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EXPERIMENTS ON WHIRLWINDS, WATERSPOUTS, AND REVOLVING SPHERES.

AT a recent session of the French Academy of Sciences, Mr. Mascart described some interesting experiments which Mr. Charles Weyher has lately performed on the artificial reproduction of whirlwinds and waterspouts, and which are as follows :

1. *Waterspouts.*—A drum three feet in diameter is mounted upon a vertical axle, which is set in revolution through a pulley and belt (Fig. 1). This drum is provided internally with six or eight radiating pieces. It is open beneath, and its rotary velocity at the circumference is from 90 to 120 feet per second. This apparatus is placed about ten feet above the surface of some water contained in a large reservoir. As soon as the drum is revolved, spirals are observed to form on the surface of the water and to converge toward the same center, where a large cone, 8 in. in diameter and 4 in. in height, then makes its appearance. This first cone is surmounted with a second and reversed one, formed of numerous drops, that rise to a height of, say, from 3 to 5 ft., and fall all around at distances varying from 3 to 10 ft. The finest drops of water rise as far as to the drum.

If straw be put upon the water, it will be drawn together by the vortex, and will form a sort of cord, that will rise spirally in the axis of the vortex. If a wet board be placed upon the water, the vortex will form upon it a focus of, say, three-quarters of an inch in diameter, and of a whitish appearance, while a peculiar whistling will be heard, as if the board contained an aperture through which a mixture of air and water was passing upward with great force. It is remarkable

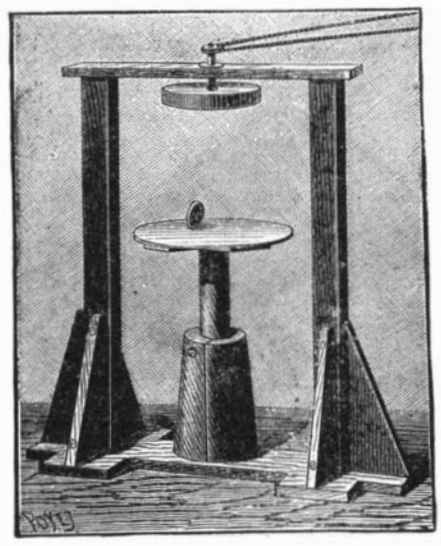

FIG. 3.—COIN HELD A PRISONER IN A VORTEX.

to see the vortex concentrate and contract on the board to a diameter of but ½ or ¾ of an inch, while the divisions of the drum leave at the center of the latter a free circle of 15 inches in diameter.

It is easy to demonstrate that the artificial whirlwind created by the drum presents exactly the same characters as the lower part of an atmospheric vortex that has descended from the upper regions to the surface of water.

As this experiment is performed in the open air, the focus quite easily shifts under the influence of the least wind, and it is, therefore, difficult to study it well. It may, therefore, be performed on a smaller scale and with a closed vessel; but the open air experiment shows that the closed vessel is not the cause of the formation of a focus, it having no other effect than that of permitting of fixing the axis of the vortex at nearly the same point.

2. *Aerial Vortices.*—A glass cylinder, about 15 inches in diameter and 24 in length (Fig. 2), is provided with a cover containing an aperture through which passes an axle furnished with one or two cardboard vanes mounted crosswise. The cylinder contains sawdust or, what is better, oatmeal. If the latter be first so arranged as to form a cone or hillock, and the axle be revolved, we shall see an imitation waterspout form at the apex, and the mass of meal will gradually hollow out into a hemisphere. The material will incessantly run in spirals from the circumference to the center, where it will first form the lower cone, and then the reversed one, whose particles of meal will describe spirals running from the center to the circumference.

The system, as a whole, forms a general, more or less distorted sphere, whose focus (where the two cones meet) is also put out of center to a certain degree by terrestrial gravity. If we examine things from above, we shall see a hollow funnel on the axis. It is here that the air is most rarefied through rotation, and it is hither that the finest portion of the material comes.

Substituting small, light balloons inflated with air for the oatmeal, let us follow the general motion. When the balloons reach the external circumferences, they slowly descend in spirals, and when they reach the circumferences contiguous to the axis of revolution, they quickly rise on a helix of more or less elongated pitch. Upon the whole, the experiment shows that, being given a mass of air, if we communi-

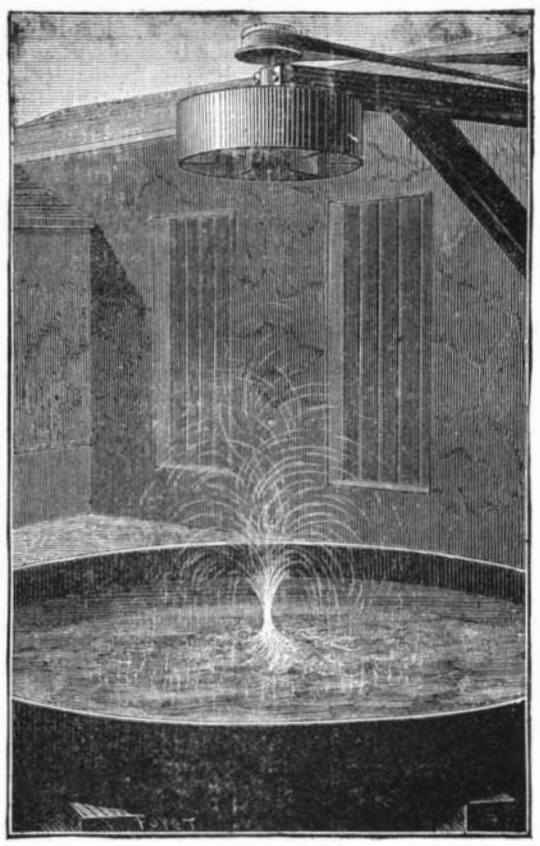

FIG. 1.—APPARATUS FOR PRODUCING AN IMITATION WATERSPOUT.

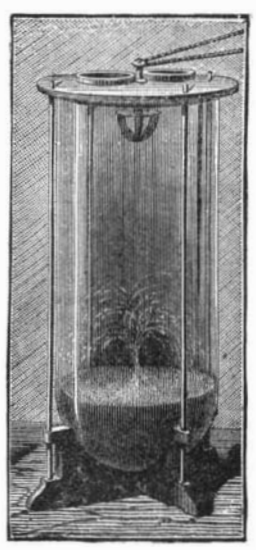

FIG. 2.—VORTICES IN A CLOSED VESSEL.

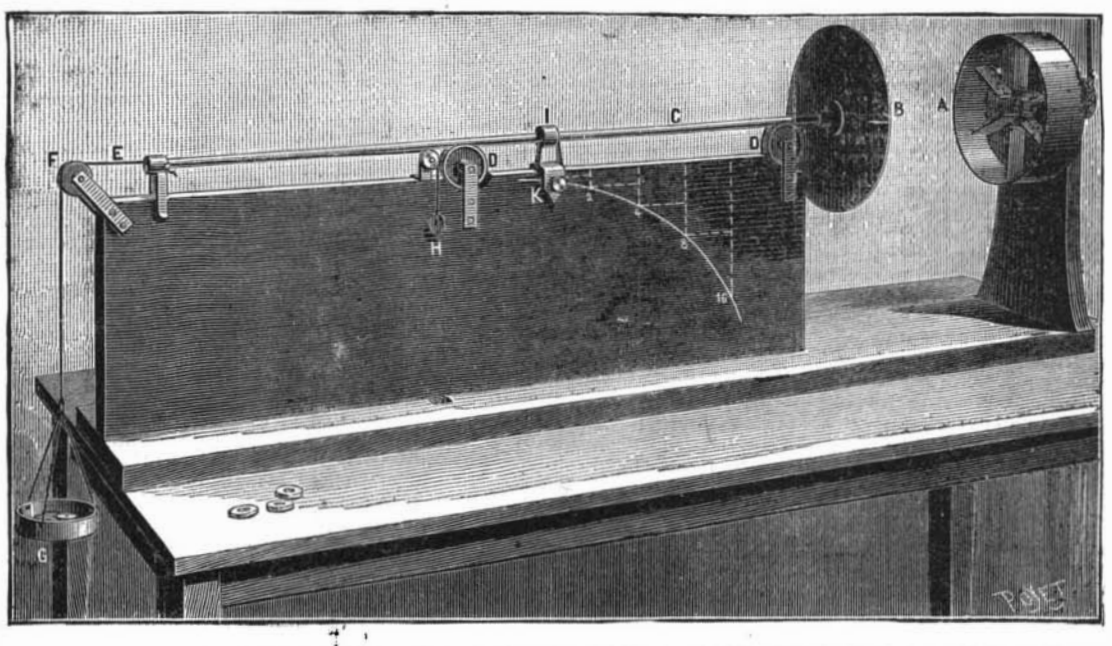

FIG. 4.—EXPERIMENT TO SHOW THE ATTRACTION PRODUCED BY A VORTEX.

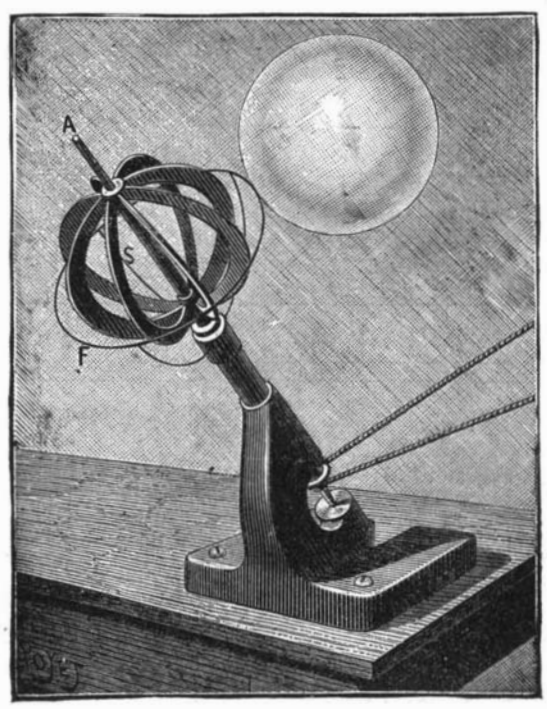

FIG. 5.—RUBBER BALLOON REVOLVING AROUND A RAPIDLY ROTATING SPHERE.

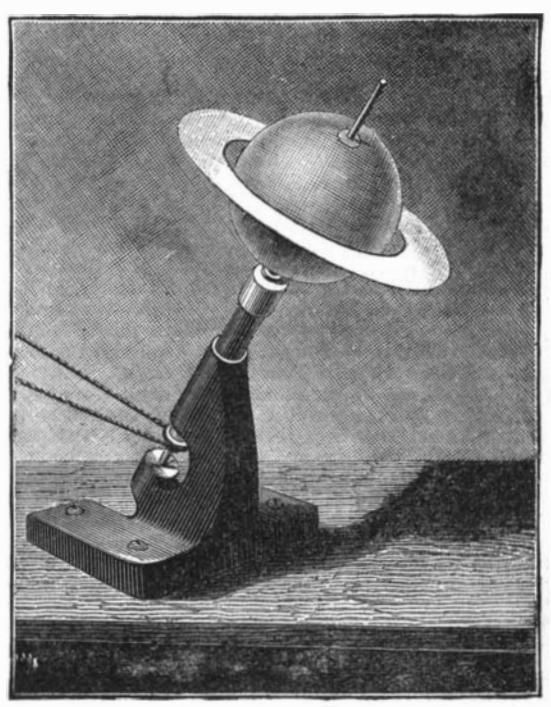

FIG. 6.—PAPER RING HELD IN EQUILIBRIUM AROUND A RAPIDLY ROTATING SPHERE.

cate a rotary motion to it around a vertical axis, it will constantly descend through the external circumferences and rise again through the internal ones, and the entire volume will continuously pass through the focus of the vortex, carrying along with it in its motion the particles that are involved in it.

3. A disk of glass or of any other material is placed beneath an axle provided with vanes. After this device has been set in motion, a coin is made to spin along one of its diameters (Fig. 3). After the hand has been taken away, the vortex continues to make the coin spin like a top, and absolutely holds it captive within its radius of action. The coin, in spinning, generates a sphere, and a subsequent experiment will show that a revolving sphere constitutes a center of attraction.

4. The experiment illustrated in Fig. 4 is designed to measure the attraction produced by a vortex. A is a device analogous to the one shown in Fig. 1. B is a cardboard disk affixed to a very light rod, C, that revolves upon two very loose pulleys, D. A thread, E, passing over a pulley, F, supports a scale pan, G, which is balanced by a weight, H. I is a stop fixed upon the rod, C. K is a slider provided with a fork that affords a slight play to I.

The drum, A, is made to revolve with a uniform motion. By means of weights put into the scale pan, G, and on seeking with the slider the corresponding positions of equilibrium, it is found that the attractions upon the disk, B, are in inverse ratio of the square of the distances. With the same apparatus, and with the aid of a balloon supported by a thread, we may likewise ascertain the lateral attraction of the vortex.

5. *Equilibrium of Revolving Spheres.*—A free sphere remains in equilibrium and revolves around another sphere having a rapid rotary motion (Fig. 5).

The apparatus consists of a spindle, A, capable of revolving in a support and provided with a pulley driven by a cord. Upon this spindle is mounted a sphere, S, composed of eight or ten rings, which may be either entire or in the form of semicircles. The spindle may occupy any position whatever with respect to the horizon. In this experiment, it is inclined at an angle of 45°, but it may be horizontal or vertical. The angle of 45° is chosen as seeming to offer the most difficulty in the way of carrying out the experiment, in order that the latter may be conclusive.

When the sphere, S, is rapidly revolved, the hand feels a strong breeze escaping through the equator on every side. If bits of paper be presented, they will be blown to a distance. Nevertheless, if a balloon be presented, it will be strongly attracted toward the revolving sphere, and will describe orbits around it in the plane of the equator. As this experiment is performed in a room where there are obstacles that produce disturbances, and as gravity, too, has too great an influence, by reason of the earth's proximity, it is very difficult to get things to run regularly. The balloon readily comes into contact with the revolving sphere, but is repulsed by the shock to too great a distance to be recaptured. A very simple artifice consists in placing around the sphere, S, a wire ring or guard, F, 0·04 in. in diameter, fastened to the support by three wires of the same diameter.

The balloon then revolves indefinitely around the sphere, and, in doing so, even leaves the guard at the lower part under the action of gravity. The experiment may be arranged in different ways, and we may even do away with the guard; but such variants teach us nothing further.

Upon studying the whirling motions produced by the sphere, we may readily find out the reason of the attraction that it exerts upon the balloon.

6. If we remove the guard from the revolving sphere, and present a paper ring (having an internal diameter greater than the external diameter of the sphere) parallel with the equator, the ring will be caught in the rotary motion and be firmly held in the plane of the equator.—*La Nature.*

RECENT PHENOMENA ON THE SURFACE OF MARS.

THE planet Mars has for a long time attracted the attention of observers through the remarkable features of its constitution. Owing to its relative proximity, the telescope has been able to furnish us with a host of data concerning its physical geography, and even its meteorology. This planet, as well known, exhibits spots—some of them brilliant, and others dark, which there is reason to consider as continents and seas (Fig. 1).

Toward the poles are seen great white zones, sometimes small, sometimes large, which are masses of ice that sometimes break up like our terrestrial icebergs. The limits around the boreal pole are marked with them toward the bottom of Fig. 1 for the year 1879. In the tenuous and transparent atmosphere, we recognize clouds and currents, and often whirlwinds very much like those cyclones that let themselves loose with us.

In addition to these intimate analogies with the earth, the study of Mars reveals special peculiarities, some of which are explained by the most satisfactory considerations of comparative geology. With the tenuity of the atmosphere is associated a more limited extension of the seas, and the relative distribution of dryness and moisture is very different from what it is upon the earth. On the surface of our planetary neighbor, astronomers point out, as one of the most remarkable peculiarities, the large number of long and narrow passes and seas shaped like bottle necks. As well known, the oceans on our globe have thrice the area of the continents, and it should be noted that Europe, Asia, and Africa together form a single great island, while another one is formed by the union of the two Americas. Now, on Mars there is an almost complete equality between the surfaces occupied by the continents and seas. Moreover, the latter are intermingled in so complicated a manner that a traveler might, either by land or by boat, visit nearly every quarter of the planet without having to leave the element upon which he began his voyage.

This stated, it is necessary to recall the fact that Mars is older than the earth, that is to say, having individualized itself more anciently than the latter, it has reached a more advanced stage of sidereal evolution; so that this planet now represents, in its broad features, and independently of its individual characteristics, a state that the earth will reach in the hereafter. Now, one of the inevitable effects of the secular cooling of the earth is to cause a progressive absorption of the water of the oceans by the successively consolidated masses of rock. Hence an eloquent comparison can be made between the present seas of Mars and the terrestrial oceans supposed to be in great part absorbed. The results of innumerable soundings have allowed of bathymetric charts being drawn, and it is now thirteen years ago that I pointed out the bottle neck shape of the Atlantic Ocean 13,000 feet below its present surface. If, then, we suppose the water of the Atlantic absorbed by the rock masses at this moment in process of solidification, so that the level of the ocean lowers by 13,000 feet, we shall at once have a much smaller surface covered with water, and a narrow and elongated form of the sea, that is to say, exactly the features presented by Mars.

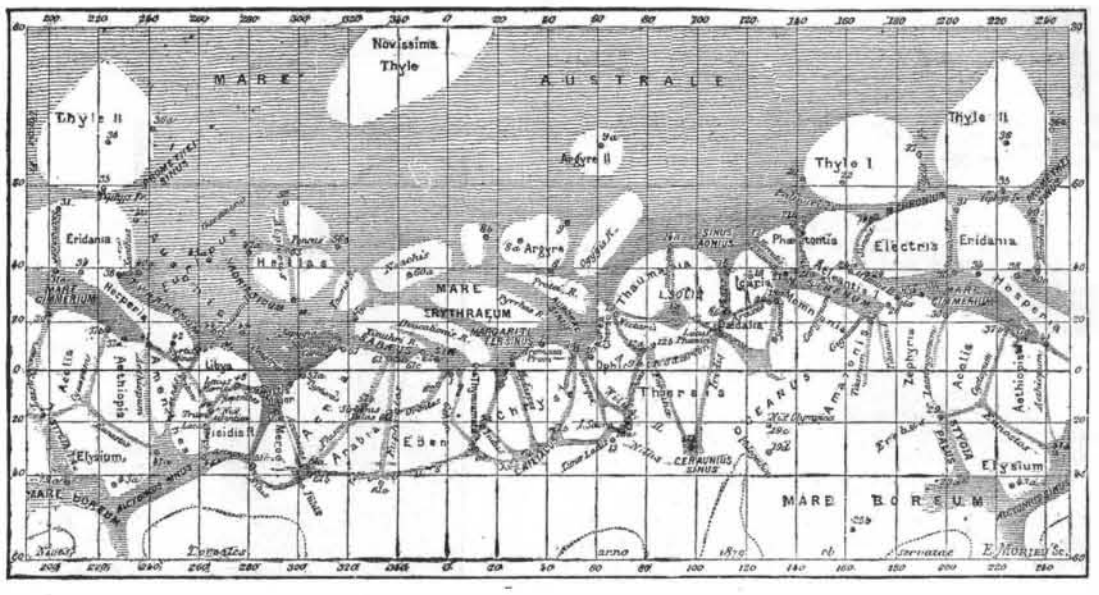

FIG. 1.—MAP OF MARS DRAWN IN 1879.

While the water is being taken up in this way, the air itself must be absorbed. All rocks are aerated. We know how difficult it is to drive the air from a rock (even the most compact one) whose density we desire to obtain with accuracy. As the various mineral masses become aerated while they are being wet, and consequently while they are cooling, the atmospheric stratum must progressively decrease. It is natural, then, that the atmosphere of Mars should be much more tenuous than that of the earth, and this, by the way, is an excellent condition for the telescopic study of our planetary neighbor.

As regards the earth, geology furnishes a sort of indirect confirmation of this successive absorption of the atmosphere. It results, in fact, from the experiments of physicists, of Mr. Tyndall especially, that a slight increase in the thickness of our atmosphere, or in the proportion of vapor that it contains, would suffice to cause a greater quantity of solar heat to become stored up therein and to be dissipated more slowly. That is to say, what we call climates would disappear, as a warm and but slightly variable temperature would extend over the entire globe.

Now one of the most remarkable characters of the ancient geological periods was precisely such absence of climate, as is shown by the uniformity of the faunas and floras of the entire planet. Herein we may see a confirmation of our opinion that the air then formed a much thicker stratum than it does to-day. But, although some features in common evidently exist between the earth and Mars, a great interest resides in the existence on the surface of the latter of these globes of very important details of structure, which are without analogy with us. As long ago as 1877, Mr. Schiaparelli began to perceive in the continents of Mars, which until then had been immense and continuous, a system of dark canals, often very narrow, which divided its surface into a multitude of lands which were isolated and separated from each other like the meshes of a net. This is very well shown in Fig. 1, where may be read the names of a certain number of these canals. These latter, despite their apparent tenuity, were not less than 72 miles in width. In length, several of them reached 2,880 miles. These results at first excited nothing but incredulity in astronomers, who were soon, however, obliged to recognize their perfect accuracy. The illustrious director of the observatory of Milan has been good enough to remit me his works, the last of which, relating to the opposition of 1879–1880, forms a voluminous quarto memoir of 109 pages, with 6 plates, and the reading of which is highly interesting.

But it is since that magnificent work was published that the author, during the last opposition of Mars, in 1881–1882, observed the wonderful phenomena depicted in Fig. 2, which is taken from a memoir that has not yet been published, and the communication of which I owe to the extreme kindness of Mr. Schiaparelli. It appears from these observations, and from those made by him between 1884 and 1886, that the surface of Mars is at present the theater of gigantic phenomena which, in the course of a few years, will suffice to profoundly change its aspect.

It will be seen from the figure, in fact, that many canals hitherto described are dividing into two, and are accompanied as it were with a second, similar in dimensions and direction. In order to produce such an effect, one of our most eminent areographers, Dr. Terby, of Louvain, who has just set up a fine eight inch, equatorially mounted Grubb telescope at his house, in view of the approaching opposition of Mars, has discovered a very just comparison. Let us move in proper position over Fig. 1 a doubly refractive crystal—one of Iceland spar—and we shall see the canals subdivide as shown in Fig. 2.

This phenomenon, which is without analogy, Mr. Schiaparelli calls the gemination of the canals, and he is preparing an extensive memoir in regard to it which will soon appear. These astonishing discoveries, which were at first received with incredulity, are being newly confirmed, as shown by the observations of Messrs. Boeddicker and Burton, in Ireland, and especially by those of Mr. Perrotin, director of the observatory of Nice, with the aid of Messrs. Trepied, Thollon, and Gautier. Other observers, such as Messrs. Green, Knobel, and Denning, have not been so fortunate in the verification of the facts, and yet their researches, published in the memoirs of the Astronomical Society of London, and in the monthly notices, are full of interest.

What further adds to the mystery is that the gemination seems to be taking place gradually. Thus, to cite but one example at the side of the canal styled Nilus, astronomers some time ago found a second one parallel with it, called for this reason Nilus II. This was very feeble, and, as sketched in the chart shown in Fig. 1, is hardly visible, but now, as shown on the last chart (Fig. 2), the two Niluses have a very nearly equal intensity.

Mr. Terby, on studying comparatively the admirable drawings made a century ago at Lilienthal by the celebrated astronomer Schroeter, and a little farther back by Herschel in England, has met with analogous modifications of Mars' surface. Among these are some local enlargements of certain seas, such as that of Kaiser, and other changes of detail in the configurations of the planet which until then had been supposed to be fixed. In the same direction, we must mention a memoir by Mr. Van de Sand Baghuyzen in the annals of the observatory of Leyden, in which the author interprets all the drawings of Schroeter, and at the same time finds therein the trace of a host of Mr. Schiaparelli's details. Finally, Father Lamey has made numerous observations of Mars, which have led him to results of extreme originality, and the prompt confirmation of which is much to be desired.

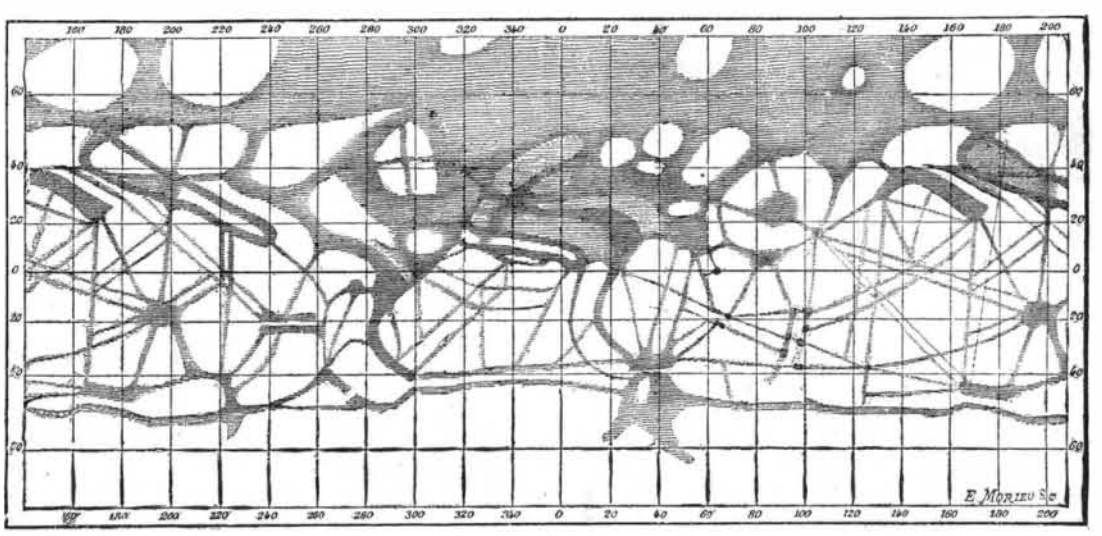

FIG. 2.—MAP OF MARS DRAWN IN 1886.

As may be seen, the wonderful studies of which Mars is the object are opening up entirely new horizons to astronomy.—*S. Meunier, in La Nature.*