HOW A PLANET IS WEIGHED.

BY FREDERICK H. HONEY, TRINITY COLLEGE.

In the measurements of astronomical distances, the unit of computation is the mean radius of the earth's orbit, i. e., ninety-two million nine hundred thousand miles. This unit multiplied a little over thirty times gives the radius of the orbit of the outermost planet, Neptune, nearly two thousand seven hundred and ninety-two millions of miles.

But the imagination is unable to grasp the meaning of these figures; and we are compelled to be content with the statement of the fact, without attempting to fathom its significance. When, however, we come to the consideration of volumes and weights, i. e., those of which we can speak with any degree of definiteness, the quantities appear to be, if not comprehensible, at least capable of being stated in terms of which we know something.

Simple illustrations are here given to make it possible for the average reader to understand the computations in the determination of a planet's volume and weight. These computations are dependent upon a knowledge of its apparent diameter; its distance from the earth; the radius of the orbit of one of its satellites; and the period of the latter, or the time of one revolution round the planet. Therefore the degree of accuracy is primarily dependent upon the ability of the observer to determine these elements.

We will take for our illustration the giant of our system, Jupiter, whose weight is about two and a half times the sum of the weights of all the other planets and their satellites. We will compare the volume and weight of Jupiter with those of the earth.

Jupiter's Volume.—In order to determine the dimensions of a planet, its distance from the earth and apparent diameter must be known. Jupiter's mean distance from the sun is 5.2 times the mean distance between the earth and the sun, i. e., over four hundred and eighty-three millions of miles. At opposition the mean distance between the earth and Jupiter is the difference between this distance and the mean radius of the earth's orbit, or about three hundred and ninety millions of miles. But on account of the eccentricity of the planet's orbit, this distance varies between very wide limits. When it is known, and the apparent diameter of Jupiter measured, his real dimensions may be computed. The equatorial and polar diameters of Jupiter are respectively 88,200 miles and 83,000 miles. The difference between these dimensions is apparent even in the accompanying small drawing (Fig. 1) which is an ellipse, the minor axis *a b* representing the axis of rotation of the planet, and *c d* its equator. Jupiter's volume is equal to that of a sphere whose diameter is 10.916 times the diameter of the earth.

Since the volumes of spheres are in proportion to the cubes of their diameters, Jupiter's volume is $10.916^3 = 1300.8$, i. e., thirteen hundred times the volume of the earth.

Jupiter's Weight.—Fig. 1 represents Jupiter and one of his satellites, Callisto, which revolves at a distance of one million one hundred and sixty-seven thousand miles from the planet; and completes her revolution in sixteen days and sixteen and a half hours. On the same scale the earth and moon are represented; the latter revolves round the earth in twenty-seven days and seven and three-quarter hours, at a mean distance of 238,840 miles. It should be noted that in the drawing, Jupiter, Callisto, the earth, and the moon are correctly proportioned, also the orbit radii of the satellites; but the latter are in each case made one-third of the length which would correspond with the dimensions of the planets and satellites, in order to bring the illustration within the limits of the paper.

Assuming that the satellite situated at *M* (Fig. 2) moves for a short distance in a circular orbit *MM'* round the planet at *E*, were it not for the force of gravity, it would travel in the direction of the tangent, and after a certain interval of time reach the position *M''*; and the distance which the satellite "falls" toward the planet under the influence of gravity is equal to the difference between the length of the hypotenuse of the right triangle *EM''* and the radius *EM'*.

In order to institute a comparison between the orbits of the moon and Callisto, they are represented as having a common center at *E*; and for the purposes of this illustration, are for a short distance assumed to be circular. The length of the radius of Callisto's orbit is nearly 4.89 times that of the moon. Since Callisto travels in her orbit eight times as fast as the moon, the tangent *CC''* is made eight times the length of the tangent *MM''*. The proportion between the distances *C''C'* and *M''M'* represents the attractive force of Jupiter upon Callisto as compared with that of the earth upon the moon.

By means of the very simple computation indicated above, we discover that *C''C'* is about 13.1 times the length of *M''M'*, i. e., the attraction of gravity is more than thirteen times greater in one case than the other. But Callisto's distance from Jupiter is equal to nearly 4.89 times the distance between the moon and the earth. Remembering that the force of gravity diminishes as the square of the distance, the attraction represented by 13.1 must be multiplied by 4.89^2 in order to ascertain the attractive force of Jupiter as compared with that of the earth reduced to the same distance from the planet.

Multiplying these numbers, $13.1 \times 4.89^2 = 313.1$, i. e., Jupiter's attractive force, and therefore his mass or weight, is three hundred and thirteen times that of the earth.

If we divide this number by that representing the volume $\frac{313}{1300} = 0.24$, we obtain the density. A given volume of Jupiter therefore weighs a little less than a quarter that of an equal volume of the earth.

In the illustration (Fig. 2) the measurements *CC''* and *MM''* are very much exaggerated in order that the "fall" of the satellite toward the planet may be apparent to the eye.

The measurement contemplated is one which in the drawing would apparently coincide with the orbit.

The work more accurately in detail is as follows: Dividing the mean radius of Callisto's orbit by that of the moon, $\frac{1,167,000}{238,840} = 4.88 +$. The periods of the satellites reduced to minutes are respectively 24,032

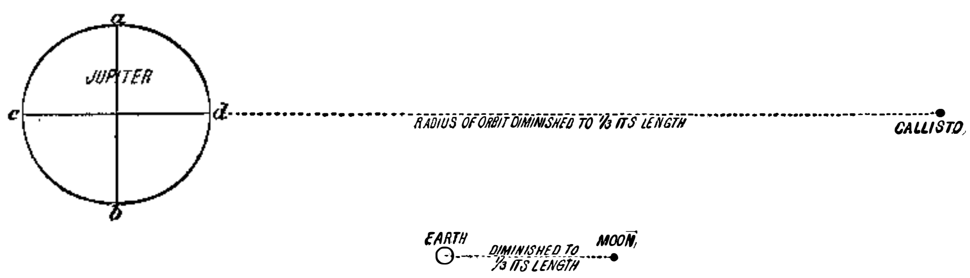

Fig. 1.

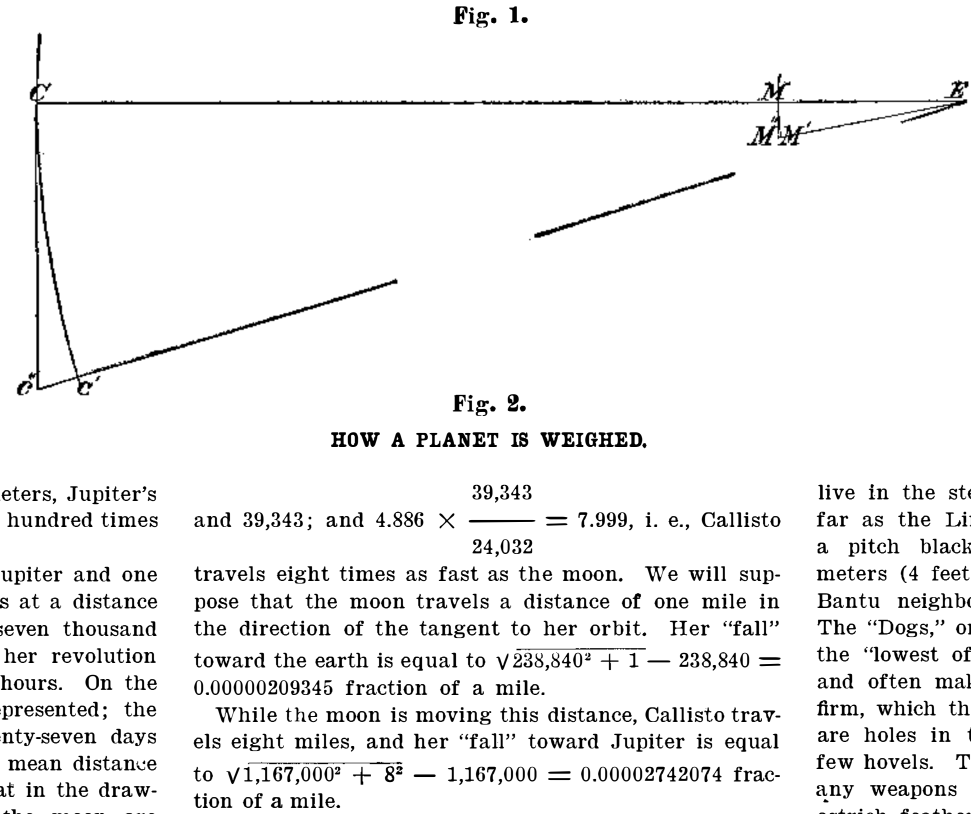

Fig. 2.

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and 39,343; and $4.886 \times \frac{39,343}{24,032} = 7.999$, i. e., Callisto travels eight times as fast as the moon. We will suppose that the moon travels a distance of one mile in the direction of the tangent to her orbit. Her "fall" toward the earth is equal to $\sqrt{238,840^2 + 1} - 238,840 =$ 0.00000209345 fraction of a mile.

While the moon is moving this distance, Callisto travels eight miles, and her "fall" toward Jupiter is equal to $\sqrt{1,167,000^2 + 8^2} - 1,167,000 = 0.00002742074$ fraction of a mile.

Dividing Callisto's "fall" by the moon's $\frac{0.00002742074}{0.00000209345} = 13.098$; and $13.098 \times 4.886 = 312.7$.

By this simple and direct process of how a planet may be weighed, we approximate within one and two per cent the latest computation of the weight of Jupiter.

A German engineer, Mr. Balderauer, of Salzburg, has proposed a method of using balloons for railway purposes, which is now being tested. A stationary balloon is fixed to a slide running along a single steel rail. This rail is carried up the side of a steep mountain, which ordinary railroads could not ascend, except by means of heavy inclines, with vast earthworks and tunnels. The balloon is moored by a steel cable to the rail, at a height of about 35 feet above the ground. The conductor can cause the balloon to ascend or descend at will. The lifting power is furnished by hydrogen gas, and the descent is caused by water pressure poured into a large tank at the upper end of the road. This is not so new as may be supposed. A similar method was described in these columns years ago.

Some Facts About Moths.

Some interesting information concerning the habits of the species of moth which creates such widespread havoc among domestic apparel has been furnished by a Scottish naturalist as the result of his prolonged investigations. There are at least three common species of this destructive pest bearing the general name of "clothes moth," and all these differ somewhat in detail. The perfect insect, *Tinea Pellionella*, is about half an inch across the wings, the front pair of which are of a grayish yellow with three rather indistinct brownish spots on each, while the hind pair are whitish gray. The caterpillar, which is the real mischief maker, is of a dull whitish tint with a reddish brown head. This very destructive species is partial to furs, and the most valuable of such articles are liable to be sacrificed unless provision be made to resist its ravages. This species is the only one of the three which constructs a movable case or house. When moving, it carries its home quite comfortably along, as a snail does its shell, but if threatened with danger it shrinks together and disappears within.

But the most interesting feature in connection with this fur-devouring insect is the way in which, as it grows, it enlarges its home. As the little caterpillar grows rapidly both in length and girth, it enlarges its home correspondingly, and marvelous is the manner in which the case is adapted to the requirements of the growing tenant. First of all, by means of its sharp jaws, the caterpillar slits the case open longitudinally from one end for just half its length, and then proceeds to weave a strip of new material between the cut edges. When this is done the creature reverses its position, slits up the remaining half from the other end in the same manner, and inserts a little strip of freshly-woven material. By this means the diameter of the whole tube is increased, but hardly symmetrically. To preserve the original shape of the case, the insect repeats these operations on the opposite side. The lengthening of the tube is a simpler process, and merely consists of adding successive rings of material as required. But even in this case it is done at both ends alternately, and thus the original symmetry of the tube, which was slightly wider in the middle, is preserved. When the caterpillar has finished feeding, and incidentally done its maximum amount of damage, it prepares itself for the assumption of the quiet, harmless chrysalis state.

The Kattea: Are They Possible Aborigines of Africa?

An obscure race may possibly be the true aborigines of Africa south of the Zambesi. These are the Kattea—or Vaalpens, as they are nicknamed by the Boers, on account of the dusty color their abdomen acquires from the habit of creeping into their holes in the ground—who live in the steppe region of the North Transvaal, as far as the Limpopo. As their complexion is almost a pitch black, and their stature only about 1.220 meters (4 feet), they are quite distinct from their tall Bantu neighbors and from the yellowish Bushmen. The "Dogs," or "Vultures," as the Zulus call them, are the "lowest of the low," being undoubtedly cannibals and often making a meal of their own aged and infirm, which the Bushmen never do. Their habitations are holes in the ground, rock shelters, and lately a few hovels. They have no arts or industries, nor even any weapons except those obtained in exchange for ostrich feathers, skins, or ivory. Whether they have any religious ideas it is impossible to say, all intercourse being restricted to barter carried on in a gesture language, for nobody has ever yet mastered their tongue, all that is known of their language being that it is absolutely distinct from that of both the Bushman and the Bantu. There are no tribes, merely little family groups of from 30 to 50 individuals, each of which is presided over by a headman, whose functions are acquired, not by heredity, but by personal qualities. So little information is available concerning the Kattea that it is impossible to say anything about their racial affinities.

A series single-phase electric railway system between Atlanta and Marietta, Ga.—the first alternating-current line in the Southern States—was recently put into service. The line, which is of standard gage, is about 15 miles long, and is supplied with power from the hydraulic station of the Atlanta Water and Electric Power Company, 18 miles from Atlanta, transmission along the feeders being at 22,000 volts, with three-phase current. Each of the two sections of the line is served by two transformer sub-stations, these stations being a little more than three miles apart.