THE BATES PLAN FOR LOCK AND LAKE CANAL AT PANAMA.—II.

In the construction of a canal at Panama, there are three primary considerations which surpass all others in importance. They are:

1. To control the Chagres River and find some safe means of passing its enormous floods down to the sea without interfering with the canal.

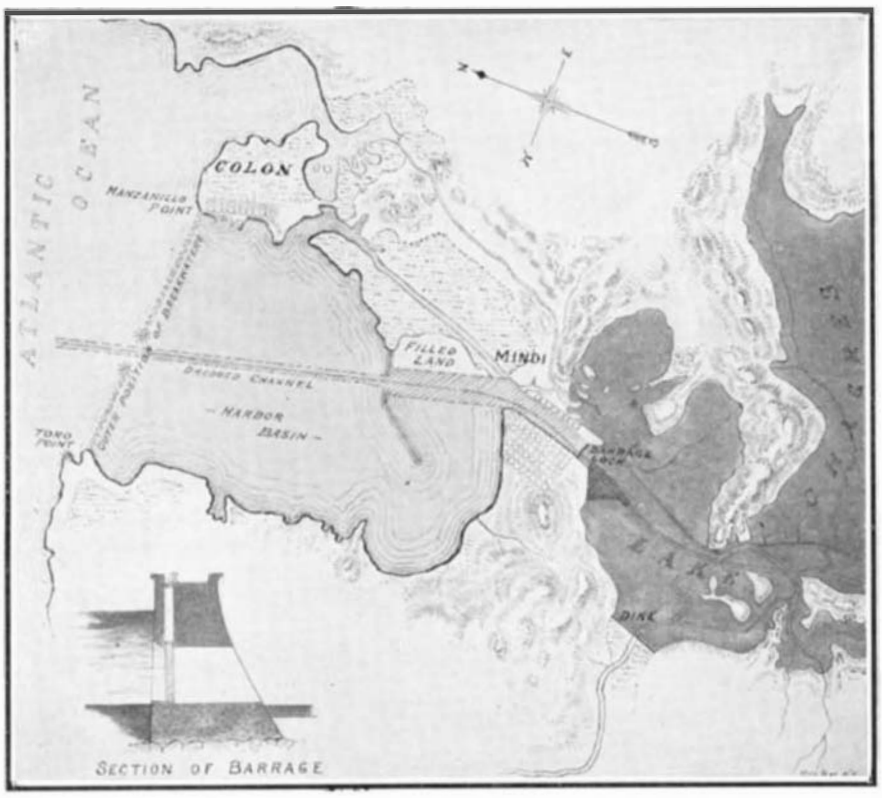
2. To strike such a fine balance between the many competing advantages of the various types of canal possible, that the particular plan adopted shall represent the best average of certain desirable qualities in a canal of this character. That is to say, it must be built within a reasonable time, for a reasonable sum, and with such due regard to engineering requirements that there must not be the shadow of a doubt as to its permanent stability. Moreover, the transit of the canal, as completed, must be made in the least possible time consistent with its possession of the above desirable qualities.

3. The third consideration, which in some respects is the most important of all, is that of finding the best method of disposal of the enormous amount of material excavated from the prism of the canal.

The plans herewith presented of Mr. Lindon W. Bates, a hydraulic engineer and contractor of world-wide reputation, are of particular interest, for the reason that he has taken up the study of the Panama Canal problem from the standpoint of an individual and unbiased technical observer. After a most exhaustive study of the subject, in which he went carefully into the history of the deliberations of the many technical bodies that have studied the Panama Canal problem, Mr. Bates made a personal visit to the Isthmus, and on his return wrote an elaborate work reviewing the history and present status of the problem, and outlining the scheme which he considers to be the best adapted to the situation. It is the purpose of the present article to give such a digest of this work, that the essential features of Mr. Bates's plan may be made clear to the non-professional public.

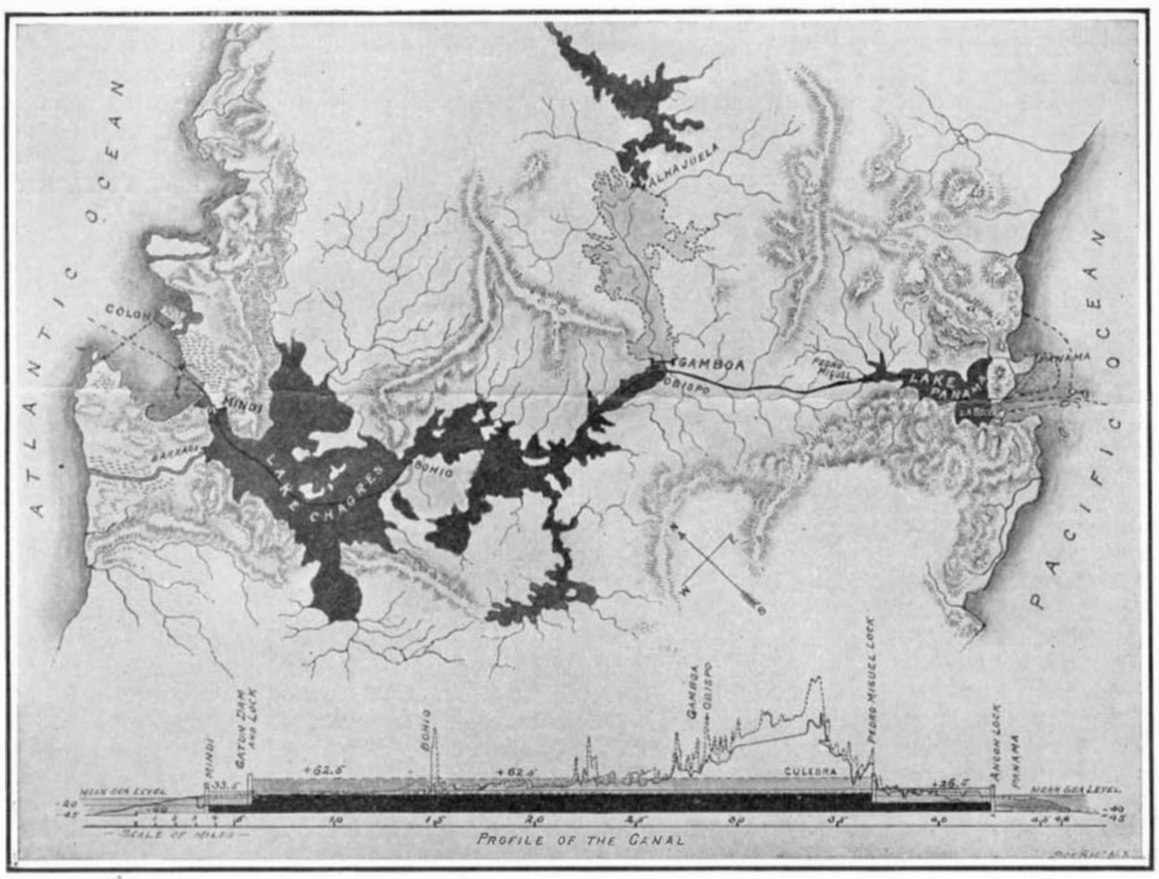
I. Control of the Chagres: A glance at the accompanying map of the Panama Canal shows that it is located across an isthmus, about 40 miles in width, which is traversed by certain ranges of hills, that run approximately parallel with the coast, dividing the isthmus into a series of rather narrow valleys. The principal range of hills is the main Culebra divide, which extends parallel with the Pacific coast at a distance of about 10 miles therefrom. The slope from this divide toward the Pacific is drained principally by the Rio Grande, which enters the Pacific near Panama at the western terminus of the canal. The drainage of that part of the isthmus lying between the Culebra divide and the Atlantic is carried to the sea by the River Chagres, which at first flows parallel with the divide in a southwesterly direction, until it strikes the axis of the canal at Gamboa, where the river swings abruptly to the right and receives, on its way to the Atlantic, the drainage of several other streams, two of which are of considerable importance, namely, the Gatuncillo, which flows down from the northeast through a valley that lies approximately parallel with the upper valley of the Chagres, and the Trinidad, which flows into the Chagres from the southwest. Under normal conditions these rivers present no great activity, the Chagres being in the lower levels somewhat sluggish; but under the influence of the tremendous downpour of tropical storms, the rivers become gorged with the waters of a mighty flood, the Chagres itself having been known to rise between 30 and 40 feet in 48 hours' time.

Now, for the safe and convenient navigation of a ship canal, it is absolutely necessary that there shall be no currents of a greater velocity than 2½ miles an hour; and hence it is obviously impossible to permit the Chagres floods to pour into the canal itself. Mr. Bates's proposal contemplates the formation of a series of massive sluice dams, of the same character as those used so successfully in controlling the floods of the Nile at Assouan. One of these would be built across the upper Chagres valley at Alhajuela, about 9 miles



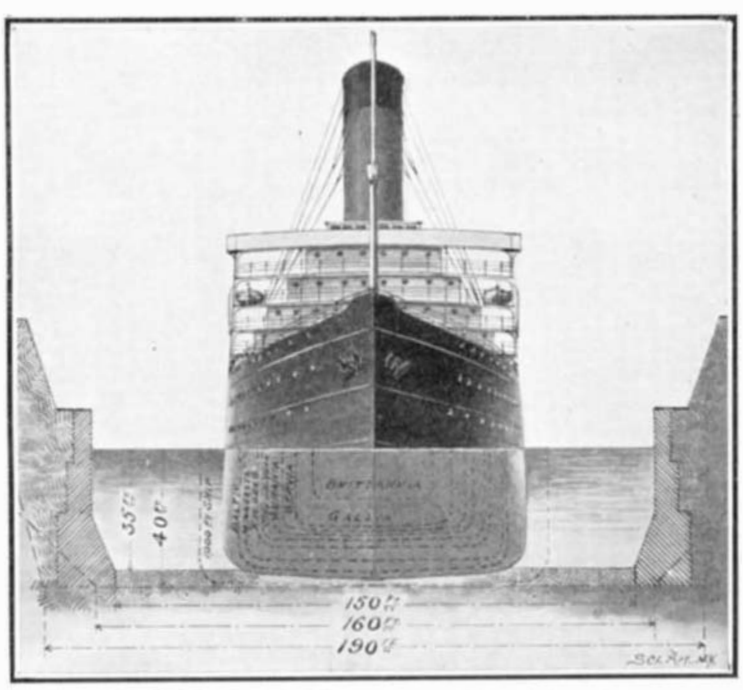
It is proposed to abandon swampy Colon and build a new town on the hill opposite Mindi.

Map Showing Fresh-Water Lake and New Harbor at Atlantic Terminal of the Canal.



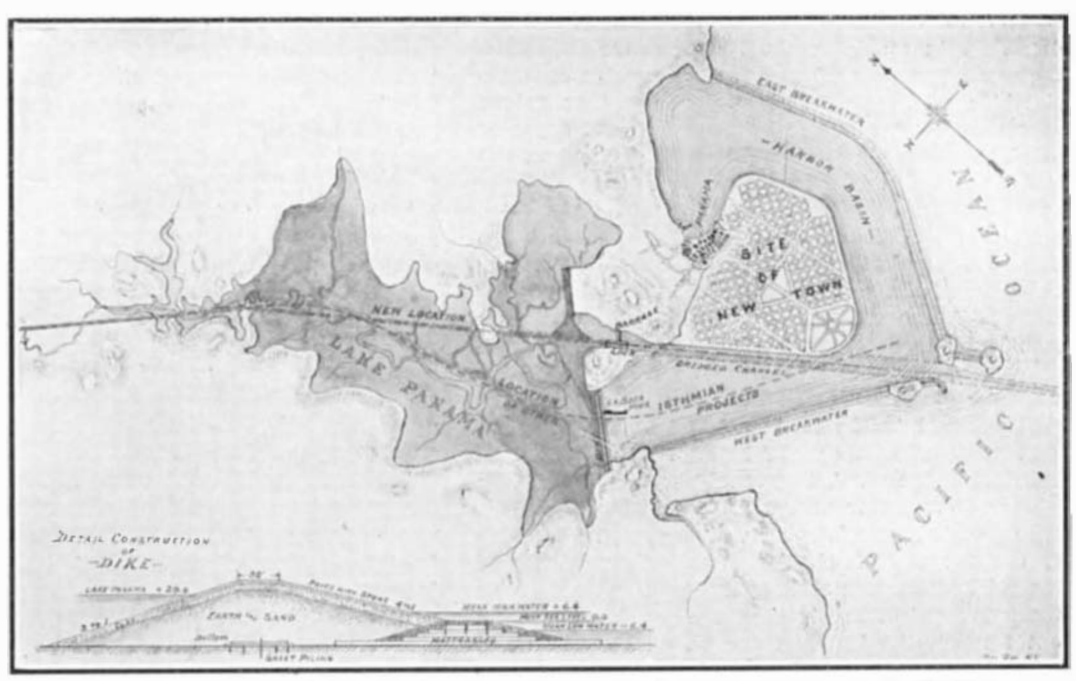
Time necessary to construct, eight years. Total cost, $125,000,000.

Plan and Profile of the Proposed Lake-and-Lock Canal.



The dotted outlines show the great increase in size of steamships.

Section of Proposed Forty-foot Canal, Showing One of the New Cunarders Passing Through.



The new town site would be formed by filling in part of the harbor with the material excavated from the Culebra cut.

Map of the Proposed Terminal Lake, Harbor, and New Town Site of Panama.

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above Gamboa; another would be built at Gamboa, where the Chagres first meets the line of the canal; the third would be built near the mouth of the Chagres on the Atlantic; and the fourth at the mouth of the Rio Grande on the Pacific. The impounding dam at Gatun would be solid and discharged by a spillway or barrage.

Now, the gates in the sluice dams at Alhajuela and Gamboa would normally be left open, and the basins back of them empty. But in times of flood the gates would be partly closed and the dams allowed to fill with the excess, their joint capacity, and in fact the capacity of the Gamboa dam alone, being far more than enough to take care of any single flood. When the flood had passed, the sluice gates at Gamboa would allow the impounded flood waters to discharge slowly into the canal, half of the water flowing toward the Pacific and the other half toward the Atlantic, the amount being regulated so that it would not produce a current of over 1½ miles per hour in the canal. The sluice gates in the barrages at the Atlantic and Pacific terminals of the canal, would be so regulated as to maintain at all times a predetermined depth of water in the central and terminal lakes.

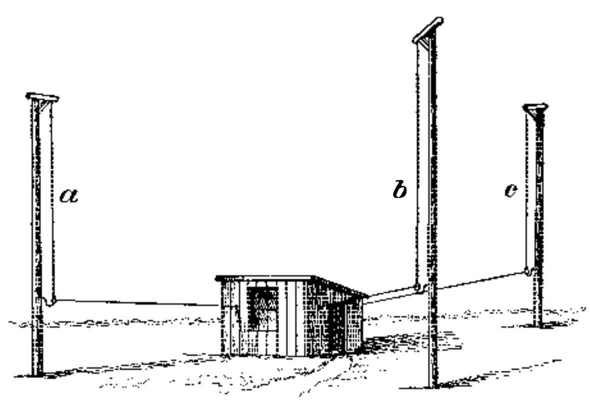
II. The Lake and Lock Project: The feature of Mr. Bates's plan which distinguishes it sharply from the plans that have preceded it, is the free use which he makes of the system of canalization by means of impounded artificial lakes. The method is not a new one as applied to the Panama problem, for it was suggested during the earlier studies of the question by the French engineer, Godin de Lapinay; and, later, it figured in the emergency plans for the quick completion of the canal, which were drawn up by the French when it became apparent that they were unable to put through a canal at sea level. No one, however, has attempted the canalization of the Chagres and Rio Grande rivers on the bold scale that is proposed by Mr. Bates. Of the three alternative plans which he offers, we have selected the one known as Plan B, which contemplates the use of four locks with two levels, and the formation of three large fresh-water lakes. The central lake (Lake Chagres) is formed by the construction of a dam at Gatun which serves to hold the water at a level of 62.5 feet above the mean sea level. In the Chagres lake the channel would be excavated along the bottom to a depth of 40 feet and a bottom width of 150 feet. The waters would back up the Chagres valley for a distance, measured along the ship channel, of about 20.6 miles. From this point the canal would be excavated, at the same surface level of plus 62.5, through the foothills and the main range of the Culebra divide for a distance of 10.5 miles to Pedro Miguel, where there would be a lock. This stretch from Gatun to Pedro Miguel, about 31.1 miles in length, would constitute the summit level, 20.6 miles of it consisting of lake navigation, and 10.5 miles only consisting of canal proper, bounded by nearly parallel banks. The remainder of the canal, both on the Pacific and Atlantic sides, would be formed by creating two large terminal lakes with their surface held at an elevation from 26.5 to 33.5 feet above mean sea level, and dredging out the ship channel to a depth of 40 feet and a bottom width of 150 feet.

These two great terminal lakes are, perhaps, the most attractive feature in Mr. Bates's plan; for they not only serve to greatly reduce the amount of necessary excavation, but by flooding the swampy land lying adjacent to the canal termini they assist in the improvement of sanitary conditions. By referring to the accompanying maps showing the terminal harbors, it will be seen that the topography of the country lends itself admirably to the construction of these dams, for in each case the rivers, as they approach the ocean, pass through a natural depression of inconsiderable width formed in the ridges that extend approximately parallel with the coast line.

III. Terminal Harbors: The provision of terminal harbors and safe entrances is an important feature in any great ship canal such as this, and in the plans under consideration it has received particular attention. As stipulated by the act authorizing the construction of the canal, these harbors should provide secure military and naval bases. By reference to our map of the Pacific terminus, it will be seen that breakwaters are designed whose arms are to inclose the whole harbor of Panama and La Boca, and extend from the mainland to the islands that face the entrance. As these breakwaters would be built of the rock excavated from the canal, they would represent but little additional cost over that which would be involved if the excavated material were wasted at sea. The location of the canal is changed from the curved line of the old location to a straight line which extends from the upper end of the terminal Panama Lake, straight out through the harbor entrance, as shown on our map. It passes through locks which will be built adjacent to the barrage on good rock foundation in the Ancon-Sosa Saddle; while to the southwest, beyond a stretch of rising ground, is the dike, less than a mile in length, which serves to impound the waters of Lake Panama. At the Atlantic end a similar provision of breakwaters serves to form a sheltered harbor at the entrance to the canal, and advantage is taken of depressions in the topography of the hills near the coast by placing the canal entrance, the barrage, and the locks in one depression, and the impounding dike in the narrow valley of the lower Chagres. In this harbor also the alignment of the canal will be straightened and its length proportionately reduced. The creation of these two harbors, coupled with the large fresh-water lakes adjoining them, will provide such extended facilities for the safe harboring of ships, both of the navy and the mercantile marine, that it is not possible for any increase in future canal navigation to cause congestion at these points.

IV. Disposal of Excavated Material: One of the greatest problems, if not the most important, is the disposal of the enormous amount of excavated material, chiefly from the Culebra cut. In the plans under consideration, Mr. Bates brings the bulk of the Culebra excavation down to the Pacific coast, and dumps it inside the big harbor formed by the breakwaters above referred to, until a large area of the harbor, several square miles in extent, has been filled in and brought well above high-tide level. Upon the site thus formed he would build a greater Panama, providing a splendid and healthy site for the great growth which must take place in this important terminal city. At the Atlantic terminus he advocates the abandonment of the old town of Colon, and the creation of a new town, to be called Balboa, on the easterly slope of the hill that flanks on the west the locks and barrage at the canal entrance. From a naval standpoint the harbor facilities, as thus presented, are very attractive, inasmuch as fresh-water naval stations can be formed back of the hills of the coastal ridges, and the protection of the ships' bottoms against marine growth, which is one of the advantages of a fresh-water harbor, gives to this feature of the plans a decided military value.

V. Water Supply and Lockage: It is claimed, and with much show of reason, that the important question



ARRANGEMENT OF THE AERIALS FOR DIRECTING THE MESSAGES.

of water supply for lockage purposes, in view of the great increase in vessel dimensions, has never received the careful attention which its importance demands. Mr. Bates considers that with the great growth in tonnage passing through the canal, which is certain to occur as the years go by, the mere creation of a single storage basin in the upper Chagres valley would not provide, especially in the dry season, a safe reserve for lockage. This is shown by the following figures: The three dry months of the dryest year in which gagings have been taken at Bohio show an average discharge of 742 cubic feet per second. By moving the impounding dam from Bohio to Gatun, the waters of the Trinidad and Gatuncillo become contributory to the water supply, and the average flow in a dry season for the same months of these rivers, added to that at Bohio, shows that there would be never less than 1,000 cubic feet per second available. It is assumed that the early traffic, when the canal is open, will amount to 7,279,000 tons, the lockage for which would require a flow of 306 cubic feet per second. Evaporation from the lakes will account for 280 cubic feet per second, leakage will equal 257 cubic feet per second, making a total of 843 cubic feet per second that is necessary to maintain the canal at its proper levels. This will give a surplus for the three dry months of at least 157 cubic feet per second. Now, if we eliminate waters coming in from the lower Chagres tributaries, it can be seen that instead of a surplus there would be a shortage of lockage water. Hence the importance of the inclusion of the drainage of the two tributaries of the Chagres above referred to in the total available supply of lockage water. When we consider the possibilities of storage in the navigated lakes and canal, it is evident that the transit capacity is far more than is likely to be required for many generations to come.

VI. Time of Transit: The most surprising claim made on behalf of the lake and lock project is, that the time of transit through the canal would be considerably less than if it were built at sea level. This is based on the fact that large ships in passing through a canal inclosed by banks, must proceed at a much slower speed than when they are steaming through a channel dredged in a navigable lake. It is claimed that the average speed through a sea-level canal could not exceed, safely, 4.23 miles per hour, including the time lost at the tidal lock on the Pacific, whereas in the lake and lock canal a speed of 7.08 miles per hour would be practicable. The higher speed in the waterway would more than offset the time lost in passing through the extra locks, so that the total transit time for the sea-level canal would be 12.39 hours, whereas for the lake and lock canal the time would be only 8.89 hours. The slow speed necessary in a canal inclosed by banks is due to the fact that, if a certain speed is exceeded, a ship, should it swerve from its course, has a tendency to swing, with accelerated turning movement, into either bank before the rudder can control it. This is due to the fact that the water cannot escape freely around the hull in a constricted channel as it can in a lake channel, where only the lower few feet of a ship's hull is in the channel and the body of the ship is in a wide expanse of water.

VII. Time and Cost of Construction: The erection of the impounding dikes and the barrages and the locks would be simplified by the fact that a good indurated clay rock exists at the selected sites, and that no difficulty would be experienced with the foundations. The creation of the inland lakes greatly reduces the total amount of excavation, which is brought down to a total of 118,430,000 cubic yards, as compared with an estimated total of 300,000,000 cubic yards for a sea-level canal. The estimated total cost is $125,000,000; and allowing from a year to a year and a half for designing the special plant that would be required and placing it upon the ground, it is estimated that the canal would be opened for navigation by the year 1915.

That the author of the above-described plan has the courage of his convictions is shown by the fact that he is prepared to put in a bid for constructing the whole canal at the rate of $3,125,000 per mile, reckoning the canal as 40 miles in length, to be completed under a guarantee in eight years.

BRAUN'S NEW METHOD OF DIRECTING WIRELESS MESSAGES.

BY A. FREDERICK COLLINS.

The first attempts toward directing wireless telegraph messages were made by William Marconi some little time before he had evolved his aerial wire system. His apparatus consisted of a small induction coil fitted with a battery to supply the initial energy, a key to break up the current into the alphabetic code, and a Righi oscillator for radiating the energy in the form of electric waves. In this case the oscillator was mounted in the focal line of a cylindrical parabolic reflector the length and opening of which was double the length of the wave emitted from the oscillator. This arrangement permitted the waves to be concentrated into a beam which could be projected in any desired direction. The receiver consisted of a resonator formed of two plates of metal with a detector connected to and interposed between them; this was likewise placed in the focus of a similar parabolic reflector the opening of which was oppositely disposed to that of the transmitting reflector. With this combination it was possible to concentrate the waves into a beam, but the scheme was not practicable, at least over any considerable distance, since the oscillator and resonator systems were so limited in size that the emitted wave lacked the requisite amount of energy to be of commercial service.

In the Scientific American of October 7, 1905, the writer described a system for directing electric waves invented by Alessandro Artour, of Italy, who by an ingenious arrangement of the spark-gap spheres and aerial wires was enabled to obtain circularly and elliptically polarized electric radiations, thus forming rays capable of being propagated in any direction and without the use of grids to reflect them. Considerable success has attended these experiments, messages having been transmitted over 300 kilometers, while another station less than 100 kilometers distant and outside the effective line could not receive them.

Prof. Ferdinand Braun, of the Strasburg Institute, has recently brought out a new method for directing wireless messages in which it is not necessary to bunch the waves into a ray. His method is based on the theory of wave intensification and rarefaction by interference. Thus, assuming that two aerial radiating wires are tuned to the same period of oscillation and are energized by currents from the same oscillator, it should not be difficult to obtain interference phenomena provided the oscillations set up in one of the aerials have a phase difference of a small fraction of a second from those of the other.

While the time difference required between the two series of oscillations is exceedingly small, yet it is not easy to tune both oscillations to the same period and yet differentiate the time sufficiently to produce a lag necessary to bring about the desired interference.

This was finally accomplished in the laboratory by throwing the two series of oscillations out of phase by means of an inductance inserted in one of them