WORK OF THE ISTHMIAN CANAL ENGINEERS.

BY FREDERICK MOORE.

The work of the Isthmian Canal Commission's surveyors, hydrographers, geographers, geologists, topographers and other assistants has resulted, at last, in definite printed material voluminous in the extreme and of value in proportion to its abundance. All these maps, diagrams, etc., fresh from the press, mean a work in which many engineers would be proud to have taken a hand.

A chief engineer was appointed for the report on each of the canal routes to which the commission was directed to give special attention. He was directed to make his headquarters in his respective territory and to take general control of the field operations therein. Considering the results of the numerous surveys made in the past, it was decided by the commission to limit the explorations in search for "other possible routes," as Congress directed, to that part of Colombia known as the Darien country, lying between Panama and the Atrato River; and a third engineer was appointed to direct the field work there.

Competent assistants, whose education and experience had fitted them for the special work to be done, were assigned to service under the three chief engineers; and laborers, boatmen and other workmen were hired wherever their services were required. Twenty working parties were organized in Nicaragua, including 159 engineers and assistants and 455 laborers. Five parties were organized in Panama, with 20 engineers and assistants and 41 laborers. And six parties were sent to the Darien, numbering 54 engineers and 112 laborers.

The chief engineers were directed to examine with the aid of these working parties the geography, hydrology, topography and other physical features of the different countries. The schemes already planned were thoroughly tested, and further surveys were made in order to vary the line and select better locations wherever the conditions were found to be unsatisfactory. Accordingly, a complete project was prepared for each route, and the center line of each canal was marked where that had not already been done.

The study involved examinations of the terminal harbors and approaches, the locations selected for dams, locks, embankments and other auxiliary works. Borings to determine the nature of the subsurface materials at the sites of the locks and along the canal lines, and observations of rainfall, stream flow, sedimental deposits, and lake and ocean fluctuations, were, in the main, the work to be done. Attention was also given to the supplies of rock, timber and other materials on the canal lines available for construction and maintenance.

The results of these examinations and observations, and the material and data obtained, were sent from time to time to the headquarters of the commission at Washington, where they were arranged and entered upon plates and profiles under the direction of the committees of the commission in charge of the respective canal surveys. How the engineers did the work is interesting, and their life in the Isthmus, indeed, an experience.

Each of the parties was allotted a certain territory. They would establish a camp along the approximate routes, living in tents, huts of palm leaves, or, if near a village, in some "hotel" therein. From these they would work from three to five miles in each direction, and then pack bag and baggage and grub by mule or canoe or other conveyance to a new camp; and so on till they met the next party or the next party's work.

The largest force was placed on the Nicaraguan line because it was the longest, because the many reports on the line were at variance, and because the data obtainable from the Maritime Canal Company was found to be of little value owing to its inaccuracy, age and the fact that the company's designs were for a canal that, for its shallowness, would be useless to-day. The number of authentic surveys that have been made on the Panama line (especially that of the International Commission of engineers) and the full and sufficient data the Panama Company holds, made a large force there unnecessary. The Darien line was foredoomed, but in compliance with the bill authorizing the investigations of other possible routes, a fair survey of it had to be made.

The method of observing the regimen and discharge of the streams was simple. A stout line was stretched from bank to bank, or from trees on the banks. Below was placed a windlass to haul out the trolley car in which the gagers rode. Of course, a point was selected as near as possible to the location at which knowledge was desired, having reference to the conditions of the stream itself, the aim being to secure high and permanent banks on both sides, as straight a channel with as uniform a depth and velocity as could be found and avoiding any location which was a short distance above any tributary of importance which might create back water. A gage graduated to feet and tenths was placed in the stream near one bank and so situated as to be conveniently read from the shore. It was usually possible to fasten such a gage in a vertical position in deep water to the trunk of an overhanging tree (for they grow over the banks and even in the streams in Central America). The height was recorded twice a day, and the mean of the two gages taken as the river's height for that day. At various intervals, depending on the change of the gage, measurements of discharge were made from the trolley cars with current meters. Soundings were taken at a known distance from an assumed initial point, and the velocity measured by submerging an electric current meter at six-tenths of the measured depth and holding it in that position for a length of time—usually 100 seconds or more—sufficient to make a good determination of the velocity at that point. This operation was repeated at short intervals for the width of the stream, and from them the discharge of cubic feet per second was computed for each section by multiplying the depth, width and measured velocity together. The discharge of the several sections added together gives the result for the stream. At the beginning and end of staging a careful note was made of the gage and the mean depth of water taken.

Every other detail of the work was done in the same simple and thorough manner. Lake Nicaragua's every tributary was gaged and its supply accurately determined; for the control of the waters of the lake is vital to the practical operation of a canal, and has an important bearing on the cost and plans of the project. It fluctuates now some 12 feet, which would materially hamper lock workings, hence the careful observations of the fluctuations, the maximum and minimum inflow and outflow and the evaporation. Because of violent breakers on the lake the gages had to be protected behind old vessels or whatever was found along the coast. At Las Lagas the boiler of a wrecked vessel was used to incase the gages and evaporating pans.

Observations of rainfall were made with a funnel and a bottle, the relations of the diameter of the funnel mouth to that of the bottle being accurately known. The rainfall is a remarkable characteristic of Central America, and particularly Nicaragua. There is a radical and striking difference between the falls on the eastern and western coast. There is a definite dry season on one, but rain may be expected the year around on the other. At Brito there is practically no rainfall from January to the middle of May, but during the rainy season the downpour often reaches 5.6 inches per day.

The evaporation test did not work as well, usually, as the others. Galvanized sheet iron pans, 3 feet square and 2 feet deep, were anchored in some protected body of water alongside a rain gage, giving the water in them the same freedom, as far as practicable, as the outside water had. But the waves would wash over and fill them, the natives would steal them or haul them ashore and make washtubs out of them, and animals would overturn them.

The same windlass that trolleyed the cars across the rivers was used to tow out the sediment gage cars. These too, were galvanized pans, one meter square and 8 inches deep. The upstream side was on a hinge. The pan was lowered into the streams and anchored. When the time came to haul it up, the gate was closed by a copper wire and the windlass put to work. First it was hoisted gently out of the water, then trolleyed to shore. The silt deposit is an all-important test and has much influence on the location of the locks. Samples were also taken of the waters and allowed to settle ashore, each day the clear water behind drained off and more muddy water poured on.

The measurements were made with 100-foot steel chains, they being checked each fortnight by comparison with steel tapes. All angles were measured carefully with a transit, deduced bearings being carried through as a check to the reading of the angles. The density of the forests and the incessant heavy rains or cloudiness materially inconvenienced the reading of the instruments. Special care was taken in chaining, plumb bobs being used on all broken ground. Elevations of surface were taken with a wye level and target rod at intervals of 100 feet, and at such intermediate points as were necessary in order to produce close and accurate profiles.

These are but a few of the innumerable tests that were made, but they go to demonstrate that dependence may be placed on the commission's report. For those among the parties who loved hunting big game and fishing there was some relief from the work, but their hardships were sometimes excessive. The food was sometimes worse than they had ever before experienced, even in the wildest places in this country, the density of vegetation hampered their work, all the labor was inefficient (this will be a serious question when the canal comes to be built), the prevalence of the "pica-pica" plant, bearing a pod which sheds a dry, irritating dust, was almost unendurable, and the extraordinary number of wasp nests was extremely harrassing.

The engineers generally say they are glad to have had their names coupled with the canal work, but they want no more of it.

THE HEAVENS IN FEBRUARY.

BY HENRY NORRIS RUSSELL, PH D.

The planetary displays, to which we have been treated for many months, come at last to an end about the middle of February, when Venus and Mercury pass together from the evening skies, and for some time only the fixed stars greet the sight. If, however, we were as well accustomed to view the skies before dawn as after sunset, we might say that the display was just beginning, for the southeastern heavens before sunrise are then enriched by the presence of several planets. But, for most of us, our interest must for a time be confined to the unchanging constellations, which in themselves are a splendid sight in the clear air of a winter night.

The following description holds good for the hour of 10 P. M. at the beginning of the month, and of 8 P. M. at its close.

The finest part of the sky lies along the meridian, and to the west of it. Gemini is nearly overhead, a little south of the zenith. Canis Minor lies below, and Canis Major still lower, extending nearly to the southern horizon. Auriga is northwest of the zenith, and Taurus west of it, the Pleiades being the lowest part of the constellation. Orion lies to the southward, with Eridanus below on the right. Aries is well down in the west, with Cetus setting below it. Perseus, Cassiopeia, and Andromeda are in the northwest. Cepheus and Ursa Minor lie below the Pole, and Ursa Major above it on the right. Leo is well up in the east, and part of Virgo is rising. About half of Hydra may be seen in the southeast.

Below Sirius to the left, low down on the horizon, is part of the great constellation Argo. Its brightest star, Canopus, which stands next to Sirius in brilliancy, is too far south to be seen from New York.

The pole is 41 deg. below the horizon of New York. Hence Canopus, even when it is directly above the pole, is 41 deg. to 37½ deg., or 3½ deg. below the horizon, and consequently invisible.

THE PLANETS.

Mercury is evening star at the beginning of the month, setting an hour and a half after the sun. On the 2d he reaches his greatest elongation, and is favorably placed for observation, being north of the sun, and unusually bright. After this date he rapidly approaches the sun, passing north of him, at an apparent distance of about 4 deg., and becoming a morning star. On the 28th he rises nearly an hour before sunrise, and is again visible to the unaided eye.

Venus passes through much the same phases. On the 1st she is evening star, setting at about 7 P. M. She moves rapidly toward the sun, so that she sets about six minutes earlier each evening. By the 10th she is above the horizon only half an hour after sunset, and on the 14th she reaches her inferior conjunction, passing between us and the sun, but so far out of line that she appears to be some 8 deg. north of him. She is then only one-tenth as bright as she was in January, but is still nearly equal to Jupiter. After this she moves out to the west of the sun, becoming a morning star and growing brighter. At the end of the month she rises one and a half hours earlier than the sun and is conspicuous in the morning skies.

All through the month she is very near the earth, their distance being 28,000,000 miles on the 1st, which decreases to 25,500,000 miles on the 15th and then increases again to 28,000,000 on the 28th. This is nearer than any other heavenly body ever comes, except the moon, the little asteroid Eros, and occasionally a stray comet.

Of the other planets there is little to say. Mars is still evening star, but is too near the sun to be seen. Jupiter and Saturn are morning stars, rising some two hours before the sun on the 15th. Uranus is in Ophiuchus and rises about 3 A. M. Neptune is in Gemini and visible in the evening.

THE MOON.

New moon occurs on the morning of the 8th, first quarter on that of the 15th, and full moon on that of the 22d. The ensuing phase falls in March. The moon is nearest on the 16th, and farthest away on the 1st. She is in conjunction with Uranus on the 3d, Saturn and Jupiter on the 6th, Venus on the night of the 8th, Mars and Mercury on the following day, and Neptune on the 17th.

On the morning of the 26th the moon passes in front of the bright star Spica, in the constellation Virgo, hiding it for over an hour. As seen from Washington the star disappears behind the moon at about 3:30 A. M. and reappears at about 4:40.

A speed of 105 miles per hour has been attained on the Zossen experimental electric railway. The main tests are to be at a speed of 125 miles per hour.