HARVARD OBSERVATORY IN PERU.

BY S. I. BAILEY.*

The first ascents of El Misti were probably made before the arrival of the Spanish, and are beyond the reach of history and even tradition. But remains of walls and fires within the crater, mentioned in the earliest ascents of which we have any record, seem to refer to some custom or rites, of which little or nothing is known at the present day. In the opinion of many, the relics found point to former sacrificial pagan rites celebrated there, but similar relics, together with remains of human bones, found at other great heights, have been thought by others to indicate a custom among the ancient Indians of burying their dead, presumably their chiefs, at great elevations. The subject is certainly an interesting one. The facts in regard to El Misti are brought out by the testimony of various persons. First, by Padre Alvaro Melendez, in 1677, who discovered within the crater vestiges of a small stone structure, evidently the work of human hands. Their existence was verified two centuries later by the late Señor Juan de Romana, and recently by myself.

In 1784, probably, was undertaken the expedition by Bishop Miguel Gonzalez de Pamplona. Although the bishop himself did not succeed in reaching the summit, his followers succeeded in placing there the celebrated cross of iron, near the summit on the side toward Arequipa. This cross still stands in its original position, where it has withstood the storms and snows of more than a century. The bishop wished to celebrate mass at the summit, a ceremony which was destined to be postponed more than a century, when it was performed by the Rev. Jose I. Rivero, cura of Cayma. This was probably the most lofty place of religious service known in the history of the world.

An expedition made in 1787 by various persons from Chiguata is especially interesting from the descriptions and particularly from the drawings of the volcano which they made.

The path which I had constructed two years ago follows in part the route taken by this party. This is somewhat curious, as at that time I had not read the description of this expedition, which chose the northern side of the volcano, instead of the common route by the east. This party claim to have found a volcanic breathing hole, or vent, at an altitude of about 15,000 feet on the northern side. I see no good reason for doubting the correctness of this statement, although none of the members of the observatory, in the numerous visits to the summit, have ever seen the least activity on that side. The drawings which they made, although very exaggerated, are nevertheless fair representations of the craters and the volcano in general, as they would appear to an unscientific person to-day, and convince me that no radical changes have taken place within the last century. It may be interesting to note that, in spite of all that had been written on the subject, the well-known authority on Peru, Paz Soldan, who attempted the ascent in 1862, and failed, doubted whether any one had ever really reached the main summit.

CLOUD EFFECT—PICHU-PICHU IN DISTANCE.

In addition to its charm as a mountain and a volcano, however, to me the greatest attraction of El Misti lay in the site which it offered for the loftiest scientific station in the world. Splendidly isolated from the neighboring mountains, its summit, if it could be made accessible, was an ideal location for lofty meteorological studies.

The growing interest of meteorologists in the study of the upper air made the success of such an enterprise most desirable. Already in Europe and the United States lofty points had been utilized. In Europe various stations had been placed on mountains of different heights, in general under 10,000 feet. At this time, however, M. Janssen was attempting, what he since accomplished, the establishment of a station on the summit of Mont Blanc, at an elevation of 15,700 feet.

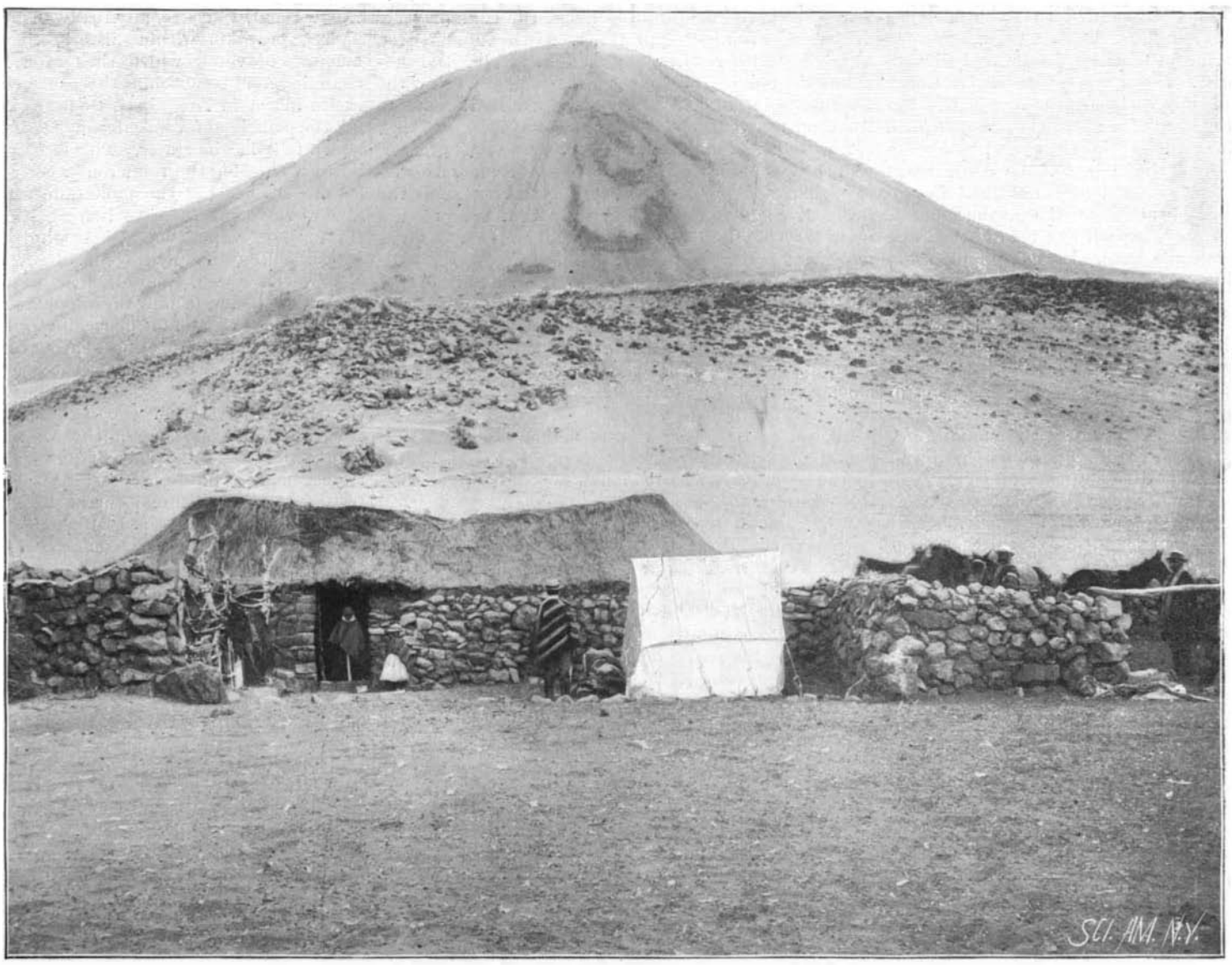
In the United States systematic observations had been carried on at an elevation of over 14,000 feet, on the summit of Pike's Peak.

El Misti stands alone. At first a sort of awe kept me from considering as possible the establishment of a station on its summit; but always, as I looked upon it, the impulse became stronger and stronger, and finally it could not be resisted.

Knowing from frequent experience in mountain climbing that mountain sickness would prevent success, unless the attempt was made with the greatest caution, I first planned an expedition entirely around the volcano, in order to examine all sides and choose that most easy of ascent. Accordingly, my brother, Mr. H. C. Bailey, and I, in August, 1893, passed entirely around the volcano, making photographs and examining its different faces with a powerful field glass.

On the east of the mountain lies the well known Alto de los Huesos. This is a broad, desert pampa, formed of volcanic materials, and overlain in certain parts with the bones of animals that have died from hunger and thirst. This lofty pampa forms the route for beasts of burden between Arequipa and the interior. It is a most cold and dreary region, without water and swept by strong winds. It rises to the height of more than 13,000 feet.

The ascent of the volcano has usually been attempted from this side, and a little wretched tambo



HALF-WAY HOUSE, ELEVATION 15,700 FEET, WITH VIEW OF EL MISTI.

* Lecture on El Misti delivered before the students of the University of Arequipa in Peru.

SCIENTIFIC AMERICAN

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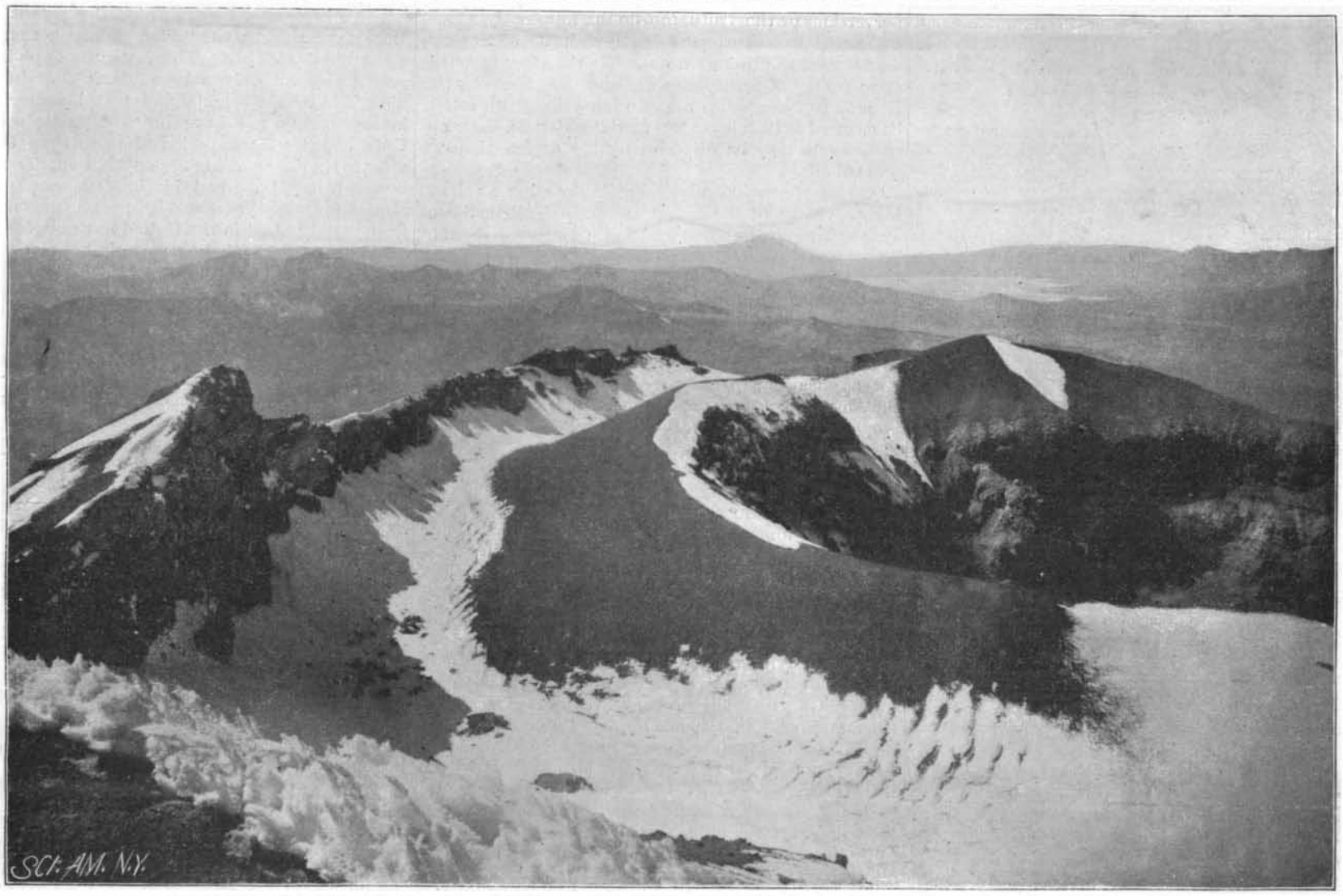
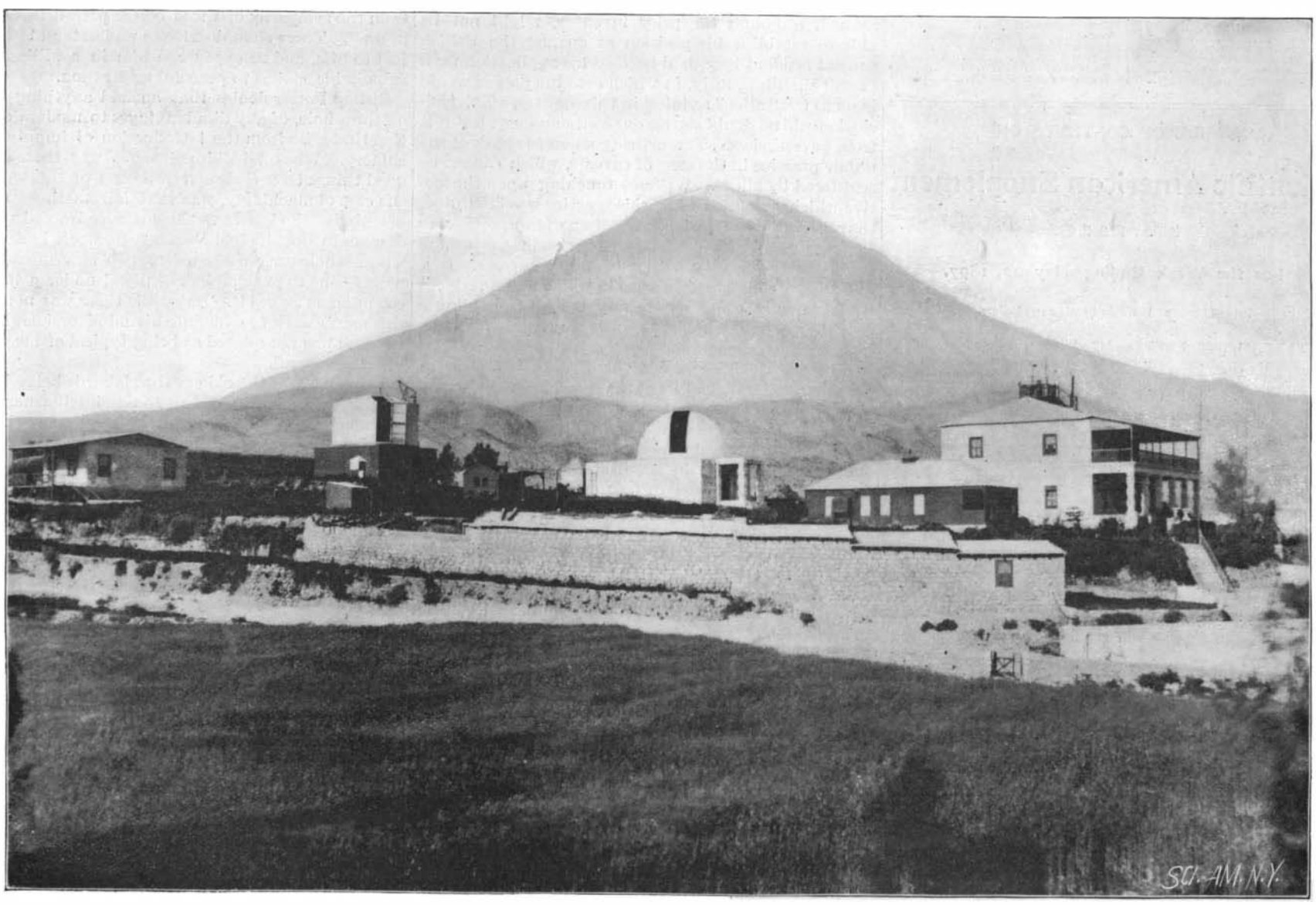


CRATERS OF EL MISTI AS SEEN FROM METEOROLOGICAL STATION, HEIGHT 19,000 FEET.



SOUTHERN STATION OF HARVARD OBSERVATORY, PERU.—[See page 329.]

there found has sheltered many persons with courageous hearts on their way to ascend the mountain, and many with sad hearts and sick bodies on their return. At least so said the old woman who kept the tambo.

The hut was of rough stone, with earth floor and grass roof. It boasted neither window, chair, nor bed. It was black with smoke and dirt. The only light at night came from a dismal little fire of twigs with which the woman attempted to cook a soup for the company. In answer to some inquiries she replied: "Yes, señor, I have lived here ever since the great earthquake. Ah! How many years that is! And during that time many, many people have come to the Misti. They have all come this way; many, many people, priests and Arequipanians, officials and foreigners, and most of all, foreigners, and some have reached the summit, and some have returned, so ill, ah! so ill; and some have died, and those who died [with a glance at us] were foreigners." She was informed that we were planning to build a path to the summit. She regarded me with pity, saying, "Impossible! impossible! Many, many many people have ascended the volcano, but always on foot. Where are there men enough to build the path, and food for them to eat, and money to pay them?" etc.

This kind of conversation by the witch of the mountain did not tend to make us more cheerful; nevertheless, at six o'clock the next morning we proceeded.

From this tambo the east summit of the volcano appears near and easy of access. Only those who have attempted it understand how difficult it is. The only possible entrance to the craters on this side is by the so-called "Portillo," or gate, which is a break in the old crater wall, allowing access to the "Callejon," or valley, which represents what is left of the old crater.

On this expedition we ascended the volcano to an altitude of 16,500 feet, and became convinced of the possibility of making a path and taking mules quite to the summit.

From about that elevation we saw a fine eruption of Ubinas, a volcano lying thirty miles to the east. At first the volcano was nearly clear from vapor or "smoke." All at once we saw a small black cloud rising from the mouth, which, within ten minutes, rose until its upper part was concealed by the clouds. But later it appeared far higher, through breaks in the clouds.

From what was known of the altitude of the volcano, I estimated that this dense cloud of volcanic sand rose at least 12,000 feet above the summit.

Seen from all sides, El Misti preserves its cone shape, but a careful examination showed that the northern side was more free from cliffs.

I shall not trouble you with the details and difficulties of the enterprise. A hut was constructed as a way station and base of supplies just at the foot of the central cone and at the head of a great cliff, at an elevation of about 15,700 feet. As this is approximately the altitude of Mont Blanc, the highest of the Alps, it was called the M. B. Station, and meteorological instruments were later placed there, as well as at the summit.

From this hut a narrow path was made about one foot wide in the volcanic sand. By careful planning we almost entirely avoided the lava cliffs, where the construction of a path would have been too difficult and expensive. Indians were used for the work. They suffer very little from the altitude, but considerably from cold at night. They worked fairly well, but toward the last of the work considerable persuasion of one kind and another was necessary.

Let us now, taking our stand at the summit, face toward the east. On the left is seen the northern wall of the old crater, a perpendicular mass of yellow, sulphur-stained rock a hundred feet in altitude. At that point I first reached the edge of the crater. I had been climbing some distance on foot, and though I was near the border, owing to the uniform slope I seemed to be as far as ever. Panting for breath, stopping every few seconds to rest, all at once I staggered on the very edge and fell exhausted and dizzy with my head and arms over the side. The impressions of that first view have never been repeated.

In front of us is the Gateway, facing the Alto de los Huesos, and a little to the right the deep chasm of the new crater. From this summit it is impossible to see the bottom of the crater. Beyond, if the day is clear, we may see the Cordillera stretching in a great line of snow-capped peaks to the north and then to the west. Nearer us lie the Salinas, whose vast deposits of salts gleam in the sunlight like snow. Beyond, to the left, is the active volcano Ubinas, and to the right the range Pichu-Pichu.

If we wish to enter the ravine and go to the edge of the new crater, we shall need to descend from the cross along the edge of the old crater wall, always in sight of Arequipa. It will be well to take great care, while passing over the snow, not to slip, since, once started, one might perish by falling into the crater or by rolling a thousand feet down the side of the mountain.

As we descend, lava cliffs, invisible in Arequipa, rise close to us, beyond which we catch varied views of the crater.

We soon reach the break in the wall and enter the ravine. Looking north along this deep valley, we see a bank of sand and pumice sloping up to the foot of the lava cliffs from which we have just descended.

From this place we will slowly climb the steep bank of sand and snow to the inner border of the new crater. We now stand directly on its edge. Clouds of vapor are always rising from numberless apertures in the bottom. This, from the incessant motion of the sulphurous vapors, together with its rough, yellow surface, has the appearance of a boiling liquid. As a matter of fact, however, we have never seen either liquid or fire, but only vapor, which varies greatly in quantity but never disappears for an instant.

At times this vapor rises more than a thousand feet. At other times it runs along the bottom, driven about by the wind, which seems to strike the crater wall and be deflected downward. All along the border, especially on the eastern and southern sides, are numbers of small holes, some of them no larger than a pencil, from which hot sulphurous vapor is rapidly puffed.

The odor of sulphur is very strong, and, were the wind from the opposite side, it would be difficult or dangerous to pass so near the edge.

No one has ever yet descended to the bottom of this "new" crater. Very few of the many who have attempted to climb the volcano have even reached the outer border. Of these, fewer have passed through by the inner border and seen all its details, but no one has yet dared to think of descending into the "Inferno." It would not be impossible to descend. Toward the left is seen a steep slope of sand and rock. By fastening a rope at the crest and lowering himself by its help, a man might possibly reach the bottom. If not asphyxiated before his return, he might be pulled up by men stationed above.

If the bottom were strewn with gold or diamonds as thickly as it is with sulphur, probably men would be found to make the attempt.

The Indians fear it and told us that the person who should throw a stone into the bottom would not escape alive.

In passing the ruins of walls, referred to above, I asked my Indian guide, "What is this?" "God knows," he replied. "But to me it looks like the ruins of the rooms of a little house," I added. "It seems to me more like a corral," the guide replied. "But who would build a corral in such a place as this?" I asked. "The devil," was his concise answer; and he and the others showed evident anxiety to leave the devil's corral as far behind them as possible.

We shall not care to pass many hours in the crater. Aside from the mountain sickness, the cold becomes very intense as night approaches. At the summit, even at midday with a clear sky and in full tropical sunshine, the temperature of the air is generally below the freezing point, and at night in winter it descends to from ten to twenty degrees below zero C.

The strong wind makes the cold seem much greater, and the low atmospheric pressure causes more discomfort than the low temperature. At the summit the barometer stands at 14·9 inches, so that the pressure upon the body has been reduced from fifteen to seven and a half pounds to the square inch.

In going from the sea level to the summit of the Misti a pressure of something like seven tons is removed from the surface of a man's body, and it is, I believe, the difficulty which the human body has in adapting itself to this tremendous change which is the chief cause of mountain sickness, though lack of oxygen may exert an influence.

Instead of returning to the main summit, which would be very difficult, and thence to the M. B. hut by the path, we can return much easier and quicker by the "gateway."

Moving along by the northern wall toward the east, we pass a great rock near which camped for two or three days Herr Falb and Doctor Moscoso Melgar.

The distinguished traveler Doctor Weddell, who ascended the Misti and entered the gateway to this point, was very unfortunate. With the greatest energy, alone of all his party he succeeded in reaching the border of the crater at the gateway and entered the ravine. Here he looked about him, and seeing nothing but a wall of rock on one side and a high mound of sand on the other, expressed himself satisfied with his achievement, and as night was coming on, beat a hasty retreat without seeing the real crater at all. His description is a little pathetic and ludicrous; for the sand hill he compares to those on the pampas, and expressly states that while most volcanoes have some kind of respirator or mouth, nothing of this sort is seen in El Misti.

Perhaps this report accounts for the apparently unkind criticism of Doctor Paz Soldan, who, after claiming that no one ever reached the summit of El Misti, says: "It is very strange that the skillful naturalist Mr. Weddell should pretend to have gained the crater itself," etc.

As we pass out through the gateway, we see the M. B. hut more than 3,000 feet below us, and far away the Alto de los Huesos, with troops of llamas, like tiny ants, trooping along on their way to Arequipa.

The descent for the first few hundred feet is over broken lava and great rocks; then for a great distance between high walls of lava on either side, but in the loose volcanic sand.

Down this we stride with steps each one of which reaches six feet. No effort is necessary except to move the feet forward; gravity does the rest. Four or five hours it took our panting mules to ascend in the morning by the path, and men have struggled on foot for twelve hours to reach the crater by the route we descend; however, in thirty minutes, in the loose sand, we drop more than 3,000 feet and reach the hut; within a few hours more we may again be in Arequipa.

Some facts in regard to El Misti, its past and possible future, will have interest.

By simple vision it is difficult to judge of the relative distances of mountains, especially in a region where the air is as pure and transparent as in this region. Strangers have often remarked to me that apparently it is an easy walk from the city to the summit of El Misti. In fact, El Misti is nearer the city than the other great mountains. To the main summit of Charcharni the distance, in an air line, is about fourteen miles, to El Misti eleven, and to Pichu-Pichu nineteen miles.

Owing to this fact El Misti has generally been thought more lofty than Charcharni. It is, however, about 800 feet lower.

Various values have been given for the altitude of El Misti, from less than 17,000 to about 21,000 feet. Few or none of these, however, were careful measurements. The true height of the highest point above sea level is, I believe, a trifle over 19,000 feet.

The volcano has frequently been referred to by the old writers as the "Colossus."

The lower slopes of the volcano proper abound with deep, fine sand, in which the feet sink, and in which a path lasts but a short time. I feared at first that this same fine sand would be found on the higher slopes and render it impossible to construct any permanent path. On this particular I consulted the Indian named Quispe, who was said to be the best authority on the mountains. "Yes, it is sand," he said; "you make a path to-day, to-morrow where is it?" He was mistaken, nevertheless, for in fact the strong winds have removed the fine sand from the surface at high altitudes, leaving only fine pebbles, so that the path is reasonably permanent.

A question which has often been asked me is, "Do you believe that El Misti will ever again be in a state of violent activity?"

This question I cannot answer authoritatively. There is not, I believe, any really authentic account of violent eruption within historic times, though the amount of vapor which rises from it is constantly changing, and has been at times of such quantity as to excite alarm in Arequipa. So far as my observations go, the emission of vapor depends largely on the snow which falls in the crater. This melts and runs to the bottom, entering the numerous apertures there which lead to the heart of the mountain, where the heat is always sufficient to drive it forth, sooner or later, in the form of vapor, but with sulphurous vapors also, such as sulphureted hydrogen, sulphurous acid, etc.

As we have seen, the wall of the new crater is 500 or 600 feet high, and usually the vapor is dissipated before it reaches the rim, and is hence invisible from the city.

At times, however, during nearly every year, it rises a thousand feet or more above the bottom and then is seen from a distance. Early in January, 1894, I visited the summit. The whole top of the mountain was covered with snow, and an immense volume of vapor was rising from the crater, in such quantity that, from the meteorological station, the eastern wall of the new crater was at times entirely concealed. At rare intervals rumblings have been heard, at which times our guides have hastened to throw themselves at the foot of the cross for protection.

All this shows that El Misti, though it may be slowly dying, is not yet dead.

From the lack of historical evidence, the last eruption of the volcano could not have occurred within four or five centuries, and from what study I have been able to give to the subject, it is my opinion that the time may be reckoned rather by thousands than by hundreds of years.

The present form of the volcano was undoubtedly caused by at least two great eruptions. So far as I know, this was first suggested by the late Señor Juan de Romana. Thousands of years ago El Misti slowly rose to more than its present height, not, probably, by one supreme effort, but through long ages. As a result the volcano then had one crater of about 3,000 feet diameter and of unknown depth.

It is indeed probable that the close of these activities was marked by one grand eruption, now traced by enormous lava cliffs and deposits of pumice and ash for vast distances.

The fact that these deposits are in many places covered with other geological formations, and that they have been cut through by ravines of great depth, in a country where rain is very scant, testify to the great antiquity of this eruption.

Wearied with these activities the volcano slept, per-

haps through many ages. Then came another period of activity, less grand and violent than before, and marked especially by the vast quantities of volcanic stone and sand, which must have made the whole region seem like night.

Again the monster slept; but will he wake again?

El Misti is not an extinct volcano. The vapor which always rises from its crater bears witness to great forces which still dwell within. It is true that the nature of the emanations from the volcano are such as are in many cases characteristic of volcanoes that are approaching total extinction, but there are exceptions, and the laws that govern them are not well understood. I believe it lies outside man's wisdom, at the present day, to predict with any marked success the future of volcanic or of earthquake activity. In spite of claims to the contrary, there is no knowledge which can predict with any certainty whether a violent earthquake will visit a given locality, e. g., Arequipa, within one or many years.

Vesuvius, in A.D. 79, after long ages of quiet, when the people had even forgotten that it was a volcano, gave an eruption which was one of the greatest in history. Later it was almost completely quiet for fifteen centuries, when it became active again. In the course of nature a thousand years are but as a day.

Will El Misti have a similar history?

I believe not, for the emanations from the crater indicate that it is slowly approaching extinction, but of this there is no certainty.

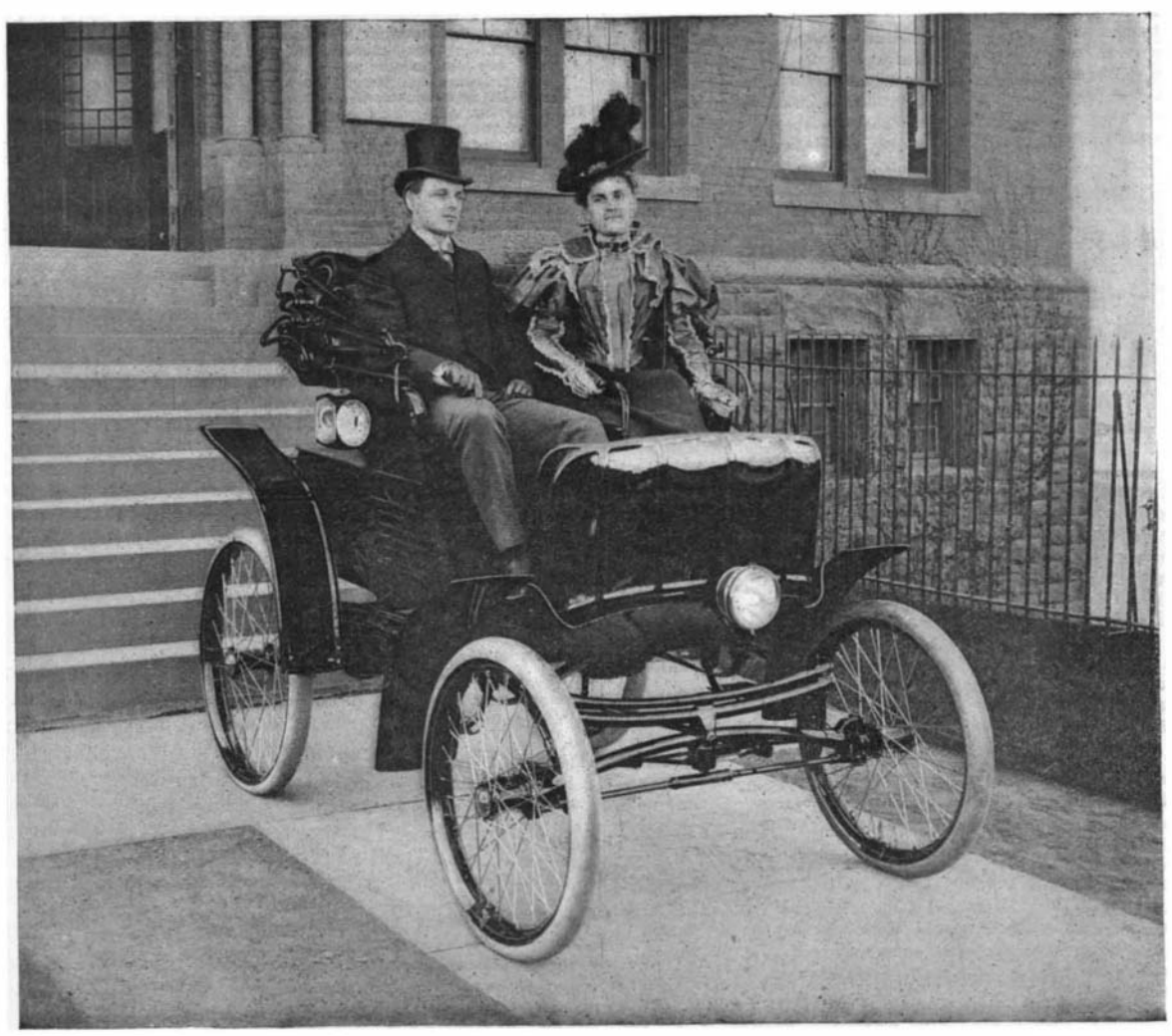
At least it may be pleasant to know that, in general, eruptions are less destructive than earthquakes, and that, unless extremely violent, an eruption of El Misti would be more interesting than dangerous.

THE COLUMBIA MOTOR CARRIAGE.

In January, 1895, the Pope Manufacturing Company, of Hartford, Conn., the well known manufacturers of the Columbia bicycle, decided to enter the horseless carriage field, and during the two years and a quarter which have elapsed since that date, elaborate investigations and experiments have been carried on without regard to expense to determine what is the best type of horseless carriage. The result of these experiments is a two-seated phaeton designed to be used for business or pleasure. The first public test of this interesting vehicle was held at Hartford on May 13 in the presence of a number of representatives of the scientific press of England and America. The particulars of the test which we give are furnished by the representative of the SCIENTIFIC AMERICAN who was present at the trial.

The frame is of the Pope Tube Company's 0·50 carbon steel, and the vehicle is equipped throughout with ball bearings, and possesses several of the features of bicycle construction which have made the Columbia wheel so famous. The wheels were fitted with heavy rubber pneumatic tires, which are practically unpuncturable, being used for 3,500 miles without being punctured. The general design of the carriage is shown in our engraving. The motor power is electricity, which is stored in four sets of batteries. There are forty-four cells in all. The current is used at a pressure of 110 volts. When once charged, the battery is sufficient to run the vehicle for thirty miles, and if the roads are good and free from mud, this distance may be increased. The motor is attached to the rear axle wheel of the carriage, where it is readily accessible. The motor is a little over two horse power. The rates of speed are four, the maximum being fifteen miles an hour and the others twelve, six and three miles an hour respectively. The entire weight of the carriage is 1,800 pounds, 850 of which is in the battery. The expense of charging the batteries is about fifty cents, so that it will be seen it only costs a trifle over a cent a mile to run it, which only goes to prove that the horseless carriage is an extremely economical vehicle.

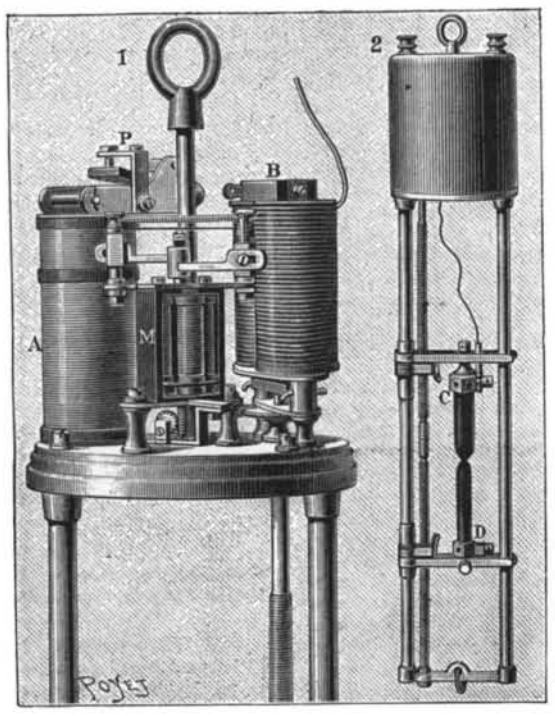
The exhibition of carriages on the day of the test was under the direction of Lieut. Harold H. Eames, manager of the motor carriage department, assisted by Mr. Hiram Percy Maxim, a mechanical engineer and other officials of the department. The speed test showed that the carriages were able to take sharp grades at ordinary speed, and that the carriage is stopped and started slowly or rapidly by turns on a sharp downward incline. The guests of the company were allowed to run the carriages themselves, and it was found that those who were totally unfamiliar with the horseless carriage were able to manage and turn them with as much ease and success as they would have guiding the gentlest horse, which only shows that no previous apprenticeship is necessary for one to be able to run an electric horseless carriage.



THE COLUMBIA MOTOR CARRIAGE, TESTED MAY 13.

AN ARC LAMP THAT OPERATES IN ANY POSITION.

There are very few regulators that permit an electric lamp to operate in all positions. Those that do exist



ELECTRIC LAMP FOR OPERATING IN ANY POSITION.

(there are, perhaps, two or three) are very high priced. All the rest, which are very satisfactory when the lamp is left horizontal, operate irregularly, or even do not operate at all, if they be inclined. This is explained by the fact that their mechanism is based upon the action of gravity to obtain the descent of the upper carbon. The use for which they are generally designed, that is to say, for public or private lighting, requires no other position. In lanterns for projections, however, it is often of advantage to be able to incline the apparatus slightly, although the limits of inclination prejudicial to the operation of the regulator are rarely exceeded. This may happen, nevertheless; but it is rather in theater projectors, that are designed to throw a luminous pencil upon a given point of the stage, that it is indispensable to be able to incline the apparatus strongly and even to exceed 45°. It then becomes necessary to use lamps in which the juxtaposing of the carbons is effected by hand, and a man is required near each projector. If the action of the carbons is to be prolonged, it would be preferable to have automatic lamps. Mr. Mougin has recently devised a type of regulator that seems to us capable of being utilized with advantage in such cases. The bringing together of the carbons is entirely independent of gravity, whatever be the position of the apparatus.

To this effect, the two carbons are mounted upon cross pieces, C and D, sliding upon two rods. A third rod, passing through the cross pieces, is threaded in such a manner that, upon being made to revolve in one direction, the two cross pieces, and, consequently, the carbons that they carry, approach each other. Now, this motion of the threaded rod takes place every time that the carbons become so worn that they need to be brought together. It is produced by a small electric motor, M, which transmits the rotary motion to the rod in question through the intermedium of a bevel wheel. The current traverses the motor and sets it in operation only at the moment desired, because it is mounted in derivation upon the circuit, and the interrupter, P, severs the communication as long as the arc has its normal length. But if the arc happens to elongate, the resistance increases and a part of the current passes through the fine wire bobbin, A, which then attracts the armature of the interrupter, P, and closes the circuit of the motor.

The coarse wire bobbin, B, is mounted in the circuit, and, as soon as the current passes, attracts the armature, which is connected with the cross piece that carries the upper carbon, and thus effects the separation of the carbons for the beginning of the operation. Such initial separation is regulatable by hand, and, once effected, is maintained through the mechanism of which we have above spoken.

These lamps are now constructed, in the form shown in our engraving, for use in general lighting. By slightly modifying their form in such a way that the regulating mechanism shall be inclosed in a base capable of being placed upon a table, the manufacturer may adapt them for use in lanterns and projectors.—La Nature.

Mysteries of the Persian Gulf.

Sir Henry Mance recently, in his inaugural address as president of the Institution of Electrical Engineers, speaking of the development of oceanic telegraphy, said in the Persian Gulf one occasionally witnessed natural phenomena which to the untraveled might appear incredible. In the midst of the mountains near Mussendom he had seen during a thunderstorm such displays of lightning as baffled description. He had, at certain seasons of the year, observed the water in the bay—which was large enough to hold all the fleets of the world—present exactly the appearance of blood. Not many miles from Mussendom he had witnessed mysterious fire circles flitting over the surface of the sea at a speed of 100 miles an hour—a phenomenon which no one had yet been able to explain. While steaming along the coast of Belochistan, he had been called from his cabin at night to observe the more common phenomenon of a milky sea, the water for miles around being singularly white and luminous. In the same locality the sea was, for short periods, as if putrid, the fish being destroyed in myriads, so that to prevent a pestilence measures had to be taken to bury those cast up on the beach. This phenomenon was doubtless due to the outbreak of a submarine volcano and the liberation of sulphureted hydrogen. In these waters jellyfish were as large as footballs, and sea snakes of brilliant hue were met with in great numbers. On one occasion a swarm of sea snakes forced their way up one of the creeks in Karachi Harbor, apparently for the purpose of having a battle royal, for the ground between high and low water mark was thickly covered with their bodies in positions betokening a deadly struggle.