-foot Equivalent Units. One TEU is the cargo capacity of a standard shipping container. The current maximum capacity is 5000 TEUs. More cargo means more money: The Panama Canal Authority estimates a 35 percent increase in cargo volume through 2025 -- and additional toll revenues of $10 billion."

***Popular Mechanics*, March 2009**

	Locks	Panamax	New locks	New Panamax[1]
Length	1,050 ft (320.04 m)	965 ft (294.13 m)	1,400 ft (427 m)	1,200 ft (366 m)
Width	110 ft (33.53 m)	106 ft (32.31 m)	180.5 ft (55 m)	160.7 ft (49 m)
Draft[2]	41.2 ft (12.56 m)	39.5 ft (12.04 m)	60 ft (18.3 m)	49.9 ft (15.2 m)
TEU		**5,000**		**12,000**

[1]New Panamax sizes are published in metric system[2]

[2]Draft in Tropical Freshwater (TF)

<u>Top Left</u>: excavation for to *Colon Locks*

<u>Top Right</u>: Construction on the *Atlantic*-side of the *Third Set of Locks Project* of the *Panama Canal* expansion. Inset shows artist's rendering of locks when complete. In view is the new *Colon Visitors Center/Canal Expansion Observation Center* (outlined)

<u>Left</u>: the old *Gatun Locks Visitors Center*

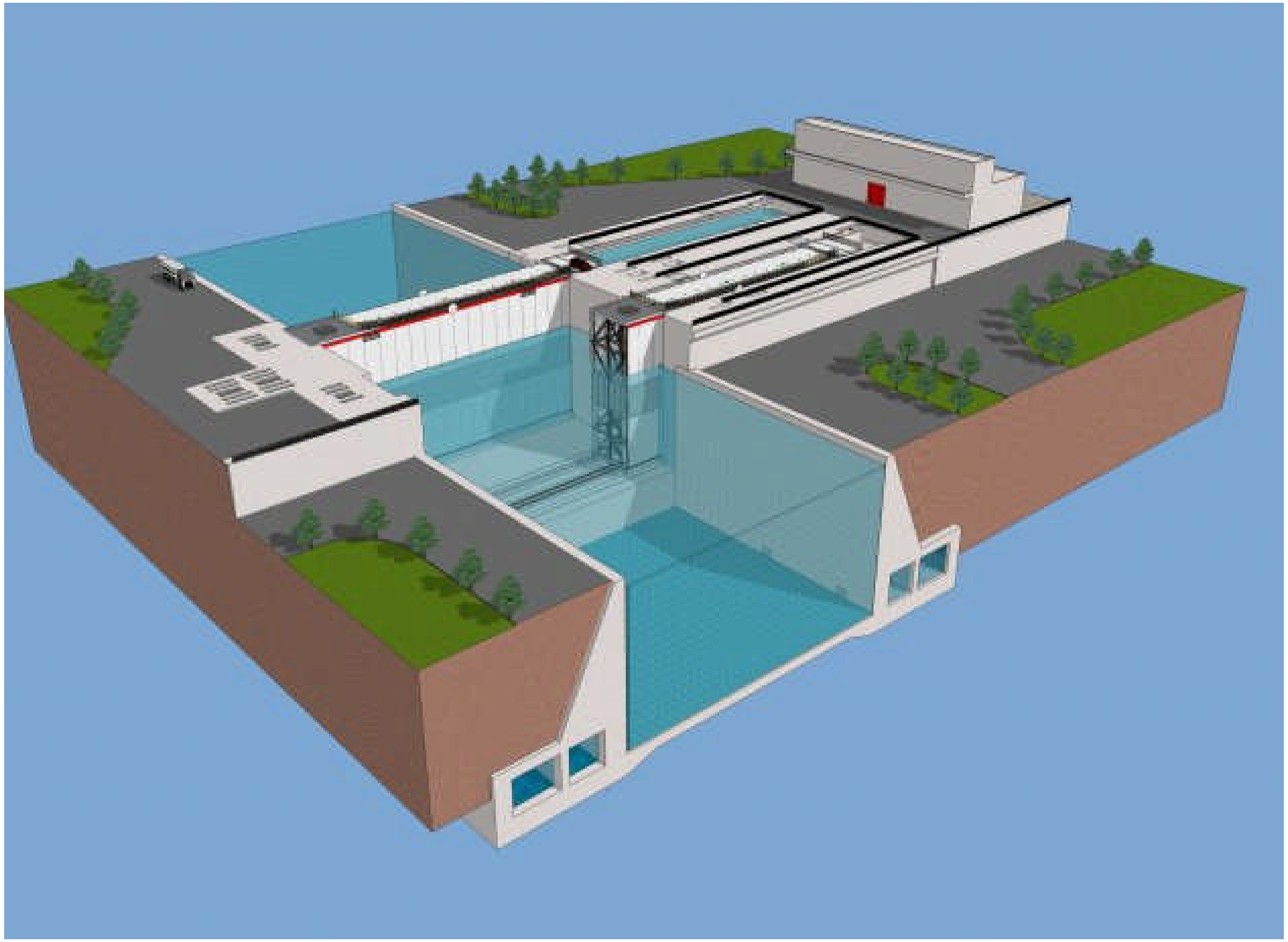
<u>Above</u>: construction on the *Pacific*-side of the *Third Set of Locks Project* of the *Panama Canal* expansion
<u>Left</u>: inset: rendering of the Pacific entrance of the Third Set of Locks project of the Panama Canal Expansion

The *Panama Canal Expansion Project* includes the construction of a third lane of locks alongside the existing lock complexes (*Gatun Locks* on the *Atlantic*-side and the *Miraflores* and *Pedro Miguel Locks* on the *Pacific*-side). For each lock-set, three levels will be constructed, one behind the other, raising ships from sea-level to *Lake Gatun* at 85-feet above sea-level. The locks are 60% wider and 40% longer than the existing ones, and each has three chambers. Double doors are being installed between the different levels to meet the stringent reliability and availability requirements. Each lock complex will have eight doors in total.

“…The canal’s current miter gates are based on a design found in the 15th century notebooks of Leonardo da Vinci: double-leaf doors hinged on chamber walls and sealed by water pressure. Each leaf is 65 ft. long, 7 ft. thick, and 47 to 82 ft. high; the most massive weighs 730 tons. For repairs and maintenance, they need to be removed and taken to a dry dock, shutting down a traffic lane and causing delays like those that occurred last August. Once again, ACP officials found a European solution, where new locks on several canals accommodate post-Panamax ships. These locks, most notably the Berendrecht Lock in Antwerp, Belgium, employ two rolling gates, which are stored in recesses in the lock wall. The gate works like a wheelbarrow, with sets of wheels on the front and rear. When tilted forward in the recess, the gate slides across the chamber; when tilted backward, it returns to its recess. Most significantly, the twin-gate design allows canal crews to seal one of the recesses with a bulkhead and pump it dry, creating an on-site dry dock for maintenance and repairs. Meanwhile, the other gate is used to keep traffic moving…”

***Popular Mechanics,* October 2009**

Each lock complex will have eight doors in total. The doors must be capable of withstanding hugely fluctuating water pressures, ship collisions and/or earthquakes. The entire lock complex must be available to shipping 99.6% of the time, a requirement with major design and maintenance implications. *v-Groep*, part of the *CICP* design team, together with *MWH Global* and *Tetra Tech* are responsible for designing the new lock doors and the transmission mechanism, including the operating system, RAMS analysis of the entire lock complex, and the supervision of construction work in progress. The lock complex walls are made of concrete and are up to 33 meters in height. On the outside, they taper down to a width of 30 meters at the base. The double lock doors are made of steel and are 31 meters high, 57 meters wide and 10 meters thick. Each door contains an average of 3500 tons of steel. The old locks are fitted with miter gates, but the doors in the new locks will have roller gates, which on opening and closing will move horizontally at right angles to the direction of navigation.

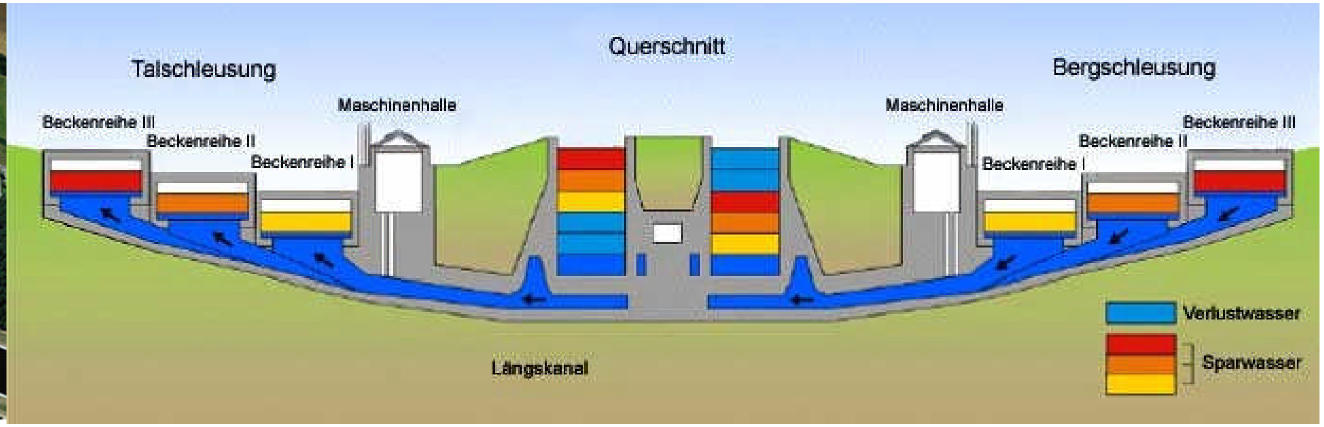


The Aha! Moment

“…The biggest tax on the water supply, though, is the canal itself. It requires, on average, more than 2 billion gallons per day to fill the locks for passing ships. An expansion plan that included bigger locks with a traditional design would have doubled water consumption. One way to address the problem - build dams to create new reservoirs - was a nonstarter. It would have meant relocating residents, even entire communities, which was politically unpalatable. Then, in 1999, canal officials visited the Hohenwarthe Locks on the Elbe River in Germany and saw a solution: locks that recycled some of the water used in transits. ‘It was one of those 'Aha!' moments,’ says Raal Brostella, an ACP port captain. ‘In effect, you are able to reuse water that would otherwise be flushed out to sea.’ Three shallow basins adjacent to each chamber in the new locks will collectively capture 60 percent of the water from the locks as they are emptied. This water will be used to partially refill the locks when another ship comes through. As a result, although the new lock chambers will hold 65 percent more water than the originals, they will use seven percent less water per transit. The canal authority also will raise the level of Gatun Lake, making an additional 550 million gallons of water available each day…by doubling up smaller ships in the new lock chambers, officials can limit the use of the older, more wasteful, locks. But even if both sets of locks run full tilt, officials say, ‘we will run out of capacity before we run out of water…’”

***Popular Mechanics*, October 2009**

Sparschleuse

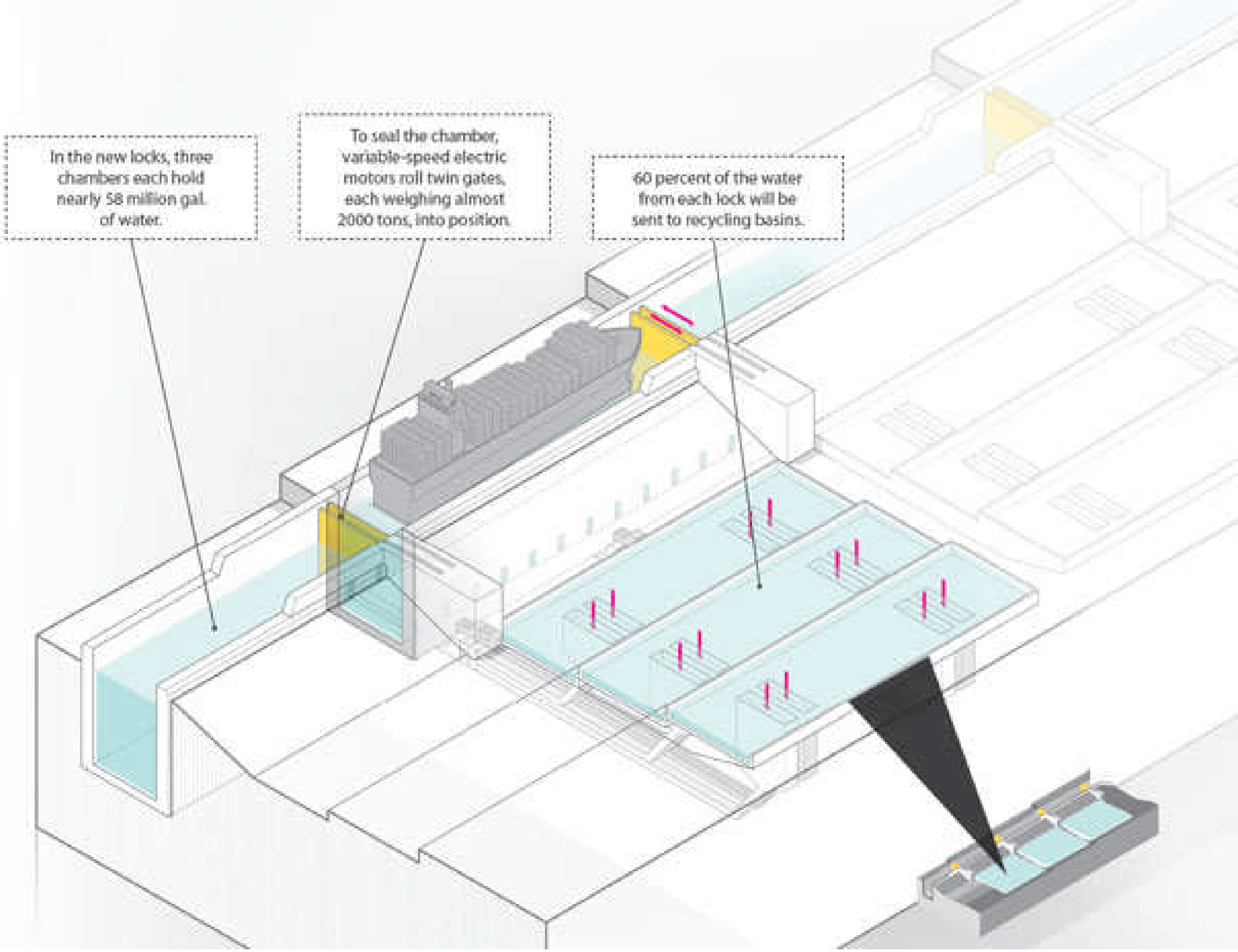


<u>Top Left</u>: *Hohenwarthe Locks* on the *Elbe River*, near *Magdeburg, Germany*

<u>Top Right</u>: sectional view of the *Rothensee Lock* (ship lift), downstream from Hohenwarthe on the Elbe River. Like the lock in Hohenwarthe, it contains water saving chambers and has a maximum difference in level of 18 meters. At Hohenwarthe, a difference of 18.5 meters in water level at normal water levels and a difference of 11 meters at high water levels must be overcome at this lock. To minimize the water consumption and the costs of pumping the water back, the lock was designed as a savings lock ("Sparschleuse"). This means that next to each of the lock chambers are three saving chambers adjoining each other, which takes up or releases the lock water. This saves up to 60 % of the water used in the lock. The other 40% is replaced by pumping water back after a downstream lock process.

“…Expansion plans for the Panama Canal call for two new sets of triple locks - one at the Atlantic entrance to the waterway and one at the Pacific. Although the new locks will be 65 percent larger than the current locks, the new design incorporates recycling basins that will reduce the amount of water for each transit by 7 percent. Currently, each transit flushes about 52 million gal. of fresh water - enough to supply a city of 250,000 people - into the Atlantic and Pacific oceans. The recycling basins adjacent to each lock chamber are 1400 ft. long, 230 ft. wide and 18 ft. deep. The highest in each set is positioned slightly below the top of the lock chamber; the lowest is just above the chamber's minimum water level. Gravity funnels water from the basins and Gatun Lake through culverts in the lock walls, filling each chamber with 15 million cu. ft. of water and raising ships about 30 ft. in approximately 10 minutes. When vessels are lowered, valves reopen and gravity feeds 60 percent of the water back into the basins. Instead of hinged miter gates, the new locks will use paired rolling gates, which have proved reliable at Pittsburgh's Davis Island Lock and Dam since 1885. The gates will roll out of wall recesses on tracks to seal the chambers. For repairs and maintenance, one gate will continue to operate while the other is returned to its recess, which is then sealed and pumped dry. Crews will work on site; traffic will still flow…”

Popular Mechanics, **October 2009**


In the new locks, three chambers each hold nearly 58 million gal. of water.
To seal the chamber, variable-speed electric motors roll twin gates, each weighing almost 2000 tons, into position.
60 percent of the water from each lock will be sent to recycling basins.

"…For generations, seamen and cruise ship passengers have watched electric locomotives known as 'mules' glide along lock-side tracks, pulling on hawsers to maneuver ships in the lock chambers. The new locks would have required 12 to 16 mules to position post-Panamax vessels. Instead, tugboats that already service canal traffic will align ships in the chambers - one at the bow and one at the stern…"

Popular Mechanics, **March 2009**

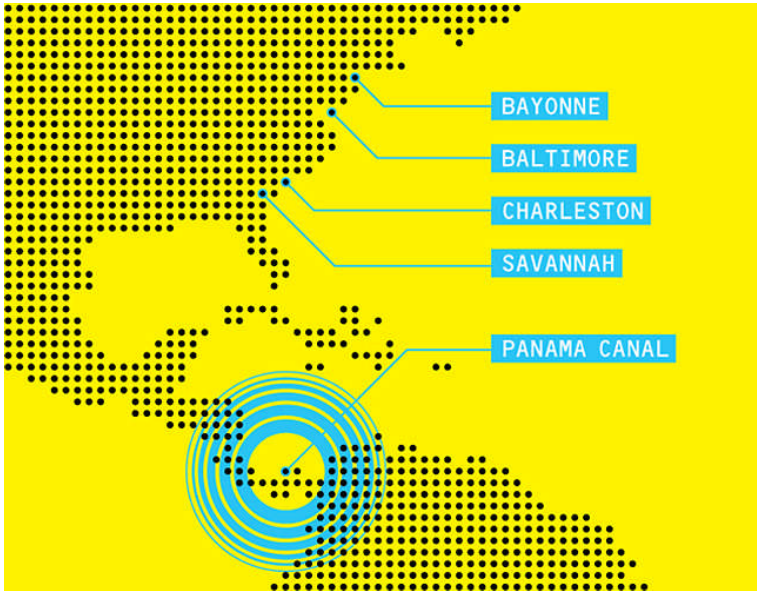
The New Panamax Era

"The operators of the Panama Canal are widening and deepening the waterway to allow larger ships to access the Atlantic and Pacific oceans starting in 2014. Even as port operators prepare for the vessels, work on other vital trade connections is lagging. Experts such as Paul Bingham, an economist with the transportation consulting firm Wilbur Smith Associates, say U.S. road and rail networks are unprepared for the increase in commerce. 'The most critical problems are in urban areas near the ports,' Bingham says. 'These are dense regions without a lot of room to expand.' Ships will unload twice as much cargo, causing logistical gridlock, says Johanna Mendelson Forman, senior associate with the Americas Program at the Center for Strategic and International Studies. 'Railroads are at capacity in the U.S., and we have not invested what we need to be competitive.' Bingham says the clock is ticking: 'Three years is a blink of an eye. It's almost too late…'"

***Popular Mechanics,* October 2011**

"…'Fiffty is the magic number,' a Coast Guard official told me. That is the depth in feet needed for a port to be able to successfully receive the post-Panamax ships that will, within 20 years, carry the vast majority of global commerce. Many ports that now rest at 43 to 45 feet are digging and dredging to get there; Norfolk, Va., is ready, as is Baltimore. New York and New Jersey are hoping, but they have to elevate the Bayonne Bridge near Staten Island to make it happen. Boston would have a long way to dig. The United States is the only modern society that does not have a federal agency responsible for port strategy. Maritime planning is left to the states. The White House can merely promise expedited engineering review, as it did last month, of the port changes in New York, New Jersey, South Carolina, Georgia, and Florida, all trying to get to that depth of 50 feet, fast. This port competition marks the end of an empire, the West Coast Empire, which has benefited from container traffic that can't currently fit through the canal; post-Panamax ships that cross the Pacific Ocean must now offload their cargo on the West Coast, from which it moves across the country on a 'land bridge' of highways and railways. According to a 2008 study, nearly 30 percent of containers coming to New England begin their transcontinental journey from the ports of Los Angeles and Long Beach. After the Panama Canal's expansion, the largest container ships will be able to steam straight through to the East Coast, cutting costs dramatically. It will finally enable ports along the East Coast and Gulf of Mexico to be major players in global commerce…"

***The Boston Globe,* September 12th 2012**



"...<u>Bayonne, N.J</u>. The Bayonne Bridge at the mouth of Newark Bay has a clearance of just 151 feet - even current ships have a hard time fitting beneath it. The Port Authority of New York and New Jersey recently approved a $1 billion plan to raise the bridge to 215 feet. Construction is expected to begin within two years and to be completed by 2016. Officials say the bridge will remain open to traffic during construction.

<u>Baltimore, Md.</u> Engineers have been increasing the depth of this shipping channel from 45 feet to 50 feet to accommodate New Panamax ships at the docks. The $105 million project will be finished in 2012, two years ahead of the 2014 opening of the expanded canal. Officials credit the quick work to the establishment of a public-private partnership that spared the project from budget cuts at the state level.

<u>Charleston, S.C.</u> The port currently supports larger Panamax ships only at high tide. This year, local officials and the U.S. Army Corps of Engineers approved a study to investigate the environmental and economic impact of dredging the channel. But a lack of funding could delay the analysis for eight years, long after the new canal opens to ship traffic. Dredging, if it happens, could cost $310 million.

<u>Savannah, Ga</u>. Big ships destined for Savannah are filled to half-capacity and enter the port during high tide in order to avoid scraping the river bottom. The state has partially funded an impending dredging project, but local environmentalists express concern that deepening the channel could decrease the already depleted dissolved oxygen levels in the river and introduce salt into freshwater wetlands."

***Popular Mechanics*, October 2011**

To the Victor Go the Spoils

"What Panamanian citizens may not realize is that when they approved the Panama Canal Extension project in 2007, it sent a shockwave through every seaport in the United States, particularly those on the East Coast that were designed specifically to adhere to 'Panamax' regulations. The Panama Canal expansion is a microcosm for the entire U.S. seaport system because the ports that will stay competitive in global trade markets are the same ones that need to modernize their sea terminals to accommodate the larger ships that will be traveling through the Panama Canal in 2014 when the extension is complete… Now that the Panama Canal is positioned to begin accepting the larger ships in 2014, the burden of upgrading port infrastructures shifts to the East Coast, where their race has intensified in recent months. The first Port Authority to prove that its port can meet New Panamax requirements will have a substantial advantage over its competitors. The potential is limitless from an economic standpoint because the favored port could ultimately become the epicenter for U.S. international trade in the New Panamax Era…To the victor go the spoils."

Supply Chain Digital, **September 12th 2011**

Above: this *Singapore*-based container ship, too wide to cross the *Panama Canal* in its original configuration, is having its cargo transferred to the other side of the canal at a private port.

A Work of Civilization

"The creation of a water passage across Panama was one of the supreme human achievements of all time, the culmination of a heroic dream of over four hundred years and of more than twenty years of phenomenal effort and sacrifice. The fifty miles between the oceans were among the hardest ever won by human effort and ingenuity, and no statistics on tonnage or tolls can begin to convey the grandeur of what was accomplished. Primarily the canal is an expression of that old and noble desire to bridge the divide, to bring people together. It is a work of civilization."

***David McCullough*, Historian/Author**