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The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are sharp, the articles short, and the facts authentic, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

A CHANGE OF FRONT.

When it became evident in the spring of last year that there was a wide divergence of professional opinion as to whether it would be better to build a high-level or a sea-level canal at Panama, the President decided that in view of the great importance of the work, it would be advisable to place the matter before an international board of the most eminent hydraulic and canal engineers, not merely in America, but of the whole world. As finally constituted, this Board included the chief engineers of the most important canals in Europe, and engineers who have been responsible for some of the principal canals, river and harbor improvements, and reservoirs for city supply in this country. In his charge to the Board made at Oyster Bay last September, the President said: "I have named you because in my judgment you are especially fit to serve as advisers in planning the greatest engineering work the world has yet seen. . . . I hope that ultimately it will prove possible to build a sea-level canal. Such a canal would undoubtedly be best in the end, if feasible; and I feel that one of the chief advantages of the Panama route is that ultimately a sea-level canal will be a possibility." In spite of this strong inorsement of the value of their professional judgment, the President has deemed it best to reject the majority decision of the Board in favor of a sea-level canal, and recommend the adoption of the minority report in favor of a lock canal at high level.

At the time that the President was expressing his decided preference for a canal at sea level, the SCIENTIFIC AMERICAN shared in the general trend of opinion in those days in favor of the low-level type. We were largely influenced by the judgment of the Chief Engineer of the canal at that time, who, as the result of his personal experience at the Isthmus, had come to regard the construction of a lock canal as impracticable. His conviction was based on the belief that the deep alluvial deposits in the valley of the Chagres rendered the construction of a perfectly reliable dam impracticable. Furthermore, the sea-level plan was attractive, because we believed that it would present a more rapid means of transit from ocean to ocean, and one that would be attended with fewer risks. During the past twelvemonth, however, the more extensive borings which have been made at the site of the proposed dams have revealed more favorable conditions. Moreover, the dam which it is now proposed to build, and the vast inland lake which it will impound, invest the high-level project with such manifest advantages of deep-water navigation and security from collision and grounding of the ships that will pass through it, that the relative advantages of speed and security of transit, which we formerly supposed to belong to the sea-level route, have practically disappeared. With these two considerations removed from the question, there remains in favor of the high-level plan the fact that it can be built for fifty per cent less cost in money, and probably in from sixty to seventy per cent less time. It is undoubtedly considerations of the same character that have led the President to favor the minority report.

It would be a thousand pities if the impression should go abroad that in the division of opinion on the Consulting Board, and in the President's acceptance of what might be called the American point of view, any motives of national exclusiveness or prejudice have played a part. The parties concerned are too statesman-like, too broad in their point of view, to be influenced in a matter of this kind by motives of a misnamed patriotism, and we consider it distinctly unfortunate that the suggestion of any such motive should have been even hinted at, much less alleged, in the dispatches that have been circulated so freely from Washington. We prefer to believe that in all the recent official

deliberations of the government upon this momentous question, the final decision has been reached purely upon a consideration of the engineering, commercial, and military aspects of the case. The exhaustive investigation made by the Board of Consulting Engineers, as embodied in their report, is by far the most valuable contribution that has been made to the voluminous literature of the Panama Canal; and the fact that the five leading hydraulic experts of the Old World have lent their ripe experience to the final solution of the problem is an added guarantee that, when Congress shall have made its final decision, the type adopted will, all things considered, be the very best that could be built.

SOME LESSONS FROM THE PAST AT PANAMA.

To date, we have expended at Panama \$60,000,000; and, comparatively speaking, we have as yet no more than scratched the surface of the ground. In the \$60,000,000 is included, of course, the purchase price of \$40,000,000 paid to the French company, the \$10,000,000 paid for the ten-mile canal zone across the Isthmus, and the first appropriation of \$10,000,000 for active construction. Although we have not yet by any means commenced "to make the dirt fly," the \$10,000,000 has, no doubt, been well expended in preparatory work, including the sanitation of the canal zone, in the provision of suitable living quarters, in the purchase of excavating machinery, and in the thorough re-survey of the canal by a large force of engineers.

At the present juncture, when the nation, having formulated its plan, stands ready to launch its energies upon the colossal task confronting it, we shall do well to gather from the experience of the past few years some very obvious lessons, and lay them deeply to heart. In the first place, the brief incumbency and resignation of that distinguished and much-misrepresented engineer, Mr. Wallace (who by the way is a past president of the American Society of Civil Engineers, and, therefore, holds a professional reputation that is surely a sufficient guarantee of his integrity of purpose) served to impress upon the administration the necessity of giving the chief engineer at the Isthmus an absolutely untrammelled hand in the direction of the engineering and constructive elements of the work he has in charge. After a careful reading of the voluminous report of the inquiry that is now going on before the Senate, any impartial critic must feel that, if this work is to be done with the dispatch and reasonable economy which mark the great works of engineering carried out by the railroad systems of this country, it should be executed along those lines which half a century's experience has proved to be the most practicable. The well-intentioned, but slow and cumbersome methods which characterize the handling of government work can never be applied to good effect at Panama. The elaborate system by which, with the best intentions in the world, the government has hedged about the purchase of supplies and material and the general payment of accounts, while it is admirably adapted to prevent fraud, is equally well adapted to act as a veritable millstone about the neck of any engineer who attempts to apply its methods to a great work like that at Panama, which must be carried on two thousand miles from the seat of government in Washington.

Another lesson that we have learned is, that in the matter of providing the necessary material, plant, means of transportation, and labor force, the authorities should feel at liberty to buy in the cheapest market, and introduce that class of labor which is found to be most effective to the peculiar conditions on the Isthmus. It was brought out in the inquiry before the Senate that the progress of the engineering work has, at times, been subjected to intolerable delay, because there is a disposition to place requisitions in certain localities or States irrespective of the question of speedy delivery. Paternalism in an enterprise of this magnitude should have no place whatever. The speedy and economical completion of the work should be the paramount consideration. Malaria and the yellow fever itself would not prove more fatal to the speedy completion of the canal than would be the encroachment of "political pull" even in its mildest form.

Finally, the experience of the past indicates that the work should by all means be done under contract. Preferably, it should be let under a single contract, to a company capable of giving the strongest guarantees; or, at most, to two such companies, building the canal under two separate contracts, with the division line drawn at the deepest part of the Culebra cut.

GATUN DAM, THE KEY TO THE CANAL PROBLEM.

As a result of the long-drawn-out investigation and discussion of the Panama Canal problem, certain fundamental truths are beginning to emerge from the mass of contending theories, and stand out as well-established facts. Chief among these is the fact that a high-level canal built on the lines of the minority report is, all things considered, a better canal than one at sea level, provided, of course, that when it is completed it will be as permanent, in spite of its artificial dams

and locks, as the simpler waterway cut at sea level from ocean to ocean. The most important feature in the high-level canal, the one, indeed, which renders it so attractive to shipping men, is the substitution for a narrow channel, 150 to 200 feet wide and over 40 miles long, of two large inland lakes, with over 30 miles of deep-water navigation free from risks of grounding and collision. But the creation of these lakes and their permanent security depends upon the erection of a number of dams, three on the Pacific side of moderate height, and one of much greater height and importance on the Atlantic side at Gatun. The nature of the foundations for the dams on the Pacific side is satisfactory, and there can be no serious doubt as to their future permanence should they be built. But around the colossal structure with which it is proposed to impound the waters of the River Chagres at Gatun, there has arisen a very spirited controversy, the majority report flatly declaring that no reliable dam can be put up in that locality, and the minority report declaring with equal emphasis that it can, and that it will be one of the safest structures of the kind ever erected.

The objections to the Gatun dam are based upon the fact that the depth to rock or its equivalent is so great, that it will be impossible, in building the dam, to include within it a core wall or diaphragm of impervious masonry, clay, or sheet piling, extending everywhere from high-water level to rock and shutting out any possibility of seepage through or beneath the dam. It has always been accepted as a fundamental axiom of dam construction among European engineers, and, indeed, until very lately among engineers in this country, that such an impermeable core wall must be included when the dam itself is built of earth or kindred material. Of late years, however, some very successful work has been done in this country in the erection of dikes, levees, and even high reservoir dams, that have been built of a homogeneous mass of earth upon an alluvial deposit that was itself impervious to water. The most notable instances of this are the great San Leandro dam in California, which is subject to a head of 120 feet of water, and also the long dyke which closes a gap in the natural basin that forms the great Wachusett reservoir for the water supply of Boston. There has been no trouble whatever with these two structures; and it is largely because of the good results obtained with them, that the minority board and the Canal Commission decided to pin their faith to the huge earth dam at Gatun.

By reference to the drawings shown on another page of this issue, the character of the Gatun dam and the bed of the valley underlying it will be clearly understood. The line of borings taken along the axis of the dam for a distance of about 10,000 feet shows that ages ago the Chagres River must have flowed through a deep gorge, the bottom of which at Gamboa was at the present sea level, at Bohio 165 feet below, and at Gatun 258 feet below that now obtaining. In this geological age the floods of the river have brought down boulders, gravel, driftwood, sand, and fine silt, which have gradually filled up this gorge, raising the ground above sea level, and pushing the waters back to their present shore line on the Caribbean Sea. In the course of ages, as the ever-recurring floods poured through the gorge, they deposited first the heavy boulders which occur between Gamboa and Bohio, then the gravel, and finally, as the water spread out and began to flow more sluggishly, the sand and fine silt. The result, as far as Gatun is concerned, is shown clearly in our sectional view of the borings. It will be noticed that the layer of gravel is buried 200 feet below the surface, and that above this is a mass of fine sand and clay, with occasional local pockets of shells and driftwood. It is the opinion of the minority report, based upon tests of the clay silt at Gatun, that if a sufficient mass or thickness of it is presented, it is practically impervious to water. Consequently, the plan of construction of the dam will be to utilize the sand and silt that will be dredged out of the channel leading from Limon Bay to Gatun, for the formation of a dam of Cyclopean proportions at Gatun. The structure is to be 135 feet in height, and over 2,600 feet in thickness at its base. Such a mass will be secure against displacement by the pressure of the water; and its density, coupled with the fact that the finest material will be built into it on the upstream side, will prevent the escape of the water by seepage. It is also contended that the great weight of the mass, added to the compact nature of the clay-sand formation upon which it is built, will similarly prevent the escape of water from the dam by seepage through the underlying material. It is expected that even if there should at first be a slight tendency to seepage, the fine silt brought into the lake will settle upon the surface of the dam and the bottom of the lake and ultimately completely seal it up, the action in this respect being similar to that which tends to seal up the sand-bed filters in municipal water works, and necessitate the periodical cleaning of the bed and breaking up of the sand to allow filtration to go on. The dam will be formed entirely by the sluicing process, the