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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 indorsement 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 statesmanlike, 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 untrammeled 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 bowlders, 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 bowlders 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 excavated material from the Limon channel being pumped onto the site of the dam, where the water will run off, leaving the solids compacted into a firm, impermeable mass. Moreover, before this pumping process commences, the surface of the valley over the area to be covered by the dam will be entirely cleared of its vegetation and top soil, until, at a depth of eight to twelve feet, the clean sand and silt is everywhere laid bare.

All things considered, while we fully appreciate the conservatism which led the majority of the consulting board to reject the Gatun dam proposal, we think that the success of the San Leandro dam, the Wachusett reservoir dyke, and of a dam of pure sand which has proved successful at Jeypore, India, coupled with the elaborate experiments made by the Commission to establish the impermeability of the material upon which the Gatun dam is to be built, to say nothing of the willingness of some of our foremost hydraulic engineers to stake their own reputation and the interests of the people of the United States upon the venture, fully justify the Canal Commission and the President in their acceptance of a high-level lock canal.

MIKKELSEN'S ARCTIC EXPEDITION.

In the Arctic Ocean there lies a group of islands which is known to geographers as the Parry Archipelago. The most extreme western lands of this group are the two large islands called Banks Land and Prince Patrick Island. Lying to the west of this archipelago, discovered over half a century ago by one of the Franklin search parties, lies the great unexplored Arctic Ocean, undoubtedly the largest unknown area in the frigid zone.

For the purpose of exploring Beaufort Sea, the most southern part of this ice-covered ocean, and for the purpose of mapping islands which are supposed to exist there, Capt. Ejnar Mikkelsen has left with an expedition fitted out by the Royal Geographical Society of England and the American Geographic Society.

There is reason for believing that Capt. Mikkelsen's expedition will be crowned, if not with complete success, at least with sufficient success to repay the time, trouble, and money which have been expended in his behalf. Although he may fail completely in exploring the entire region, he should at least succeed in plotting the formation of the continental shelf, in other words, that part of the sea floor extending from the edge of the continent at depths of from 600 to 1,000 feet before the bottom suddenly drops.

That such a shelf does exist most geographers are certain. They base their belief on the experiences of previous expeditions. Shallow waters caused the "Jeannette" to drift for two years in a course which took her far west and but little north. The "Fram" was also carried west but far to the north, simply because she floated over the ocean in regions where there were no lands to set up currents that prevented her from drifting in that direction.

Unknown lands probably arise from the continental shelf, and impede the free movement of the currents. Hence the drifting of the "Jeannette" and other vessels. If Capt. Mikkelsen succeeds in definitely fixing the outlines of this shelf and its position, his expedition will be considered eminently successful.

In the hope of discovering the lands which project from the shelf, Capt. Mikkelsen will make long sledge journeys westward from Banks Land over Beaufort Sea, skirting well within the continental shelf. Actual exploration, however, will not begin until the spring of 1908.

THE MOTH AND THE FLAME.

Why does a moth fly toward a flame? Because it is inquisitive, was the rather puerile answer given by the great Romanes. Because of some inexplicable inherited instinct, was the reason advanced by other naturalists. Because it is the nature of the insect, was a third and equally unsatisfactory reply. One reason was as good as another, but that of Romanes undoubtedly carried off the popular palm. Perhaps we owe it to him that the moth and the flame have pointed many a moral and adorned many a sad tale of curiosity tragically satisfied.

The investigations of Prof. Jacques Loeb bid fair to relieve the moth of the moral burden that has rested on his wings. Prof. Loeb has proved very conclusively that a moth, in common with many insects, flies toward a flame for the same reason that some plants turn their leaves toward the light. "Heliotropism" is the awesome name in which this tendency of plants and animals rejoices.

It happens that there are two kinds of heliotropism. If your moth or bug flies toward the light, it is positively heliotropic; if, like the earthworm, it shrinks from the glare, it is negatively heliotropic. Plants, too, may be classified into these divisions. Just as some flowers open only by day and others only by night, so some moths fly only by day and others only by night.

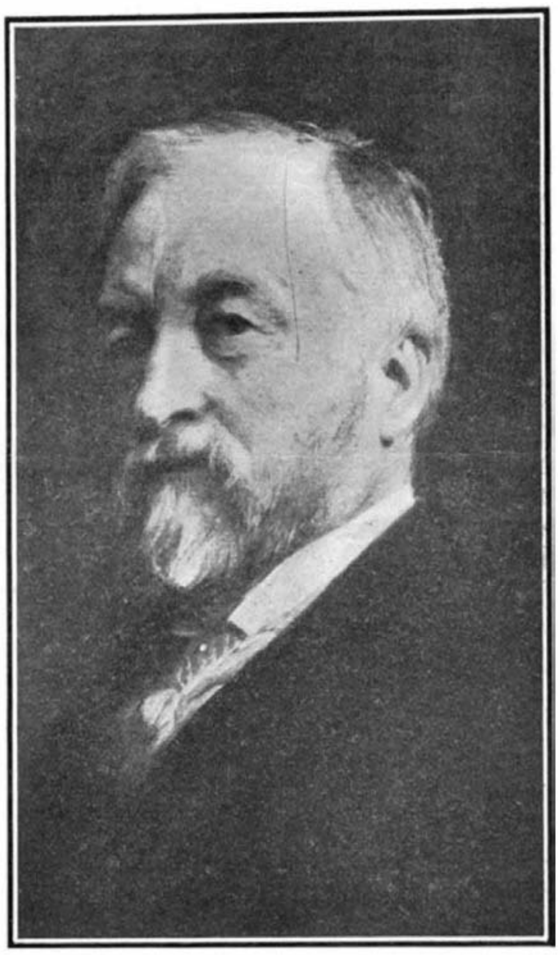
The results of Prof. Loeb's experiments explain with astonishing simplicity the causes of a June bug's merry antics as well as the apparently aimless movements of squirming, new-born vermin. Insects, it seems, move in the direction of the light rays that fall upon them. Change the position of the light, and the insect changes his course likewise. But the light must be of a certain intensity to produce a very marked effect. Suppose that in your experiments you exposed your bug to diffused light. He would move toward the light, to be sure; but he would creep toward it rather leisurely. Expose him to a bright glare, however, and he will hasten toward it with cheerful rapidity. That is why winged insects flutter gayly about in direct sunlight. Curiously enough, the influence of light is limited by atmospheric temperature.

From the circumstance that insects tend to arrange themselves and to move in the direction of light, it would almost follow that their structure must have something to do with their heliotropism. And such Prof. Loeb's experiments prove to be the case. The head of an insect is much more sensitive than the tail. Here the omnipresent skeptic will probably remark that an insect sees with his head and not with his tail, and that Romanes may be right after all. But such notoriously blind animals as the earthworm and other eyeless creatures are far more responsive to light at the head than at the tail. The mere possession of sight cannot, therefore, account for the earthworm's avoidance of light or for the moth's apparent liking for it.

Sometimes it happens that an insect is stimulated by light only at certain periods of its existence. In winged ants, for example, the period coincides with the time of the nuptial flight; in plant lice, with the appearance of wings; and in some larvæ, when full growth has been attained. Occasionally a caterpillar may crawl toward a flame, while the butterfly to which it gives rise may be repelled by light.

What is the cause of this curious effect? It must be confessed that science can give no satisfactory explanation. We might just as well ask, What is the cause of gravitation? The phenomenon is exactly the same as that which is produced in plant life. And that, in animals, it cannot be due to the nervous system is evident from the fact that leaves and branches have no nerves.

To be paralyzed by light, to be confined to a certain path, or to be incarcerated in an impalpable luminous prison would seem a serious limitation in the search for food. Yet it so happens that heliotropism may actually assist an insect in its struggle for existence. Certain caterpillars just after they are hatched, and when they are ravenously hungry, are compelled by the mechanical effect of light to crawl to the tips of branches, where they find their first nourishment in tender buds. After their first meal, the caterpillars lose much of their sensitiveness to light. Their heliotropism explains what has heretofore been vaguely attributed to instinct. Prof. Loeb even ventures the suggestion that the periodic migrations of many animals, such as those of birds of passage, may also be explained in part by heliotropic irritability.



S. P. Langley

SAMUEL PIERPONT LANGLEY.

With the death of Prof. Samuel P. Langley on February 27 there has passed away not only one of the most distinguished American workers in the field of pure science, but a physicist of world-wide reputation.

Prof. Langley was born in Roxbury, Mass., on August 22, 1834. Although astronomy was the study which most attracted him, even from his boyhood days, he drifted into the profession of civil engineering, where his mathematical taste found employment and likewise his manual dexterity. He soon gave up civil engineering for the allied profession of architecture. For seven years he worked patiently and then decided to abandon the profession. With no certain plans for the future he began to take up the study of astronomy in earnest. After a brief visit to European countries he obtained a position at the observatory at Cambridge, and was thus launched in his life work at the age of thirty. After a brief service at Cambridge, and at Annapolis, he became director of the Allegheny Observatory.

When Prof. Langley went to Pittsburg in 1867 he found there only an observatory in name. The equipment was inadequate, the endowment small. It was imperatively necessary that some means should be found whereby the work could be carried on. It was from the very poverty of the Allegheny Observatory that the greatest results came. In order to obtain money, Langley inaugurated "time-service systems" on a scale never before attempted. He first began by regulating the clocks of the Pennsylvania Central and other railroads associated with it, a system then comprising over 2,500 miles of railroad east and west of Pittsburg and along which 300 telegraph offices were located. Accurate time signals were communicated twice daily to each of these offices. Eventually some 8,000 miles of railway were run by this single Allegheny Observatory clock. The present system by which the railroad system of the whole continent is regulated may be said to be an outgrowth of that developed nearly forty years ago at Allegheny by Prof. Langley. The income thus derived was applied exclusively to the uses of the observatory.

In the course of two or three years the observatory affairs had prospered to such an extent that original work could be undertaken. Langley's first work was a laborious and minute study of the sun's disk, which study he completed in 1873. He revealed the true character of the "granules" upon its disk, discovered that the polarization of the corona is radial, and gave us the first complete account of the structure of a sun spot. A detailed study of the distribution of heat on the solar surface, begun in 1870, resulted in the previously unknown thermochroic action in the solar atmosphere, by reason of which, owing to the difference in wave length, it transmits heat more readily than light.

This early work upon solar heat was accomplished with the aid of the thermopile, an instrument not sufficiently sensitive for the more minute work which it was his desire to undertake. He invented a new instrument which he called the bolometer—a thermometer of almost infinite tenuity, which measured radiant heat with an accuracy that has never been excelled. In its more recent forms the instrument can detect differences of temperature amounting to no more than the one-millionth part of a degree on an ordinary thermometer.

In the hands of Langley, the bolometer demonstrated experimentally that the maximum heat in the normal spectrum lies in the orange and not in the infra-red spectrum, as commonly supposed. Before the invention of the bolometer the distribution of heat in the spectrum was almost entirely unknown. In the course of three years' patient work, however, Langley completed a map of the principal lines of the heat spectrum and thereby furnished new material for a study of the interaction of solar heat and terrestrial atmosphere. What Kirchhoff did for the upper rays of the spectrum Langley accomplished for the lower spectrum.

One important result of all these bolometric investigations was the discovery that the earth's atmosphere acted with selective absorption to a remarkable degree, keeping back an immense proportion of blue and green, so that which was originally the strongest became, when it reached us, the weakest of all, and what was originally weak became relatively strong. The action of the atmosphere is just the converse of that of an ordinary sieve, or like that of a sieve which should keep back small particles analogous to the short wave lengths (blue and green) and allow freely to pass the larger ones (the dark heat rays). Langley, therefore, proved that white is not the sum of all radiations as we used to be taught, but that it resembles pure original sunlight less than the electric beam which has come to us through reddish-colored glasses resembles the original brightness.

An expedition to the top of Mount Whitney resulted in the discovery of an entirely unsuspected extension of the solar spectrum; in a calculation of the relative intensity of the different rays of the sun before they

(*Continued on page 211.*)