

**A NEW DETERMINATION OF THE QUITO ARC OF THE MERIDIAN BY THE FRENCH GEODETIC COMMISSION OF ECUADOR.**

BY JACQUES BOYER.

At its meeting at Stuttgart, in 1898, the International Geodetic Association decided upon a redetermination of the arc of the meridian measured in Peru by La Condamine, because the improved scientific methods and instruments of the present day permit the various elements from which the dimensions of the earth are deduced to be determined with greater accuracy than was possible in the eighteenth century.

The United States offered to perform the work if France, to which nation it properly belonged, should decline to undertake it. Naturally, however, the government of the French republic felt bound, in honor, to continue to play its historical rôle and sent to Ecuador Capt. Maurain and Liacombe, who explored the Cordilleras from southern Colombia to northern Peru (July to November, 1899).

In their report they showed that this region, which is crossed by two high parallel mountain ranges, is admirably well adapted to the establishment of a meridional chain of triangles, with apices formed by peaks, taken alternately from the two Cordilleras.

Finally, after a report by M. Poincaré and an appropriation by the French parliament, the task was confided to the geographical service of the French army. On December 9, 1900, the vanguard of the expedition, commanded by Capt. Lallemand and Maurain, started for Ecuador, and on June 1, 1901, the main body landed at Guayaquil with twenty tons of scientific apparatus, which had to be carried, mainly on mule-back, over bad roads to the pass of Chimborazo, more than 13,000 feet above sea-level. A month later the little geodetic caravan, by order of Col. Bourgeois, had reassembled at Riobamba. The ac-

companying photographs give an idea of the life of the detachment on the Andean plateau. A few tents, equipped with rudimentary furniture, scattered about, a portable house for the observation pier and azimuth circle, and some rather primitive kitchen apparatus completed the camp. The work of the expedition was arranged in the following manner: First came the funda-

mental geodetic and astronomical operations, including the measurement of the base line, the determination of the latitudes of the stations at the center and the ends of the arc, and the measurement of certain differences of longitude, for example, between the principal station at Riobamba and the observatory at Quito. The measurement of angles and bases of verification

was reserved for the following years (1902-1905). In addition, in order to obtain the exact altitudes of the stations, it was necessary to run a careful leveling survey from one of them to the sea. The programme of the expedition also included geological studies, the collection of topographical data for a reconnaissance map on a scale of 1 to 200,000, based upon a very

the difference of longitude between Riobamba and Quito by means of telegraphic signals exchanged with M. Gonessiat, of Lyons, who had installed himself in the observatory at Quito. This observatory was built by the government of Ecuador a few years ago but is yet unprovided with observers!

After the completion of these operations the geodetic expedition separated into several divisions, while Col. Bourgeois returned to Paris whither he was recalled by his duties in the geographical service of the French army. In consequence of the rebellion then in progress in Colombia, it became necessary to abandon the northern

part of the proposed arc and to seek a new terminal astronomical station and a new base in Ecuador.

Capt. Lallemand made a reconnaissance of the Carchi country, built a temporary observatory near Tulcan and selected the plateau of San Gabriel de Tusa for the location of a base, which he measured four times with the Jäderin wires, with the assistance of Capt. Perrier and Dr. Rivet.

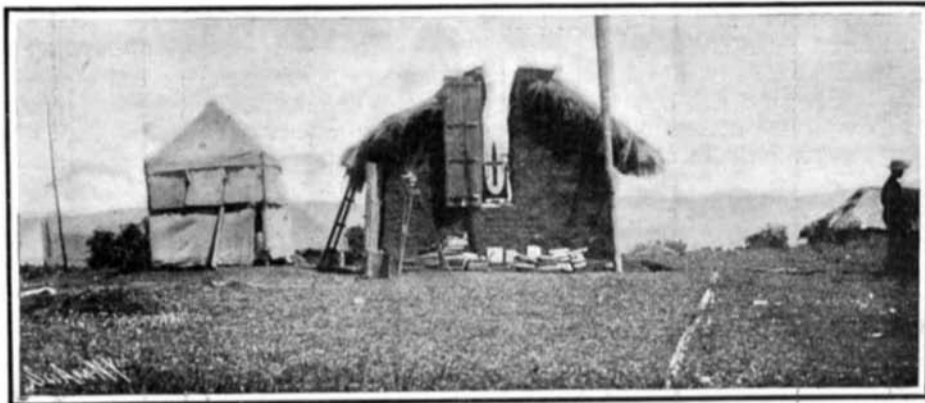
These operations were conducted with difficulty and nearly always in the rain. After bravely acquitting himself of this fatiguing task, Capt. Lallemand finished the construction of all the monuments of the northern section of the arc, while Capt. Maurain and Perrier determined the latitudes of the two end stations, the southern one at Païta, Peru, and the northern one at Tulcan, Ecuador, and thus

fixed the length of the arc of the meridian at 5 deg. 53 min. 33 sec.

From this time onward the French officers, divided into three groups, devoted themselves to secondary geodetic observations along the line from Tulcan to Païta, passing through Riobamba and Cuenca. Capt. Perrier occupied the northern stations of Troya and Mirador (3,500 and 3,800 meters above sea level), while Capt. Maurain and M. Gonessiat operated in the center and Capt. Liacombe in the south. Soon after

ward all these observers returned to France after having completed the redetermination of the Quito arc. In the course of their five years' labor they were forced to surmount all sorts of obstacles, from the inclemency of the weather to the hostility of the natives, who destroyed the monuments.

The following is a typical example of these difficulties. Because of fogs, ten weeks were consumed at Mirador in making observations which could be made in less than a week in France. In this work, therefore, not only were scientific knowledge and experience of the utmost importance, but the participants in the labors of the expedition had to possess patience, perseverance, and courage.



The Astronomical Station at Tulcan.



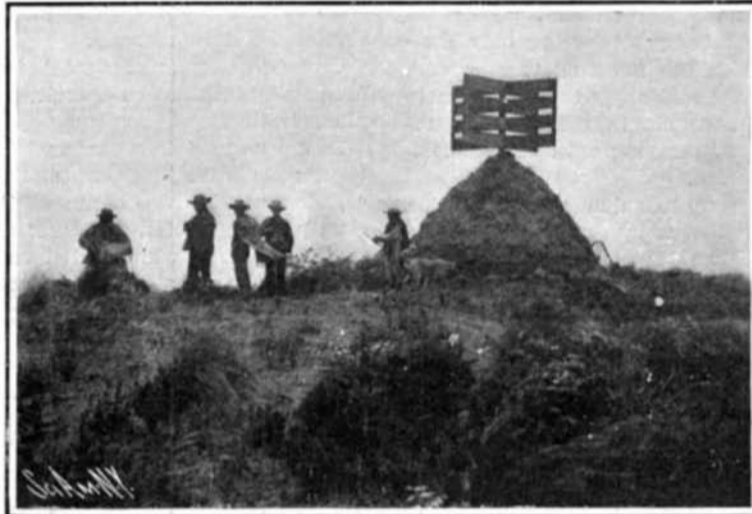
Terminal Monument of the Riobamba Base.

exact triangulation, and a study of the native tribes, and the fauna and flora of Ecuador by Dr. Rivet.

The determination of the fundamental base, about 10 kilometers long, at Riobamba, was not made without difficulty. The surveyors arranged along the selected alignment a series of microscopes whose axes coincided exactly with a vertical plane passing through the extremities of the base, and then observed a bar, 4 meters in length, through each pair of microscopes

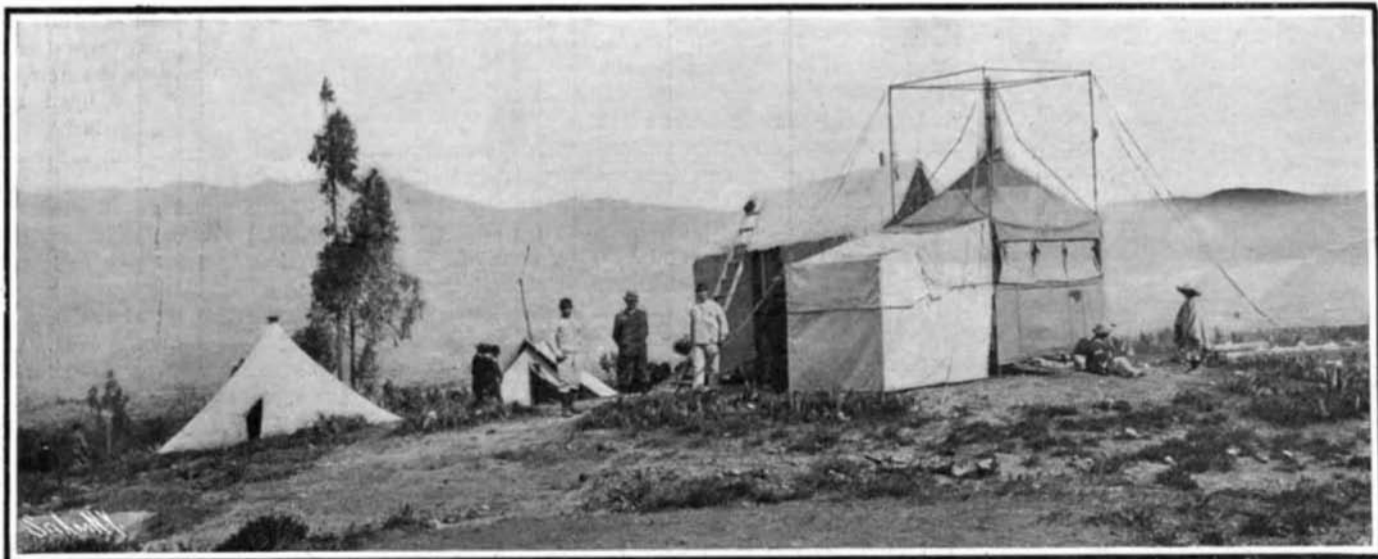


Leveling the Tulcan Base.



A Geodetic Monument in the Cordilleras.

in succession. The bar really consisted of two parallel bars, one of copper and the other of platinum, the difference of expansion of which indicated the surrounding temperature and, consequently, afforded data for the reduction of the observations to zero. The wind and the blinding, sandy dust raised by it compelled the observers (Capt. Perrier and Liacombe) to begin work very early in the morning and to stop at one o'clock in the afternoon. They were able, how-



The Geodetic Station at La Laura de Quito (Ecuador).

**A NEW DETERMINATION OF THE QUITO ARC OF THE MERIDIAN BY THE FRENCH GEODETIC COMMISSION OF ECUADOR.**

ever, to advance the bar about ninety times each day, thus measuring a length of 360 meters, with an error not exceeding one part in 450,000. The same base was afterward measured twice with the more practical and less cumbersome Jäderin apparatus of metal wire.

Meanwhile, Capt. Maurain set monuments on the peaks near Riobamba, and Col. Bourgeois determined