in hot sand under pressure upon plates of chalk or plaster for several days. The chalk supporting plates must be renewed daily. The resulting material can be readily carved. If greater durability, whiteness, and elasticity be desired, the potatoes are macerated in water containing 3 per cent of soda instead of the acid above mentioned. To produce the horn imitation, the potatoes, after being treated as last stated, are boiled in water containing 19 per cent of soda. By substituting carrots for potatoes, a good imitation coral is produced.

A REMARKABLE ERUPTION.

A curious land slide recently occurred on the line of the Hudson River Railroad near Dutchess Junction, N. Y. At about 200 feet above the Hudson river, there is a level plateau which rises slightly to the foot of a large eminence called the Sugar Loaf, and apparently is a rocky spur of that hill. Suddenly a portion of the plateau was lifted from its place and hurled, with its load of trees and shrubs, into the cove beneath, dashing up the water like a tidal wave over the railroad track and destroying the fences beside the same. A crater about 200 by 150 feet in size was left. Four hours afterward, another slide took place, accompanied by an explosion, and during the succeeding night still another upheaval occurred, which was followed by a torrent of water gushing from the crater. So great was the force of the explosions that trees nearly a foot in thickness were hurled from their places to great distances like straws; and one massive timber was driven into the solid bed of the railroad to a depth of 8 feet. The phenomenon was due to a vast accumulation of water which had formed in the sandy land. This had been fed by the watershed of the Sugar Loaf and by the recent rains, until the huge underground lake found vent with the tremendous force described. The most recent reports at the time of writing (three days after the event) state that the water is still escaping, and the land still crumbling away, a condition of affairs which will probably continue until the water has spent its force.

Correspondence.

The Cause of the Glacial Epochs.

To the Editor of the Scientific American:

It may be said of the earth that she has five distinct motions, which are these: First, a rotary motion, on an axis, say, in herself. Second, an orbital motion, on an axis, say, in the sun. Third, a retrogyratory motion, on an axis centered in the center of the sun's orbit. Fourth, a retrogressive motion round the center of the sun's orbit, and always at the same rate as Sol's motion. Fifth and last, a motion at right angles to the plane of her equator. It is by this motion that the earth's obliquity to the plane of the ecliptic is gradually becoming less and less.

It was held by La Place and several other astronomers that the obliquity of the earth to the plane of the ecliptic would ever be permanent, and that the earth would, as it were, "rock to and fro, never departing more than two or two and a half degrees from her present inclined position." We claim that there is not a power, neither in the earth nor the sun, that will sustain that idea. The earth must (and we claim that the forces in her and in the sun compel her to) revolve round an axis running through her equator, as it were from one side of it to the other: and thus comes first, say the equator, next her pole or poles, if you will; next her equator again, next her pole or poles; and so on for ever, to the sun.

It is by this motion of the earth that she has had all her glacial epochs; and the motion is not at all peculiar to the earth. No doubt all the planets have seen their glacial times, for they all revolve in the manner alluded to. See Uranus at the present hour; he is passing now through such an epoch. Fearfully grand it must be, compared to those of the earth; but it is nothing to what it would be were the plane of his equator in the plane of the ecliptic or of solar motion. No, that is the period when the vastly broad and thick sheets of ice gather over and all around his poles for many thousands of miles. Look at Jupiter, and think of the vast ice sheets which must now and for many centuries to come cover his poles and nearly one half of each hemisphere. How exceedingly thick and vastly broad must Jupiter's glacial ice fields be at this present moment.

Turning to the earth, we find, by quoting from certain of our authors, that at the beginning of this century the obliquity was 23° 27' 54·78", and that it shall be, by the end of this century, 23° 27' 9·08". That gives, for the nineteenth century, 45·70." Now supposing the motion to be regular and uniform, the earth will complete her revolution, and, say, her glacial epoch revolution, in a period of about 2,832,700 years. Therefore, we have four glacial epochs in less time than three millions of years. Five hundred and twenty-three thousand three hundred years ago, the poles of the earth lay in the plane of the ecliptic. Then each pole, during its winter, would be subjected to intense cold and darkness for more than three months, and in summer to thirty days (720 hours) of almost perpendicular sunshine. During such epochs as that, tropical vegetation would grow right at the poles, and animals, accordingly, would feed and dwell there. Broad and thick sheets of ice would accumulate annually, and cover nearly a whole hemisphere at a time, although but thin around their edges. And the speedy thawing of them would cause great floodings and carryings of *débris* from certain localities to other parts. But now to the coming epoch.

In about 184,800 years from now, the equator of the earth will again lie in the plane of the ecliptic. That will be the middle of one of the greatest glacial epochs which come to our earth. It comes on and goes off gradually, of course, and therefore it will begin some fifty or sixty thousand years before that, and be gone in another fifty or sixty thousand years.

Then will be the time when the vast circular fields of ice grow in thickness to perhaps several miles, especially at and near the poles. Think of ice accumulating for perhaps 100,000 years, and conceive of its thickness. Think of the attractive force of the sun drawing such huge fields outwardly toward the equator, and causing them to move with an eastward tendency all the time; and see how it becomes possible for the ice mass to tear the crest off one mountain and set it down on the top of another lying in its path. It was, doubtless, during the latest one of the kind (that is, something near 1,231,000 years ago) that the crest of a certain mountain was placed on the top of another. I forget their names just now, but the fact is well known to geologists.

These are the periods which, as it were, turn animal and vegetable creation upside down. The gradual change of inclination of the earth to the sun causes all her climatic changes; and thus creatures and vegetation, foreign to certain localities now, will be found in others than they are now in, in the far future, as has been the case many times in the past; for the earth has seen several glacial cycles, and her animal and vegetable genera may truly be called wandering, restless, and ever shifting things, for neither, individually, has any permanent abiding place on the earth. No, not any one thing!

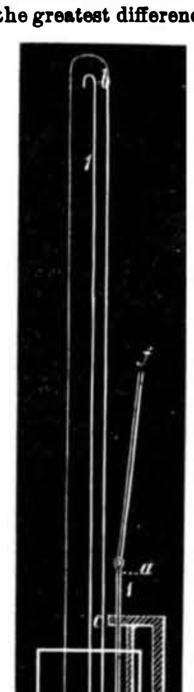
I humbly recommend the above theory to geologists and other scientists, men whose practical knowledge and superior talent can show the facts up to better advantage than I can do. JOHN HEPBURN.

Gloucester City, N. J.

New Registering Barometer.

To the Editor of the Scientific American:

I send you a sketch of a registering barometer, which differs from the ordinary barometer in having a longer tube. The cistern is below the end of the tube a distance equal to the greatest difference of the barometer, with sufficient clearance for the mechanical part immersed in the mercury. From the open end of the tube projects upward a small insulated wire, preferably of tempered steel, terminating in a platinum point. This point is amalgamated, and is hook-shaped, the end being bent down so that it is the lowest uninsulated part. This wire is represented at 1 in the engraving; the wire and all of its connections are insulated from *a* to *b*. At 2 is a standard, to guide the working parts. The bearings, *c*, *d*, and *e*, are in holes drilled in the standard; and the sliding parts should be covered by small iron tubes, slipped on over the insulating substance and fastened with shellac or its equivalent. The standard should be made of iron. For working the instrument, I use an ordinary striking clock, and I deepen all the teeth of the count wheel so that the count hook will drop and stop after one stroke. Above this, there is in the train a wheel which makes one revolution to each stroke; and on the end of the arbor of of this wheel is a crank, which will stand with the crank pin up, when at rest. This crank should have throw sufficient to cover all of the variation, from high to low, and a little over. The fly should be of large size, to give a very slow motion to the crank, to prevent producing waves and fluctuations in the mercury; and for the same reason the tube should be large enough, and the insulation should be as smooth as possible. In connection with the crank motion there should be a pair of feed rolls, carrying a paper ribbon for the record. There should be a ratchet motion to bring the paper to a new place for each record. I use chemical telegraph paper for the record, as it requires a smaller battery, not liable to produce sparks to turn the connections, one or two small cells of the gravity battery being sufficient. The connection to the crank is made with the rod at *f*; the top of the wire, 1, is adjusted so that, when at rest, the end of the wire inside of the tube, at *b*, will always be above the highest point that the mercury reaches. Connection with the battery is made by putting one pole in communication with the mercury in the cup, and the other with a plate which the paper passes over, and lies upon. The record can be taken hourly, half-hourly, or at as short periods as 5 minutes. If it be desired to take it once an hour, the hand arrives at the hour and, instead of striking, the wire inside of the tube begins to descend; when the platinum tip touches the mercury, electric communication is made through the mercury in the cistern to the top of the tube, thence through the steel wire down the tube and outside to the clock movement. This crank movement carries an iron wire, which moves down, pin-like, over the paper; at the instant that the platinum tip touches the mercury, the current passes through the paper and produces a blue mark to the bottom of the stroke; when, or just before, it begins to rise, the iron pen lifts from the paper, to prevent tracing both ways or tearing the paper, also to secure greater accuracy: as the mercury, wetting the platinum point, will lift above the actual level by capillary attraction, and will keep the connection too long, and so will spoil the accuracy of the record.



I put in connection with the iron pen a thermostat, which raises or lowers the pen, making allowance for the expansion of the mercury by heat, so that a thermometrical record could be kept at the same time and on the same paper. On the paper I place points of copper in connection with the battery, and these make lines at right angles with those of the barometer record, which will be perpendicular. These copper points are placed to indicate inches or their fractions. They are adjustable to the exact point, and then are set by screws. They are all in electric communication, but the conductor to them has a greater resistance than the iron pen, to prevent their taking too much force from it. The paper going between the copper points is lined lengthwise in red, and these lines are crossed by blue lines, of greater or less length, according to the state of the barometer, all ending alike at the bottom, each line representing the period of time which the clock registers. I can dispense with all but one of the copper points; and if this represents the 30 inch point, I can measure from this. It is, however, but little trouble to graduate to very small divisions, if necessary. The copper points I make by soldering thin pieces of copper, with the edges toward the paper, to pieces of steel wire. I place two of them very close together for the whole inches, the fine white line between being the inch line.

The advantages I claim for this barometer are cheapness in making and running. There is no work for the mercury to do whatever, as the mechanical part is all done by the clock; and it will do the most accurate work possible, if it is made nicely. I should be pleased to hear, from any one who tries this plan, as to its success. WM. A. BARNES

Bridgeport, Conn.

THE MOON.

LECTURE DELIVERED AT THE STEVENS INSTITUTE OF TECHNOLOGY BY PROFESSOR C. A. YOUNG, OF DARTMOUTH COLLEGE.

If this were a literary instead of a scientific lecture, it could not be more appropriately introduced than by quoting some of the beautiful lines which the poets of all ages have lavished upon the moon, the empress of the night. The moon was perhaps the first of the heavenly bodies that was regularly observed. The ancient observations of eclipses form the basis of many determinations in the chronology of the earth's history. To the mariner at sea, its regular passage across the heavens has always been a means of knowing the time. The modern astronomer is able, without leaving the observatory, to determine the earth's size more accurately by studying the moon than he could by traveling all over the surface. To a person observing the path of the moon from any point of the earth's surface, it will appear less than a semicircle by an amount proportional to the radius of the earth at that point. If the moon could be observed from the center of the earth, we assume, for the sake of simplicity of illustration, that its path would appear a complete semicircle. Hence we have the means of determining the radius of the earth. Even the density of the earth could be determined by a careful observation of the moon's influence upon the tides.

The most convenient way of determining the distance of the moon from the earth is from two distant stations, whose positions on the earth's surface have been accurately ascertained. One of these stations is usually at the Cape of Good Hope, and the other either at Greenwich, Paris, or Berlin, etc. The distance between the two stations, measured on the same meridian, forms the base line, and the observed direction of the moon, when it crosses the meridian, will give us the angles at the base, from which the distance can be calculated. This distance is, in round numbers, 238,000 miles, or about ten times the circumference of the earth. A good pedestrian could travel that distance in 23 or 24 years. The determinations of the moon's distance are so accurate that the probable error does not exceed 15 or 20 miles. This distance is not, however, constant, because the moon's path is not a circle but an oval, the eccentricity of which amounts to about $\frac{1}{18}$.

The size of the moon's diameter is determined by measuring its apparent diameter in the telescope, the difficulty of the operation consisting in the fact that the brightness of the disk causes it to present a circumference which is not defined with perfect sharpness. Having measured the apparent diameter of the moon, and knowing the value of the earth's diameter, as seen from the moon, a simple proportion will give us the moon's real diameter, 2159·6 miles, or about the $\frac{1}{110}$ part of the distance between the earth and the moon, that is to say, 120 moons placed in a line would fill up the distance. The determinations of the value of the moon's diameter are correct to within two or three miles. Then, as the volumes of spheres are to each other as the cubes of their diameters, the volume of the moon is $7930^3 \div 2160^3$, or about $\frac{1}{49}$ that of the earth, that is, 49 moons rolled up together would make a ball as large as the earth. The determination of the density, and consequently of the weight, of the moon is more difficult than that of the most remote of the planets. One method of accomplishing it consists in studying the effect on the tides when the attractions of the sun and moon conspire to raise them, and when they act in opposite directions. In this way a relation is established between the masses of the sun and moon. If the sun and moon were at equal distances from the earth, their attractions would be in direct proportion to their masses, but the sun is about 400 times further off; hence the law that the attraction is inversely as the square of the distance must be also applied. This method, however, is not very accurate. A better one depends on the fact that the earth and the moon revolve about their common center of gravity, and that the position of that center must necessarily depend on the relative masses of the two bodies. The earth describes a much smaller orbit about that center than the moon, and would be displaced from the position which it would have if it traveled alone around the sun. This displacement will appear in the observed position of the sun, and can be calculated. It has been found to be 6½ seconds of arc; and from this it results that the earth's mass is 81½ times that of the moon. Hence the moon's density is $\frac{3}{5}$ that of the earth.

The force of gravity on the moon is only $\frac{1}{6}$ of that on the earth, that is, a man able to jump up 3 feet on the earth would be able to jump up 18 feet on the moon's surface.

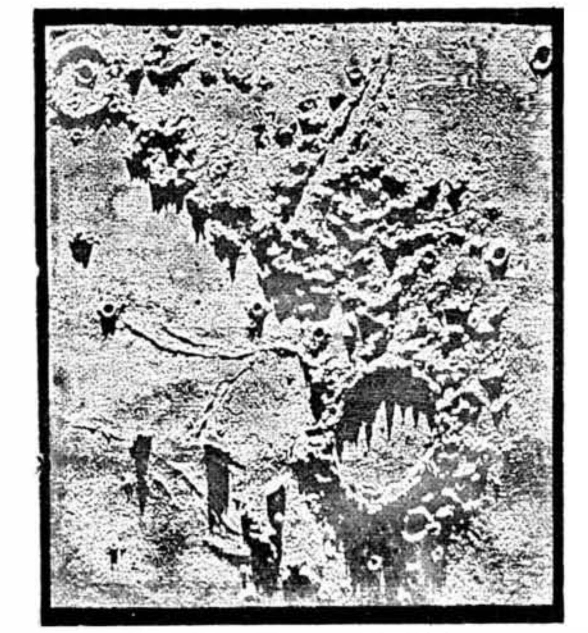


Fig. 1.—THE CRATER OF PLATO.

The moon's path around the earth would always be an oval of exactly the same dimensions if the earth alone acted upon it; but owing to the attraction of the sun, the moon is sometimes in advance and sometimes behind the place she

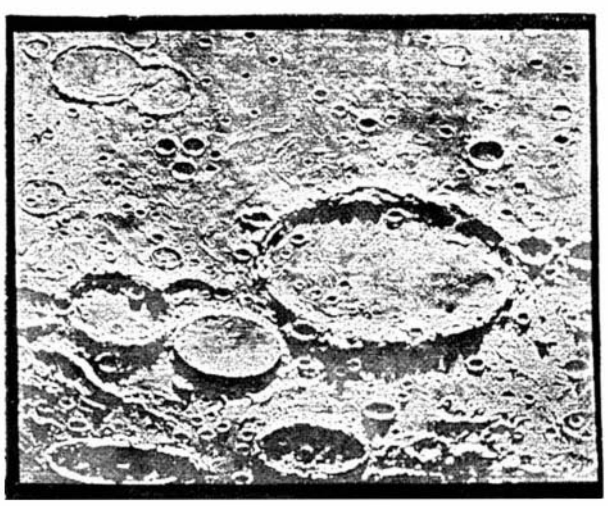
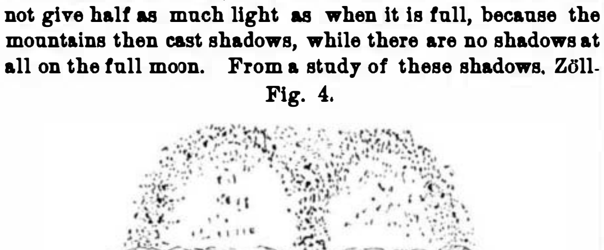


Fig. 2.—THE CRATER WARGENTIN.

ought to occupy according to the laws governing motion in an elliptical orbit. These attractions are called perturbations and necessitate as many as 60 to 75 different corrections in calculating the position which the moon is to occupy at any required moment. Up to about 1870, the calculated position of the moon was only about two miles out of the way; but since that time, some error has crept into the nautical almanac, and the difference is now 5 to 7 miles. Professor Airy thinks some perturbation must have been overlooked. If a mariner had a watch that kept perfectly Greenwich time, he could always ascertain his position by consulting the nautical almanac. The moon is indeed a perfect timekeeper in its passage across the heavens; but its motion is so slow that it would take very accurate observations to obtain the time from its position.

According to Zöllner, the light of the moon is only $\frac{1}{618000}$ of that of the sun. If the sky were packed full of moons, it would not give us quite as much light as the sun. It has been found that, when the moon is half full, it does not give half as much light as when it is full, because the mountains then cast shadows, while there are no shadows at all on the full moon. From a study of these shadows, Zöllner has found that the average slope of the hills and mountains on the moon must be about 52°, without reference to their hight.

Fig. 4.



Zöllner has ascertained, by experiment and calculation, that the moon reflects only about $\frac{1}{6}$ of the light it receives, in other words that its reflective capacity is the same as that of sandstone rock. Snow reflects 78 per cent, granite 10 per cent, and marble 50 per cent. Sir John Herschel had come to the same conclusion. "I have frequently," he stated, "compared the moon setting behind the gray perpendicular façade of the Table Mountains illuminated by the sun just risen in the opposite quarter of the horizon, when it has been scarcely distinguishable in brightness from the rock in contact with it."

Until quite recently, it was supposed that no heat could be detected in the rays of the moon. They were collected in the focus of a large mirror, and directed upon a very delicate thermopile connected with a galvanometer. The lecturer had this apparatus upon the table, and showed the effect of the heat of a candle placed at a distance. It was discovered by Melloni that the feeble heat coming from the moon was rendered insensible by the earth's atmosphere, and Professor Smyth, on repeating the experiment on the summit of Teneriffe, about 10,000 feet above the level of the sea, discovered that the heat of the full moon was equal to $\frac{1}{3}$ that of a candle placed at a distance of 15 feet from the apparatus. The moon is hottest between the last quarter and the new moon, because it has then been exposed continually to the sun for 14 days. Its temperature must then be from 400° to 500°;

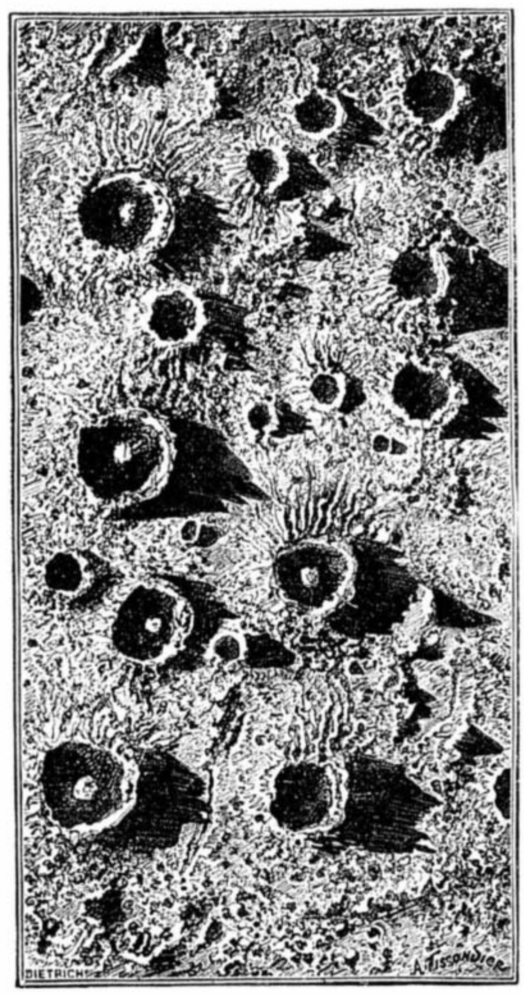
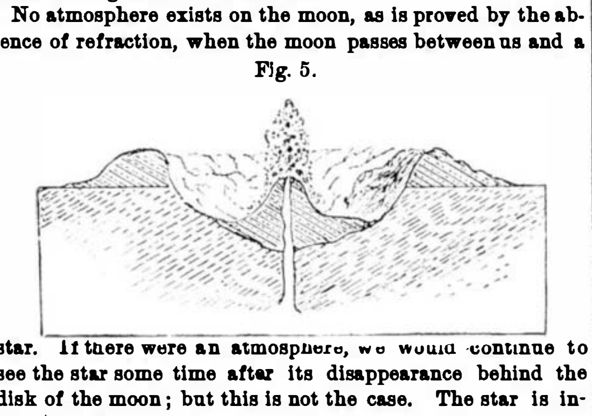


Fig. 3.—SURFACE OF THE MOON.

again, during the long night, 14 days long, it must cool down to something like 100° to 200° below zero.

No atmosphere exists on the moon, as is proved by the absence of refraction, when the moon passes between us and a

Fig. 5.



star. If there were an atmosphere, we would continue to see the star some time after its disappearance behind the disk of the moon; but this is not the case. The star is instantly extinguished. The observations on this point are so accurate that a refraction of 4 seconds of arc could be easily detected. If therefore, there be an atmosphere at all, it must be more rare than that under the receiver of an air pump after we have exhausted all the air we can.

The moon always turns the same face towards the earth, and we only obtain glimpses of the edges of the opposite hemisphere, on account of the irregularities of its motions called librations. Hence we conclude that it turns once around its axis while it performs one revolution about the earth; otherwise we should see the whole of its surface.

If the moon ever had an atmosphere, as is very likely, it may have been absorbed, or it may have entered into combination with the rocks on its surface; but this is mere conjecture. As there is no atmosphere, there is also no moisture, and hence the moon cannot be the abode of beings constituted as we are.

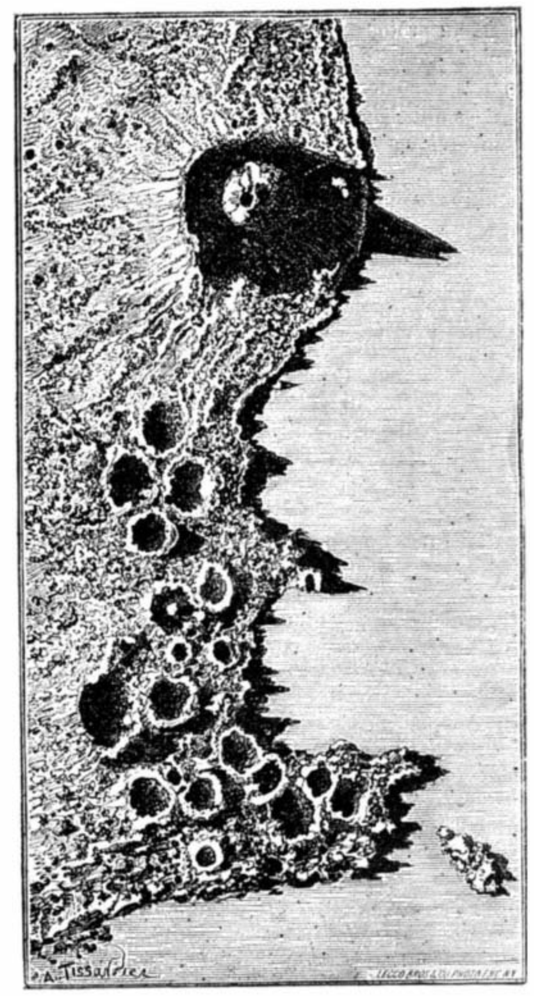
It has been stated that the powerful telescopes of modern times bring the moon down to within 40 miles of us; but that is not sufficient for distinguishing any of the works of inhabitants, if there be any. A city would appear as a mere dot.

The surface of the moon has been carefully studied with the telescope and by means of photography. The first successes by the latter method were obtained by Dr. J. W. Draper, of New York, in 1840, and Rutherfurd's excellent results are well known. The lecturer then threw upon the screen a large number of photographic representations of the moon's surface, showing the principal mountains, craters, valleys, and other points of interest. Some of these mountains have a hight of 18,000 feet.

Fig. 1 represents the crater of Plato, the bottom of which has been observed to grow darker as the sun rises higher above it, which is by some supposed to be due to its being covered with some sort of vegetation. Notice also the ravine below, looking like a deep railroad cut. Fig. 2 is a view of the crater Wargentin, which presents the peculiarity of being entirely filled up, while the other lunar craters resemble that of Kilauea on one of the Sandwich Islands, a great basin about 1,000 feet deep, out of which numerous cones rise.

Fig. 3 is a representation of a comparison of craters on the moon with the appearance of the volcano Vesuvius and the country in the vicinity of Naples. Both were studied topographically and modeled in plaster of Paris, with the most scrupulous care, by Nasmyth, and the accompanying engraving was made from a photograph of his models.

The only difference between the lunar craters and that of



VESUVIUS AND ADJACENT COUNTRY, ITALY.

Kilauea is that the former are of enormous dimensions. Copernicus, for example, is 56 miles in diameter; its central mountain is 2,400 feet high, and the terraces around it rise to a hight of 12,000 or 13,000 feet above the bottom, and are composed of ridges, cliffs, and deep ravines.

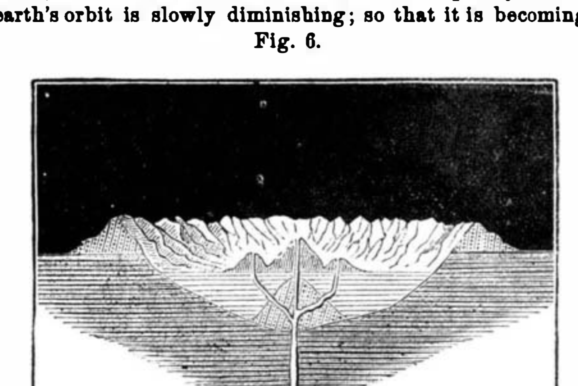
Figs. 4, 5, and 6 illustrate Nasmyth's theory of the formation of these craters. The first eruption, being probably the most violent, projected the stones, lava, etc., to a considerable hight, and these, in falling, would accumulate in ridges encircling the crater at some distance. The hight to which they would rise would be much greater than on the earth, because the force of gravity is much less.

During the second eruption, which would probably be less violent, the projected matter would not rise so high, and in falling back it would cause the formation of the central cone.

During the subsequent eruption, when the force of the volcano was almost entirely spent, the lava would simply overflow and tend to fill up the basin to a greater or less extent.

There is a gradual change going on in the orbit of the moon, which deserves to be noticed. The ellipticity of the earth's orbit is slowly diminishing; so that it is becoming

Fig. 6.



more and more nearly circular, and its area is becoming greater every year. As a consequence the earth tends to draw the moon nearer and nearer to itself, and causes it to describe a constantly diminishing orbit. The end of this might be to pull the moon down upon the earth. The change is, however, so exceedingly small that we need not entertain any apprehensions for our posterity for many years. C. F. K.