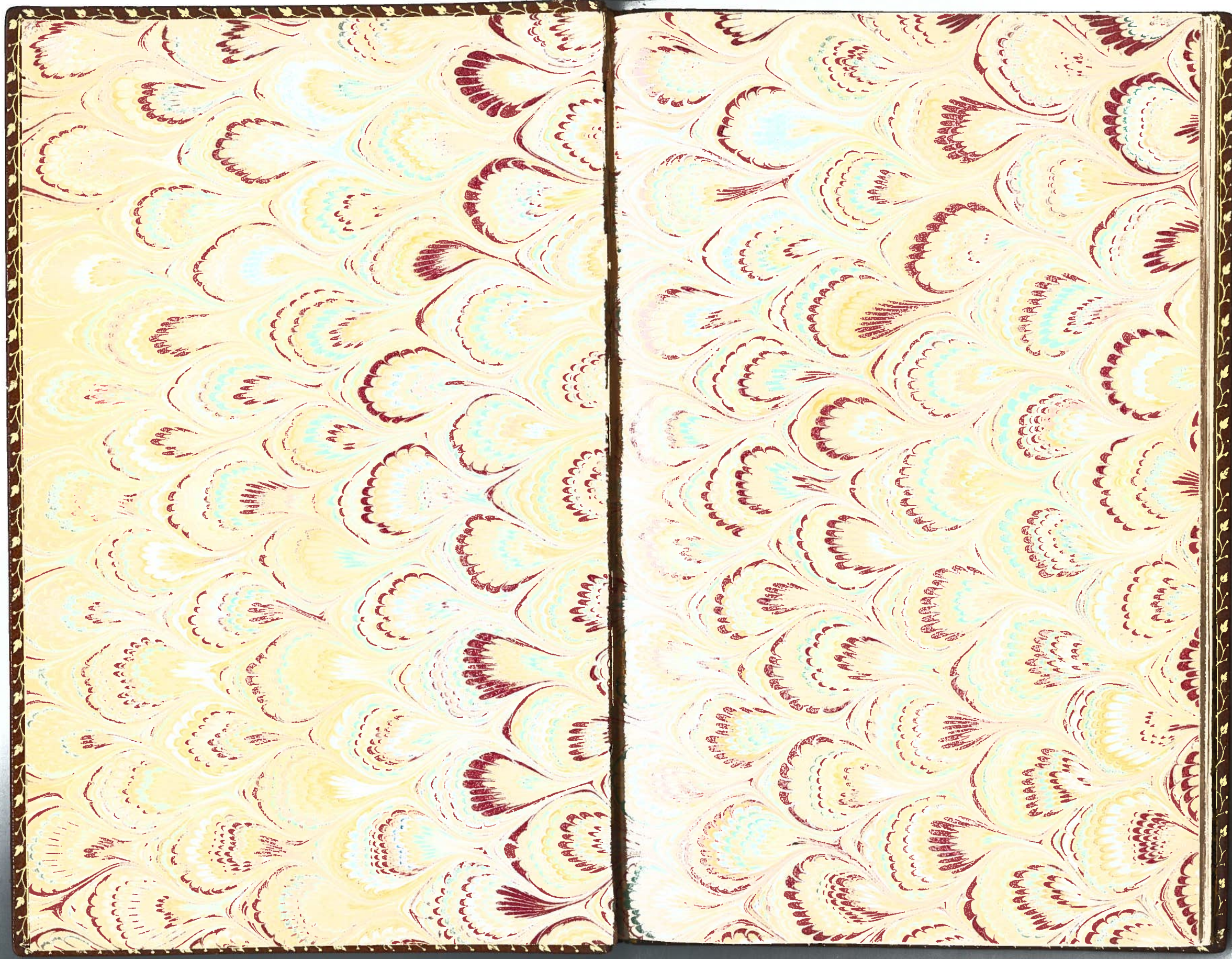


AU GRAND INGENIEUR ANGLAIS SIR JOHN WOLFE BARRY SOUVENIR DE SA

MÉMORABLE INTERVENTION DANS LE PROBLÈME DU DÉTROIT DE PANAMA

LE 23 JANVIER 1907

PHILIPPE BUNAU-VARILLA



A Lr John Wolfe Barry
Hommage de
P Bunau Varilla
Nicaragua or Panama

The Substance of a Series of Conferences made

before the Commercial Club of Cincinnati
before the Engineers' Club of Cincinnati
before the Commercial Club of Boston
under the Auspices of the National Business
League in Chicago
before the Princeton University in New Jersey
etc., etc.

and of a formal address to the

**CHAMBER OF COMMERCE OF THE STATE
OF NEW YORK**

By

Philippe Bunau-Varilla

Former Engineer-in-Chief of the Panama Canal ; Director of the Congo Railway
President of the Madrid, Caceres, Portugal, and West
of Spain Railways

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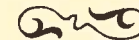
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The Knickerbocker Press
New York
1901

I firmly believe that when the Truth is advancing nothing can stop it ; I firmly believe that its irresistible pressure will overthrow any dam of prejudice erected in order to hold it back.

At the same time I think that individual efforts may largely help the Truth in its progress, by clearing from its path the obstructions of ignorance.

This was my aim when I answered affirmatively to three American friends who invited me to come to this country of free discussion in order to say publicly what they had heard in private conversation with me in Paris.

I am not here as the representative of any private interest ; I came to defend a grand and noble conception which gave me several happy years of struggle and danger, and for which I suffered many years of anxiety, during which I do not remember one hour of despair.

It has been to me a great privilege to have the opportunity of exposing to the clear light of day all the irrefutable facts which show that Providence has subjected to a severe test the sagacity of man, by giving apparently to the Isthmus of Nicaragua all good qualities, and to the Isthmus of Panama all defects for an interoceanic waterway, when in reality it has given to the latter and refused to the former all the attributes necessary for the establishment of this natural highway of nations.

I have been happy to speak in this great country, where the first official word of justice for Panama has come from the eminent Isthmian Canal Commission.

My purpose has been attained. I have worked for the scientific Truth on one of those fields, where, as Mr. Carnegie recently and justly said, there is no room for selfish and private aims.

PHILIPPE BUNAU-VARILLA.

NEW YORK, March 15, 1901.

GENTLEMEN:—It will be my effort to lay before you a series of facts officially or scientifically established and to show at their clear light the real aspect of this question of paramount importance.

Those facts, drawn from absolutely reliable sources, will help to pierce the dense mist of prejudice and erroneous impressions that floats over public opinion, which was misled both by the deceitful appearance of the natural conditions of the two canal routes of Nicaragua and Panama, and at the same time by the false idea that the Panama enterprise was paralyzed by technical impossibilities, when, on the contrary, the financial difficulties were the only cause of such paralysis, and came when, after a long struggle, all technical problems had been entirely solved.

It would have been a short time ago impossible to make the same demonstrations with the same authoritative statements because, though the facts that I could have brought had been the same, I would have been obliged to place them under the authority of the books that I published nine years ago, and I would have hesitated to ask from you so much credit for them.

To-day the situation is changed; an official commission formed of the most prominent engineers of this great country, so rich in eminent engineers, has thoroughly studied the question, and though they have

presented but a preliminary report, which did not embrace all the points of this complicated question, nevertheless the facts already definitively settled by this high court of technical skill are so numerous and so precisely stated that a stable and permanent basis is at last offered for a clear, open, and loyal examination of the question.

In order to avoid any confusion about the authority of the statements that I am going to make before you I shall divide my speech into two distinct parts, which correspond to two natural divisions, from the point of view of the subject examined and from that of the authorities which cover the statements.

I am going first to submit to comparative examination all the points that characterize the routes of the Nicaragua and Panama from the point of view of construction or operation.

For the first part I shall not give any figures that are not extracted from the two American official reports on the subject, namely: The preliminary report of the Isthmian Canal Commission of November 30, 1900, and the report of the Nicaragua Canal Commission, 1897-1899.

Only some figures referring to the curves of the Panama Canal, and which are not to be found in said reports, will be extracted from the report of the Comité Technique of the Compagnie Nouvelle de Panama, made under the authority of first-rank engineers of America, England, Germany, and France; also some figures about the Chagres floods will be extracted from public documents of said Compagnie.

In the second part the facts that I shall state in relation to the stability of the construction are not given under the authority of the Isthmian Canal

Commission, who did not speak of that part of the subject in the preliminary report, and some facts only will be extracted from the report of the Nicaragua Canal Commission.

Before going into the discussion let us first have a look at the external appearance of the two routes.

APPARENT RELATIVE VALUE OF NICARAGUA AND OF PANAMA ROUTES.

The Nicaragua Lake is separated from the Pacific by a narrow Isthmus of 17 miles in width whose divide is very low (44 feet above the lake), while the Panama Isthmus is 45 miles wide, and its continental divide 330 feet above the sea. This exterior aspect is, I think, responsible for the false ideas formed in public opinion about the easiness of the Nicaragua Canal construction, because one is led to forget that the real and immense difficulties are not on the western side of the lake, but on the eastern side, in the valley of the San Juan (120 miles long), which a superficial examination leads one to consider as a natural waterway between the lake and the Atlantic, which it is far from being in reality.

Owing to that erroneous impression people generally believe that only a very short canal navigation will be met on the Nicaragua Isthmus, and that during nearly all the time of transit from ocean to ocean, ships will float in free deep water.

PART I

RESPECTIVE LENGTHS OF CANAL NAVIGATION.—
There is an evident impossibility of utilizing the lower half of the San Juan for canal navigation, on

account of the immense amount of sand brought into it by torrential and powerful tributaries coming from the volcanoes of Costa Rica.

Mr. Menocal, though abandoning the lower San Juan, hoped to replace that part of the river by two artificial lakes, formed by damming two northern tributaries of the lower San Juan, the San Francisco and the Deseado.

He further projected, in the Isthmus of Rivas, a third artificial lake between the Nicaragua Lake and the Pacific.

Those three lakes, as well as the San Juan River, between the Lake Nicaragua and the Ochoa dam, had to be kept at the same level as the lake itself. This route seemed to transform into reality the advantage which the Nicaragua route appears to have, namely, a short canal navigation, combined with the long free navigation in deep water.

This is how it was often asserted that under that plan, if not exactly 17 miles canal navigation, at least not more than 28 miles had to be expected between the oceans.

I showed in 1892 that this figure was much too low, and that 85 miles of canal navigation had to be met, if one takes into account all parts of the way, where ships have to navigate in a channel dug either in open land, or below the bed of a river, or below the bottom of a lake.

I pointed out also to what extraordinary difficulties such an extraordinary amount of damming would lead, and the danger of receiving above the Ochoa dam such tributaries as the San Carlos, with its enormous amount of sand.

The Isthmian Canal Commission, and before them

the Nicaragua Canal Commission, rejected the Menocal plan as impossible, and thought that the first place admissible for the location of a dam was above the mouth of the San Carlos.

According to figures given by the Isthmian Canal Commission, the total length of canal navigation, under the plans they adopted, will be 120.53 miles, to which are to be added 66 miles that will be made in free deep water, either in river or in lake, making a total of 186.53 miles from ocean to ocean.

Of that total length of 120.53 miles of canal navigation, 22.19 miles will belong to an artificial channel dug below the bottom of Nicaragua Lake, and 27.96 miles to an artificial channel dug through sand and silt below the bed of the upper San Juan River, of which the larger part will be more than 16 feet below the natural level of the bed of that great river, which carries in flood 100,000 cubic feet of water per second, half given by the lake itself and the other half by lateral tributaries. Outside of the channels opened below the water, 67.33 miles will be dug through open ground, the harbor approaches forming the balance of the total length.

The 66 miles of deep-water navigation are formed by 48.74 miles in Lake Nicaragua, and 17.26 miles in the San Juan, immediately above the dam.

Let us now examine the situation in the Panama Isthmus as it will result by the project adopted by the Isthmian Canal Commission.

In Panama we find but 38 miles of canal navigation, to which must be added 7 miles deep-water navigation through the artificial lake formed above Bohio, by the dam projected there across the Chagres at a distance of 15 miles from the Atlantic Ocean.

In fact, the canal navigation in Panama will be less than one third that of the Nicaragua route. I need not say how much reality differs from the external and apparent aspects of the two routes in regard to lengths of canal navigation.

DEPTHS OF GREAT CUTS.—The continental divide is in Panama, 330 feet above the level of the oceans, and 274 feet above the bottom of the cut projected by the Isthmian Canal Commission; those measurements applying to the natural and original state of the ground. This is the so-called Culebra cut.

The work executed by the old and the new Panama Company leaves to-day 110 feet excavation to be made above said bottom. It is the deepest cut that remains to be excavated on the line of the Panama Canal. One sees to what to-day is reduced this terrible difficulty of the Culebra, which was really the greatest that the construction of the Panama Canal has met, and which during the first six years of the construction remained as an unsolvable problem.

I have related, in 1892, by what method I had been able to meet that immense difficulty and to take it out of the way of the construction of the Panama Canal. It is to that task that I mostly consecrated the last two years of my presence on the Isthmus of Panama.

Let us now see what aspect the question of deep cuts on the Nicaragua Isthmus presents.

On the Nicaragua route, we find that the continental divide is not the place where the deepest cut is necessary.

As already stated, the cut at the continental divide is insignificant (44 feet above the lake), but a high cut of 297 feet above bottom and others of 218 and

170 are to be met in the low valley of the San Juan to go through high ridges projecting in said valley.

These facts show that most unexpectedly the Nicaragua location is, from the point of view of depth of cuts, by far the worse of the two routes, and that the ratio of 1 to 3 in favor of Panama is to be found equally for length of canal navigation and depth of cuts.

DAMS.—I will not weary you about details of technical descriptions as to the relative importance of the two dams to be built, either in Nicaragua or in Panama. Let me only say that the Isthmian Canal Commission stated that the dam to be built in Panama can be built of earth as well as of masonry, which indicates that neither its difficulty nor its cost is extraordinary, and that the same Commission, speaking of the Boca San Carlos dam, on the Nicaragua route, said that "the most difficult engineering work in connection with the Nicaragua Canal project is the construction of a dam across the San Juan River to hold back the waters of the lake, and enable its level to be regulated."

This dam would necessitate compressed air foundations to a depth of 100 feet below low-water level of the river, and have a total height of 150 feet from the crest to the foundation.

The Commission estimates that eight years would be necessary for its construction.

CHAGRES REGULATION.—Let me add that the dam to be constructed at Bohio (Panama) does away entirely with this monster of imagination called the Chagres. What has been said of the Chagres, and the difficulty its regulation presents, has been immensely exaggerated. The Commission has proposed

to build a dam in order to form a lake whose normal level would be at 85 feet above the sea. The outlet of that lake will be 2000 feet wide, and the surface of the lake combined with the dimensions of the outlet are such that the largest floods ever known will be incapable of raising the surface of the lake more than a little over 5 feet. I do not wish to enter into tiresome technical details, but I trust you will accept the statement about the easy regulation of the Chagres, because it is a conclusion arrived at by the eminent American Commission itself.

We have seen when speaking of deep cuts to what the Culebra difficulty, which was a great and real one, is to-day reduced; we have also seen to what the Chagres difficulty, which was never a real one, has been reduced.

Culebra and Chagres are the two names that symbolize in public sentiment the impossibilities of a passage through the Panama Isthmus. Both of them must be totally erased and disappear from the public mind.

LOCKS.—In reference to the locks which will be constructed, it will be sufficient for me to state that nine locks will be necessary in Nicaragua and only five in Panama, and that the level to which the ships will have to be lifted will be, in the case of the Nicaragua route, 110 feet at maximum, and, under equal conditions at Panama, 90 feet.

The foundation of all locks in Panama will be on rock, and only five in Nicaragua will enjoy such advantages; the other four, says the Commission, "are located on foundations that are believed to be safe."

NICARAGUA GALES.—The winds in the Nicaragua Canal location are exceptionally violent and permanent.

This is the result of the geographical situation of the San Juan valley, open to the trade winds and parallel to their general direction. The lateral high mountains of Nicaragua and Costa Rica form a barrier to the continuous trade winds, which is only open through the San Juan depression. Those continuous and violent gales, much heavier than trade winds at sea, will be a great obstacle, and a great danger for navigators. In Panama nothing of the sort is to be feared, as the Canal is in a direction from northwest to southeast, perpendicular to the trade winds. Lateral mountains shelter absolutely the Canal from any access of trade winds.

CURRENTS.—Concerning river currents, it will be easily understood that, the San Juan River having a much larger watershed than the Chagres, and the Nicaragua Isthmus being much more rainy (from 2 to 2½ times more than the Isthmus of Panama), the quantity of water, though its flow is regulated by the Nicaragua Lake, will be much greater, and generate much more permanent and intense currents than will be the case in Panama, where the great floods of the river are of very short duration, and do not occur at more frequent intervals than three years or more.

To illustrate this state of things, the appendices to the Nicaragua Canal Commission's report and the official documents of the Panama Canal Company give most interesting figures. From measurements taken during ten consecutive years (1889 to 1898), at Gamboa, at the beginning of the five miles where the Chagres and the Canal will be in the same location, the average discharge of the Chagres has been 3400 cubic feet a second, and the average discharge

during the last six months of every year has been 4800 cubic feet a second.

Measurements taken in 1898 in the San Juan River show that the average mean discharge above the mouth of the San Carlos has been 25,000 cubic feet a second for the whole year, and 31,400 for the last six months.

This shows the relative importance of the two rivers. And at the same time it must be borne in mind that the rainfall at the Atlantic terminus of the Nicaragua Canal at Greytown in 1898 was only 201.64 inches, while the other figures given in the Nicaragua Commission's report are 296.64 inches for 1890,—214.27 inches for 1891,—291.20 inches for 1892, these being the only years when the rainfall was reported for Greytown. It shows that the figures above given for river discharges in Nicaragua are more like a minimum than anything else and that probably half more may be often expected.

In the same comparatively dry year of 1898, the average of the maximum discharge of the San Juan measured in every one of the last six months of the year was 45,500 cubic feet a second, the highest maximum discharge for that period being 70,500 cubic feet a second, in November. (Measurements above mouth of San Carlos.)

In the Chagres in the last twenty-one years five great exceptional floods have taken place, which lasted only a few hours and gave at Gamboa a discharge of 72,000 cubic feet a second in 1879,—58,000 cubic feet a second in 1885,—58,000 cubic feet a second in 1888,—58,000 cubic feet a second in 1890, and 42,000 in 1893.

It is obvious that the great floods of the Chagres,

which may be considered as an exceptional incident, lasting for two or three days, and occurring at very rare intervals, give about the same amount of water if not less as the average monthly winter great flows in the San Juan above the mouth of the San Carlos River.

MAINTENANCE OF THE CANAL CHANNEL IN THE BED OF THE SAN JUAN RIVER.—What will be the effect of each flow on the maintenance of the canal channel dug into the bed of the San Juan is extremely difficult to calculate.

There is not a part of the technical science where man feels more the weakness of human knowledge than in such a question.

The form of the bed of a big river is the resultant of the very complicated mechanism of different factors associated together, namely, the amount of water discharged, the variation to which the discharge is submitted, the quantity of gravel, sand, or silt carried by the floods, the relative densities of those materials, the obstacles met by the river, the declivity of the country on which it flows, etc.

It is impossible to calculate the part every one of those factors has in the definitive determination of the form of the bed, but it may be stated that when the industry of man makes it necessary to change with brutality the natural form of the bed, and to transform it into a new channel, this channel, if in harmony with our needs, is in absolute contradiction with the natural needs of the river, and one may expect to sustain with nature one of the most dangerous struggles, one of those where man has been often totally defeated.

A striking example of the variety of forms that a

and Sarapiquí. *These all head upon the slopes of the Costa Rican volcanic range* which forms the southern margin of the Nicaraguan depression."

To judge the influence of the entrance of such a stream in the middle of the section of the San Juan which will be consecrated to canal navigation, it would be very desirable to have exact measurements of the volume of its discharge and of the quantity of sediments brought.

Unfortunately no measurements of that large stream were reported by the Nicaragua Canal Commission, as has been done for the three other great and torrential tributaries, falling from the slopes of the volcanic range of Costa Rica, namely, the Frio at the west of the Poco Sol and the San Carlos and Sarapiquí at its east, all three bringing enormous masses of water in floods and enormous masses of sediment.

In the absence of precise data some very probable notion may be formed of the relative importance of the Poco Sol.

The San Carlos has a drainage area of 1450 square miles. The Sarapiquí has a drainage area of 1100 square miles. The drainage area of the Poco Sol has not been given, but the drainage area of the tributaries of the San Juan from the Savalos River to a point near and above the San Carlos is 750 square miles. The only important tributary in that section of the river is the Poco Sol, and its watershed may be estimated with that of the Poco Solito as at least between half and two thirds of the total surface.

One may say for the sake of comparison that the drainage area of the Poco Sol is between one quarter and one third of that of the San Carlos, that it comes

from the very same volcanic region as the San Carlos and flows on the very same ground. The natural consequence ought to be that it brings a proportional quantity of water and sediment. We have a statement which confirms that view in what regards water discharge.

The total discharge of the tributaries into the San Juan between Savalos River and San Carlos River was calculated to have been in 1898 about 4,500,000 acre feet, to which, according to the above estimate, between 2,290,000 and 3,000,000 ought to have come from the Poco Sol River. The similar figure calculated for the San Carlos proper is 7,661,000, of which the third part would be about 2,500,000, an amount which approximately confirms the above estimate.

We fail to see any material fact that could lead one to think that a similar proportion should not be the very same one between the quantities of sediment brought into the San Juan River by the Poco Sol and by the San Carlos.

Only the fact that the river bed is, for a distance of fifteen miles above the San Carlos, deep and that the San Juan River there is sleeping at low water could lead to a different conception, but we have shown that it does not prove anything about the amount of sediment of the upper river, and results simply from the different factors that determine the form of the bed and which do not allow any sediments to stay there, but force them farther down the stream.

If such a proportion as three or four to one was proved to be the real one between the amount of sediment brought by the San Carlos River and that brought by the Poco Sol River into the San Juan River, or even a much lower one, as the amount of

sediment brought by the San Carlos River was considered as equivalent to a formal impossibility of maintaining any channel in the San Juan below the San Carlos, the maintenance of the depth and width of the canal channel in the same river between the Poco Sol and the San Carlos, which was estimated by the Isthmian Canal Commission as being within the limits of practicability, could not fail to be an extremely difficult one.

Most likely the exact determination of the watershed of the Poco Sol, from precise surveys in the volcanic region from whence it comes, as well as its mean and flood discharge, and the appreciation of the amount of its sediment in flood, as much as can be done by experimental tests, will be found in the definitive report of the Isthmian Canal Commission, and will settle this very important point.

We shall finish the study of this chapter by saying that even leaving aside the amount of sediment carried by the river or thrown into it by its tributaries, the maintenance of a channel of the required width and depth is by itself a very difficult problem in such a powerful stream as the San Juan.

Nature does not like a regular depth and width in the bed of a great river; it is contrary to its laws. In curves the river fills up the concave side of its bed and digs the convex side, and when it changes its curvature from one side to the other, the river expands and fills up its channel to get an intermediary state for passing from the deep channel on one side to the deep channel on the other side.

This any great river will do constantly with the proper elements of its bed without borrowing any foreign material, and the problem, even without any

intervention of sediments from lateral tributaries, is a difficult one to solve. The difficulty can, of course, easily go over the boundaries of human practicability when the question becomes complicated with that of great masses of sediment brought into the bed.

CURVES.—To examine this very important subject of curvature, the most essential of all for safe navigation, we have not yet the definitive plan of the Isthmian Canal Commission, for the Nicaragua Canal, but as this Commission has adopted in its essential lines the Nicaragua Canal Commission's project, and as curvature is commanded nearly absolutely by the natural disposition of the ground, one may take, as a fair approximation, the curvature of the Nicaragua Canal Commission's route as the one that will be more or less presented by the definitive project. Leaving aside the curves in harbors, or at the entrance of the locks, where the ships have a very reduced velocity, we find that the Panama route has 23 curves of a totalized length of 19.5 miles, and that the Nicaragua route has 82 curves of a totalized length of 53.5 miles.

It is not enough to state the number of curves; it is much more important to state their radii. All the curves of the Panama canal are of 10,000 feet radius or more, with the exception of three, which have 8200 feet radius. There are, on the contrary, 69 curves in the Nicaragua Canal below 8000 feet, of which 50 are between 3000 and 4000 feet radius.

But it is not only the number of curves and their radii which has to be considered, but also whether they are located in places where water will be still or not.

In Panama there are only three curves of 10,000 feet radius where the Canal and the Chagres will be in

the same location, that is to say, where eventually currents may take place. In Nicaragua we find 58 curves, having a total extension of 37 miles, where the Canal will be located in the San Juan River itself, and of those 58 curves, 43 are between 3000 and 4000 feet radius, and have a total extension of 26 miles.

It must be borne in mind, that in that part of the Canal there will be nearly 28 miles excavated into the bottom of the river to a depth of 16 feet for the larger part. The maintenance of that channel opened into silt and sand seems (from my personal point of view) to be extremely difficult, and will necessitate constant dredging in a river carrying in floods 100,000 cubic feet of water, that is to say, one quarter of the amount in the Niagara Falls.

It is obvious that ships will meet there an accumulation of extreme difficulties, sharp curves, heavy river currents, constant heavy gales and impediments either from the dredges themselves, or from the sand and silt they will have to remove.

Who could guarantee that those combined difficulties when brought to the extremes simultaneously would not stop sometimes, even if not often, all transit?

In Panama, the large and easy curves, the absence of winds, the scarcity of river currents, and the rarity of floods, give quite a reverse impression as to the eventual facilities offered to ships.

HARBORS.—With regard to harbors, the advantage, as every one admits, is with Panama, both of whose terminals have excellent harbors. The Nicaragua Atlantic terminal is very bad. The immense quantity of sand thrown into the sea by the San Juan, whose

mouth lies south of Greytown, is maintained in suspension by the continuous agitation due to the constant easterly trade winds, and brought into Greytown by a continuous northern stream of sand. The Greytown harbor, which, fifty years ago, was a good one, is now virtually closed by the constant accretion of the sand, and the maintenance of the entrance to the Canal there would be very difficult.

If it is understood by the designation of harbors, those points of the route where canal navigation is changed for a navigation into an immense body of water beaten by storms, and liable to give great waves, one is entitled to say that the Nicaragua route, outside of its ocean harbors, has two others in the Lake of Nicaragua.

This lake is a real sea, about as large as the sea of Marmara.

The violent gales that continually blow over it, with sudden changes of direction due to the reflection of the currents of air on the mountains, make this interior sea always agitated. Its violent storms are quite characteristic and well known.

An inferior current brings to the southeastern side all the light sediment thrown into the lake by its tributaries, and this sediment accumulates in the region where the outlet of the lake, the San Juan, is located.

An artificial channel twenty-two miles long has to be dug in that mass of mud, and this channel forms, so to say, the harbor approach on the east side of the interior sea. Close to the point where this channel leaves the shore, a great torrential tributary of the lake, carrying a considerable mass of sediment, brought from the volcanic ridge of Costa Rica, falls

into the lake: it is the Rio Frio, which will not add to the facility of maintaining the channel depth.

To judge at the same time the extraordinary difficulty of that maintenance and the danger to which transitting ships will be exposed in that harbor approach, one must forget the name of lake, which conveys the erroneous idea of still, sleeping water, and think what an unprecedented enterprise it would be to make an harbor approach in the ocean consisting of an artificial channel, twenty-two miles long, opened into mud or silt, and constantly exposed to be brutally filled up by the sweeping waves at every storm.

Such a point of view would be in the actual case much nearer to reality, than the conception of a channel opened into the bottom of a Swiss lake.

BUILDING EXPENSES AND TIME OF TRANSIT.—The exceptional advantages which characterize the Panama route compared to the Nicaragua route are in no way counterbalanced by larger building expenses. According to the estimates of the Isthmian Canal Commission, the completion of the Panama Canal will cost 58,000,000 dollars less than the construction of the Nicaragua route, which is estimated at 200,000,000 dollars. It is obvious that the estimation of the cost of completing such a work, where already 77,000,000 cubic yards have been excavated, in all parts of the Isthmus and in all conditions of work, enjoys a far higher degree of certainty than an estimate made on a line where no works have been executed*;

* The Isthmian Canal Commission states that the only excavation executed on the Nicaragua Isthmus consists of a channel between 150 and 230 feet wide, 16 feet deep and three quarters of a mile long. This insignificant work made in the Greytown swamps represents a cube inferior to one three hundredth part of the total volume of the prism of the Nicaragua Canal.

on the other hand it is a matter of common experience that whatever be the care with which surveys, soundings, and plans are made, the unforeseen circumstances which are met in a new ground do not modify the provisions towards reduction of expenses but towards increase.

The time of transit is estimated by the Isthmian Canal Commission, at twelve hours for Panama and thirty-three for Nicaragua. If one remembers the length of the two routes, and the number of locks, it is evident that this calculation must have been based upon the hypothesis that ships will go at the same speed in both cases, and that no allowance was made for the difficulties to be met on the Nicaragua route.

This shows that the advantage of distance over Nicaragua, between both sides of North America, is practically erased by time of transit.

PART II

STABILITY.—I propose now to touch upon another point which does not concern the construction proper of the Canal, but has reference to future contingencies, and which was not discussed by the United States Isthmian Canal Commission in its preliminary report.

I wish to speak of a danger arising from seismic disturbances, both during construction and after.

In Panama, there is within a distance of one hundred and eighty miles from the Canal no volcano, even extinct. The Isthmus there, since its formation in the early quarternary period, before man appeared on the earth, has not been modified.

This is quite the contrary in Nicaragua, which has been always the site of seismic convulsions, whose

lake was formerly a gulf of the Pacific Ocean, and whose name was associated with the most terrible volcanic explosion ever recorded in history before the Krakatoa explosion in Sound's Islands.

The explosion of the volcano Coseguina in 1835 lasted 44 hours, the noise was heard at a distance of 1000 miles, the ashes were brought 1400 sea miles by the winds, the mass ejected into the air was calculated to have covered a surface equivalent to eight times the surface of France, and the volume was calculated to be equal to 50 cubes having sides of 1100 yards, which allows me to say that during these 44 hours the volcano *ejected every six minutes a volume of stone and ashes equal to the total volume of the prism of the Nicaragua Canal*, as it was calculated by the Nicaragua Canal Commission, and which will necessitate eight years of excavation.

In the very centre of Lake Nicaragua is a volcano in constant activity, the Omotepe, whose last great eruption occurred in 1883.

Between the two above named volcanoes we find a series of volcanoes in recent or continuous activity, the Hell of Masaya, on the shore of Lake Nicaragua, the celebrated Momotombo, on the shore of Lake Managua, the volcano of the Pilas, which was born in 1850, the Santa Clara, the Zelica, the Nindiri, being the best known of them.

The continuity of volcanic disturbances is stated in an appendix to the Nicaragua Canal Commission's report: "In the northwestern part of Nicaragua slight earthquakes are frequent. *Scarcely a month passes without one or more being noticed.* The centre of these disturbances is always near the line of the Nicaragua volcanoes; *the line of volcanoes begins with*

Madeira (near the Omotepe), at the southern end, in Lake Nicaragua, and terminates at Coseguina, at the northern end, near the gulf of Fonseca."

Two most important facts have been recently established by Mr. BERTRAND, foremost geologist and member of the Institute of France.

(1) *The Lake Nicaragua is one of the three lines of least resistance in Central America, which are a site of election for great seismic disturbances.* It is the line of depression between the Costa Rican volcanoes and the Nicaraguan, and plays the same part as the other two: the bay of Fonseca, which is a volcanic lake characterizing the depression between the Nicaraguan and Salvadorian volcanoes, and the Lake Pacayan, characterizing the depression between the Salvadorian and Guatemalan volcanoes. These two last lines of least resistance have been the site of the most terrible convulsions owed to the Coseguina for the former, and to the Fuego (Fire) for the latter.

(2) *The underground fire is going south, and increasing in Nicaragua.* From the figures given by Mr. BERTRAND I calculated that before the nineteenth century, out of all the great explosions or earthquakes recorded, 45% belonged to Guatemala, 35% to Salvador, and 20% to Nicaragua, whereas in the nineteenth century, only 30% belonged to Guatemala, 45% to Salvador, and 25% to Nicaragua, showing an evident tendency to a displacement of the activity southward and an increase in Nicaragua.

To justify these figures one can say that several volcanoes became extinct in Guatemala, and that none was extinct in Salvador nor in Nicaragua, but, on the contrary, that two were born in Salvador,

Izalco, in 1770, and Ilopango, in 1880, and one was born in Nicaragua, that of Las Pilas, in 1850.

DANGER FOR CONSTRUCTION.—The continual earthquakes may have a fatal influence on the definitive transformation from half-liquid mud into hard stone, of the concrete, which will during eight years be continually poured in the great Boca San Carlos dam; these violent shocks, interfering every month or more with the gradual crystallization of the elements of concrete, may destroy their reciprocal adherence, and ruin the perfect homogeneity of the solid mass which is imperatively necessary for the part it has to play.

DANGER FOR THE CANAL ONCE BUILT.—It is entirely false to compare the equilibrium of dams and locks with that of a high tower or of a church. A wall or tower even fissured can stand after an earthquake. A longitudinal fissure in a dam, which will not alter its equilibrium as a wall without pressure of water, would mean its immediate overthrow when the water pressure is exerting its force upon the surface of the inside fissure.

Outside of the impending and terrible danger of seeing ruined the dam or the locks by a great seismic commotion, one must not forget that there is great probability of seeing formed in the sea of Nicaragua, which is 100 miles long and 45 miles wide, one of those terrible tidal waves which were so destructive in Lisbon (earthquake of 1752), and Krakatoa, 1883, the latter being 100 feet high and the former 40, and which caused unlimited disaster.

It must be borne in mind that these terrible menaces would mean, if realized, not only the destruction of that costly Canal, but the ruin of the immense interests of both sides of America, which

will have been developed by the great waterway and receive a death blow by its paralyzation.

TRANSFORMATION OF THE PANAMA CANAL INTO A BOSPHORUS.—Nothing similar can be feared in Panama, as no trace of any local volcanic activity may be found on that Isthmus, whose rare and small seismic vibrations come from distant centres.

The future, on the contrary, far from being open for destruction, is open for a gradual transformation from a lock canal into a level canal, into a Bosphorus, which means a rapid transit in five hours from ocean to ocean. This can be done without stopping or troubling the navigation even for a quarter of an hour, by following the solution I have given years ago to this question, which is extremely simple, and consists, all engineers will understand me, in making the two gates of a lock of the same height.

CONCLUSION

The facts that I have related demonstrate the following statements:

I. It is very questionable whether the continuous earthquakes will allow the construction, on the Nicaragua route, with all its indispensable qualities, of a substantial masonry dam, which is the key of the whole Canal.

II. Admitting a dam could be built, the Nicaragua route, whatever may be the engineering skill displayed and the expenses made, will *never acquire* the two most essential qualities necessary to an interoceanic canal,—*continuity of operation* and *security of transit*.

The large ocean steamers will have there to struggle, deprived of any means of resistance,* against the combined efforts of the continuous violent gales, of the heavy river currents, of the impediments resulting, of the constant modifications of the depths in the channel, and of the presence of the numerous dredges that will have to keep the way open, and this when they will be steering with great difficulty around an extraordinary number of curves, the short radii of which ought to be, in themselves, considered as incompatible with the navigation of big ocean ships in a narrow channel.

The ships will also have to meet two bad, exposed, and dangerous passages, when going from the Atlantic into the Canal and from the Canal into the Lake of Nicaragua.

One is allowed to say that *continuity of transit* and *safety of navigation* will be constantly at the mercy of *conflicting elements* and *beyond the control and prevision of man*.

III. If the experience of four centuries is not a mere word, if the undisputable proofs, written in letters

* It is a fact well known to naval men, that a big ship floating in shallow water is partially deprived of its steering faculty. The reaction of inferior currents on the rudder disables it to a certain extent, and its action is uncertain and irregular.

The accident suffered by the battleship *Massachusetts*, that got aground going out of Pensacola on the 21st March when this pamphlet was in course of printing, is a good illustration of this disability of steering in shallow water.

of fire on the surface of the soil,* of the continuous violent and increasing volcanic activity in Nicaragua, are not a mere dream, the route over that Isthmus is not only eventually exposed to, but certain, sooner or later, to be the prey of, that uncontrollable power of nature before which flight is the only resource.

If one thinks that not only the enormous cost of such a waterway would be at stake but also the very basis of the prosperity, the wealth of the millions of people who will settle on the west coast of North America, as soon as the construction of the Canal will join them with the other side of the continent and with Europe, one hesitates to calculate the consequences that would result from one of those seismic convulsions, which most probably will be still more terrible in the future than they have been in the past on that part of the Isthmus.

To prefer definitively the Nicaragua route to the Panama route, the unstable route to the stable one, would mean to prefer the stability of a pyramid on its point to the stability of a pyramid on its base when to that stability is attached the prosperity and welfare of a whole continent.

IV. The Panama route, having no winds, no currents (except on rare occasions), no sharp curves, no sediments, no bad harbors, no volcanoes, enjoys to the highest degree the three essential qualities totally wanting for the Nicaragua solution,—*continuity of opera-*

* To the people who think I am exaggerating this capital point I will say: Open any dictionary of geography, any encyclopedia, and read the article titled "Nicaragua." I will say also: look at the coat of arms of the Republic of Nicaragua, look at the Nicaraguan postage stamps. Young nations like to put on their coat of arms what best symbolizes their moral domain or characterizes their soil. What have the Nicaraguans chosen to characterize their country on their coat of arms, on their postage stamps? Volcanoes!

*tion, security of transit, stability of structure.** Outside of that it is three times shorter, will cost much less than the Nicaragua route and is easily transformable into a Bosphorus, the only form that will definitely answer to the world-wide interests to be served by the route, and allow of a passage from ocean to ocean in five hours.

* The superior qualities of the Panama route, from the point of view of safe and continuous operation, are such that it can be fairly asserted that, assuming the two canals were built and that of Nicaragua freed of any tolls, ships would, in the intermittent periods of navigability of the Nicaragua Canal, still prefer the Panama route, as the tolls of this Canal would certainly be less than the insurance fees to be paid to pass over the unsafe route of Nicaragua.

RESPECTIVE LENGTHS OF CANAL NAVIGATION OVER THE **NICARAGUA** AND PANAMA ROUTES.

THIS plate, drawn at the same scale of one inch per twelve miles, gives the relative lengths of canal navigation in both routes, according to the figures of the Isthmian Canal Commission's Report, being understood by canal navigation all the parts of the way where ships will have to follow an artificial channel, whether dug in open land or below the bed of a river or below the bottom of a lake, and without taking into account the part of the way where ships will float in free deep water. Canal navigation will be 120.53 miles in Nicaragua, and 38 miles in Panama, to which must be added 66 miles in Nicaragua, and seven miles in Panama, for deep-water navigation.

NICARAGUA ROUTE



PANAMA ROUTE



RESPECTIVE DEPTHS OF GREAT CUTS
ON THE NICARAGUA AND PANAMA
ROUTES.

THIS plate gives, drawn at the same scale of one inch for sixty feet, the respective depths of great cuts that are to be dug on both routes.

On the Nicaragua route, according to the figures of the Isthmian Canal Commission, the greatest cut is at Tamborcito, and is 297 feet deep.

On the Panama route the Culebra ground, originally 274 feet above the bottom of the Culebra cut, according to the project adopted by above named Commission, is to-day reduced to 110 feet, owing to the works executed by the old and the new Panama Company.

NICARAGUA ROUTE



PANAMA ROUTE



CURVES ON THE **NICARAGUA** AND **PANAMA** CANAL ROUTES.

THIS plate gives the successive curves that would be met by transitting ships on the Nicaragua route* and on the Panama route, drawn at the same scale, one inch for 12,000 feet, together with their respective radii and their distribution in the different sections of each canal, leaving aside the curves in harbors or at the entrances of locks, where ships have a very reduced speed.

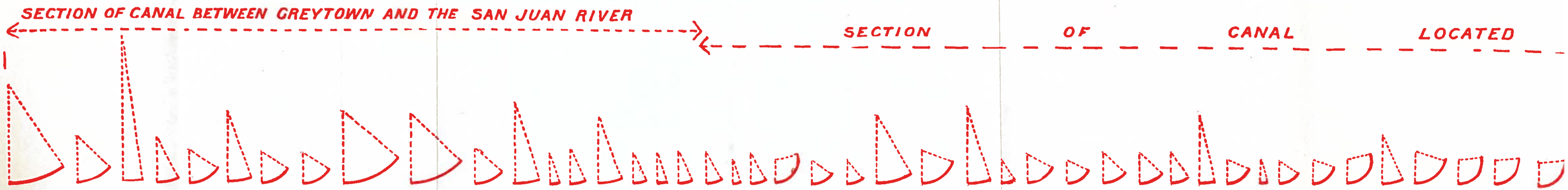
The consideration of the curves of the Nicaragua route will show how numerous and sharp the curves are in the section of the Nicaragua route where the Canal will be located in the San Juan River proper, in whose bed an artificial channel has to be opened for a total length of 27.96 miles, through sand and silt to a depth of sixteen feet below the bed (for the larger part). It must be borne in mind that ships steering around these curves will at the same time have to meet not only the river currents but also the abnormally heavy, continuous winds of the San Juan Valley and the dredges that will have to keep open the artificial channel in that big river, whose floods are estimated at 100,000 cubic feet a second, and whose measured mean discharge was, from July to December, 1898 (a comparatively dry year),† 31,000 cubic feet a second, the average monthly maximum being 45,500 cubic feet a second, and the highest maximum 70,000 cubic feet a second.

The consideration of the curves on the Panama route will show how few they are, and that they have the large radii indispensable for an easy transit of large sea ships. It will be seen that only three curves each one of 10,000 feet radius will be met where the Canal and the Chagres are in the same location. Outside of the small number of large curves, ships will meet there with no winds and very little current, as the average discharge of the Chagres at Gamboa is only 4800 cubic feet a second from July to December; and the great exceptional floods (four in twenty-one years) having given 72,000 cubic feet a second in 1879, 58,000 in 1885, 58,000 in 1888, 58,000 in 1896, and 42,000 cubic feet a second in 1893, each one lasting two or three days, and the natural bed of the river being all along below the bottom of the Canal.

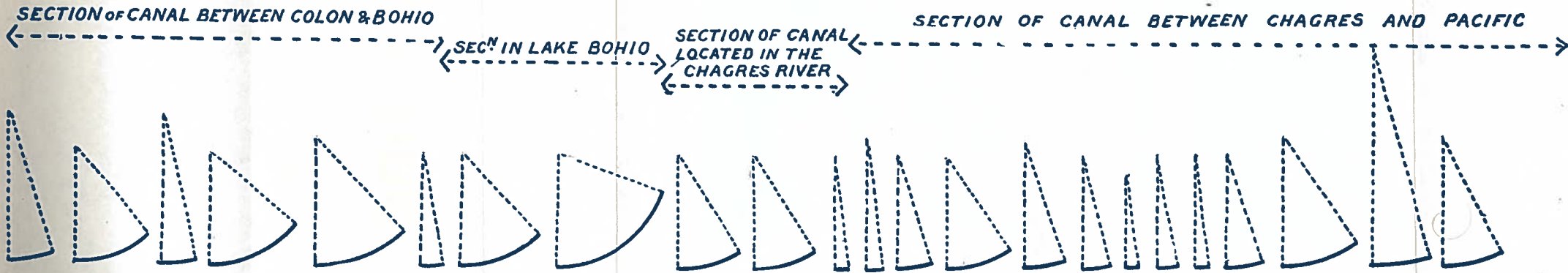
*The Isthmian Canal Commission not yet having published their definitive project, the Nicaragua curves are taken from the Nicaragua Commission's reports (profiles), whose route was adopted in its essential lines by the Isthmian Canal Commission.

†The report of the Nicaragua Canal Commission gives the following data for rainfall at Greytown, which only apply to four years: In 1890 the total rainfall was 296.94 inches; in 1891, 214.27 inches; in 1892, 291.20 inches; and in 1893, 201.64 inches, which shows that much greater flow of water may be normally expected than that measured in 1898.

N I C A R A G U A



PANAMA ROUTE



A

ROUTE

LOCATED

IN

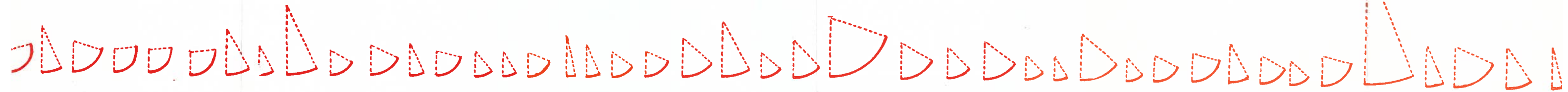
THE

SAN JUAN

RIVER

PROPER

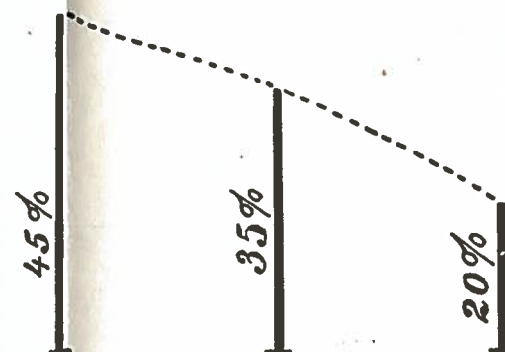
SECTION OF CANAL BETWEEN
LAKE NICARAGUA & PACIFIC



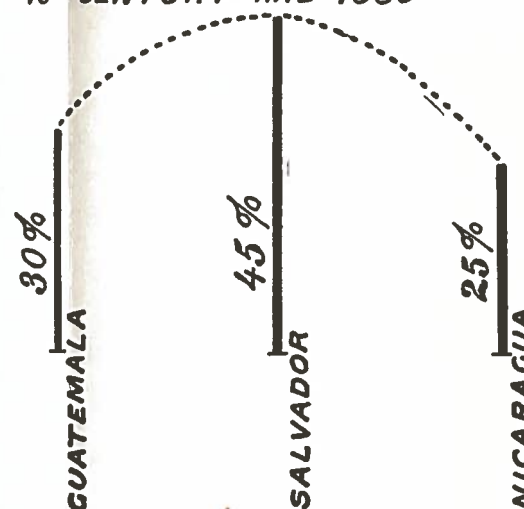
RELATIVE FREQUENCY OF GREAT
SEISMIC DISTURBANCES IN THE
THREE VOLCANIC GROUPS OF
GUATEMALA, SALVADOR, AND
NICARAGUA.

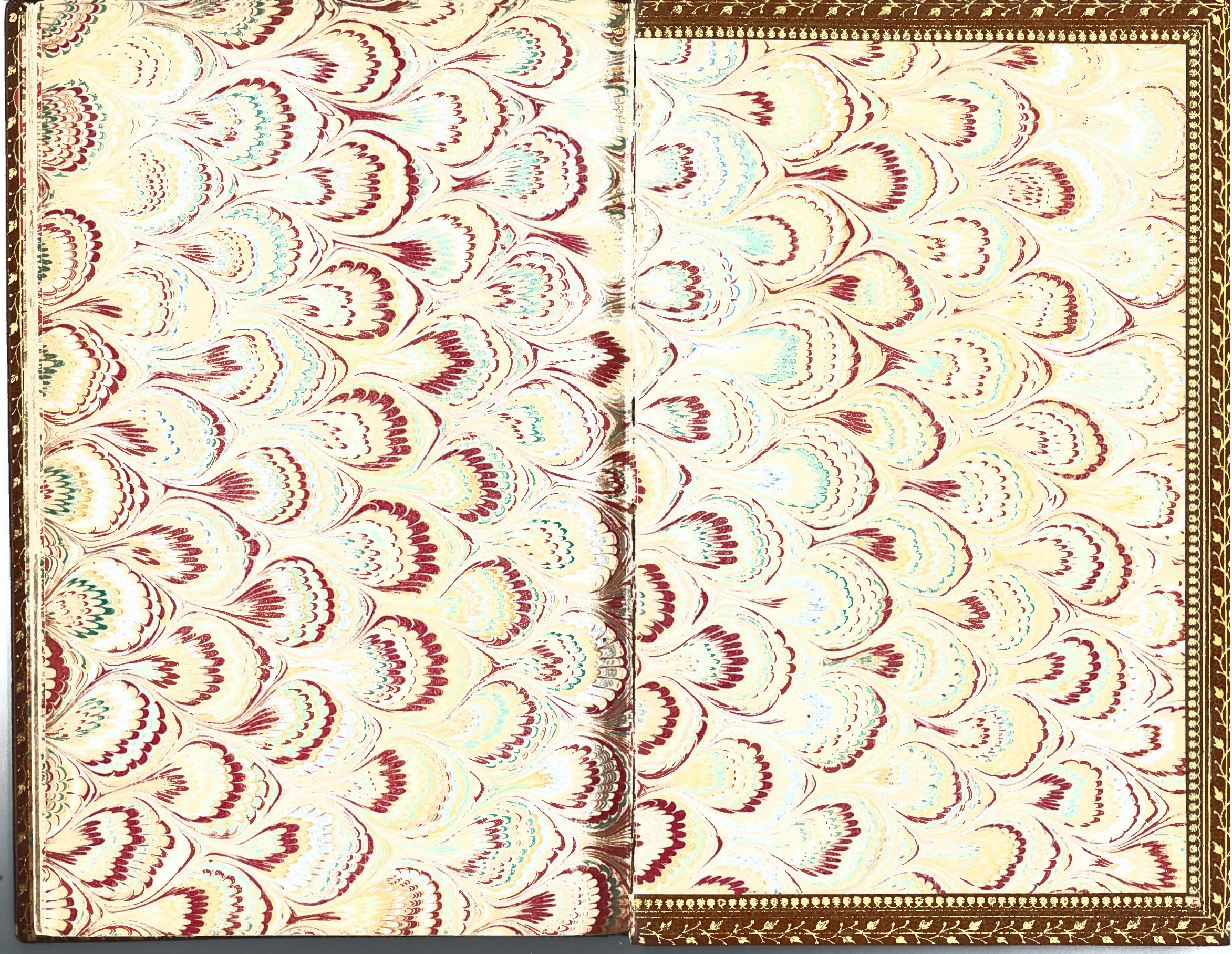
FROM the statistics produced by Mr. Bertrand, member of the Institute of France, in relation to the number of great volcanic explosions or exceptionally violent earthquakes recorded before the beginning of the nineteenth century and from that time to 1885, in the three powerful volcanic groups of Central America, Guatemala, Salvador, and Nicaragua, I have calculated that before the beginning of the nineteenth century 45% belonged to Guatemala, 35% to Salvador, and 20% to Nicaragua; and that the corresponding figures for same groups were in the nineteenth century 30% for Guatemala, 45% for Salvador, and 25% for Nicaragua, which demonstrates a displacement towards Nicaragua of the maximum of seismic activity, as is shown by comparing the two dotted curves, which can be considered as representing the intensity of volcanic activity along the line of volcanoes from North Guatemala to South Nicaragua.

RELATIVE SEISMIC ACTIVITY IN THE PERIOD
ANTERIOR TO THE 19TH CENTURY



RELATIVE SEISMIC ACTIVITY IN THE
PERIOD BETWEEN BEGINNING OF THE
19TH CENTURY AND 1885





1901

AU GRAND INGÉNIEUR ANGLAIS SIR JOHN WOLFE BARRY SOUVENIR DE SA

MÉMORABLE INTERVENTION DANS LE PROBLÈME DU DÉTROIT DE PANAMA

LE 23 JANVIER 1907

PHILIPPE BUNAU-VARILLA

P. BUNAU-VARILLA — NIGARAGUA OU PANAMA