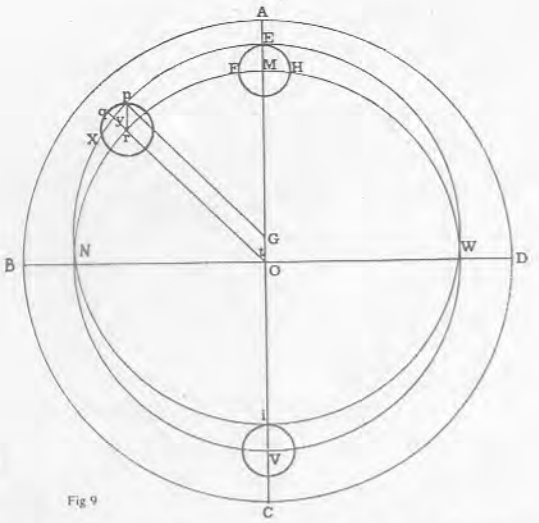

Fig 9

The same proposition is demonstrated in this manner: we have the zodiac ABCD and the solar epicycle EFH having its center on the circumference of the circle MrVW which is concentric around the center O of the universe. We also have point E, the point furthest from the earth, at 5 ½ degrees of Gemini. I propose that the epicycle HE, being carried on the circumference of the circle MrVW by a uniform movement which is opposite to that of the universe, and the sun, travelling the epicycle EFH at the same time in a uniform movement which is opposite to that of the epicycle and consequently in the same direction as the universe, will then describe an eccentric circle equal to the concentric circle MrVW.

Let us now suppose that the center M has described any arc Mr, and that the epicycle has arrived at pqX. The sun, starting from point E, that is to say from point q, will have described at the same time arc qp, similar to arc Mr. Let us take the line OG, equal to the radius ME and draw the lines Gp and Oq. Since the arc qp is similar to the arc rM, the angle y is equal to the angle t. [27] Thus line pr is parallel to OG, and is also equal to it; the line pG is then equal and parallel to line rO. Now line Or is equal to line GE. Thus line Gp is equal to line GE. Therefore the circle described from the center G with radius GE, will pass through p and will be equal to the circle MrVW.

Let us describe the circle EpNiW (from the center G, with Gp = GE for radius); this circle will be eccentric. Since pG is parallel to

[27]Theon designates the angle qrp by y and the angle rOM by t.

qO, angle y will be equal to angle t, that is to say to pGE, the arc Ep is therefore similar to arc pq (of the epicycle pqX). The sun, starting from point E, will consequently describe the similar arc Ep of the eccentric circle. One could likewise demonstrate that it is always thus, so that the sun, having travelled the entire epicycle, propelling itself on a concentric circle, describes also a whole eccentric circle. This is what had to be demonstrated.

The converse proposition can also be demonstrated. Let us again take the zodiac ABCD whose diameter is AC and whose center is O, and again the eccentric circle of the sun ENiW, point E being furthest from the center of the earth, under 5 ½ degrees of Gemini, and its center G on the line AO. [28] Let us describe from the center O, with the radius GE, the circle MrVW, and from the center M with the radius ME, the circle EFH. It is clear that this will be the same as the epicycle. I propose then that the sun uniformly describes the circumference ENiW of the eccentric circle, and will consequently also describe the epicycle EFH carried uniformly at the same time on the concentric circle MrVW.

Let us indeed suppose that the sun has described any arc Ep of the eccentric circle. Let us draw line pG and its parallel Oq. We take rq equal to OG and draw pr. Since the lines Gp and Or are equal and parallel, lines GO, and pr will also be equal and parallel. But we have OG = ME, therefore rq = rp, thus the circle described from the center r with radius rq will pass through point p and will be the same as the epicycle EFH. Let us describe this circle pqX. Because of the parallelism of the lines (rp and OG) the angles t and y are equal But in circles, similar arcs correspond to equal angles, and in equal circles, equal arcs correspond to equal angles, whether these angles be at the center or the circumference. Therefore, the arcs qp, Ep and Mr are equal.

Therefore, in the same time as the sun travels the arc Ep of the eccentric circle, the center M of the epicycle, describing the arc Mr, will carry the epicycle EFH to pqx, and the sun having travelled the arc Ep of the eccentric circle starting from point E, that is to say from point q, will describe the similar arc qp of the epicycle. It can be demonstrated that it is thus for the whole movement. Therefore, in travelling the entire eccentric circle, the sun also describes the entire epicycle. This is what it was necessary to demonstrate.

XXVII. The same demonstrations can be applied to the other planets. The sun appears to make all these movements, in both hy-

[28]Refer again to Fig. 9.

potheses, with regularity, for the times of its return to the same longitude, to the same latitude, and to the same distance which produces the irregularity called anomaly, are so little different from each other that most mathematicians regard them as equal 365¼ days. Thus, when one attentively considers the time of the return in longitude during which the sun travels the zodiac, going from one point back to the same point, from one solstice to the same solstice, or from one equinox to the same equinox, it is very close to the time noted above, so that at the end of four years, the return to a point at the same longitude occurs at the same hour.

As for the time of the anomaly after which the sun, at the point furthest from the earth, appears smallest and slowest in its movement towards the following zodiac signs, or after which, at the point closest to the earth, it appears to have the largest diameter and the greatest speed, it is close to 365½ days, so that at the end of two years the sun appears to return to the same distance at the same hour. Finally, the time of its return in latitude, the time after which, starting from the extreme north or south point, it returns to the same point in such a way as to give the same shadow-lengths on the sundials, is 365⅛ days. Consequently, it might be said that at the end of eight years, it will return at the same hour to the same point of latitude.

XXVIII. Regarding each of the other planets, we have said that their various times vary greatly, some are longer, some are shorter. The durations of the returns appears so much the more variable and changing in one hypothesis as in the next, that it is not in the same lapse of time that each planet travels its epicycle and the epicycle its concentric circle (in the zodiac): the movements are more rapid for some and slower for others by reason of the inequality of the circles, of the inequality of the distances from the center of the universe and of the differences of obliquity with respect to the circle of the middle of the zodiac signs, that is to say, of the differences of inclination and of position.

XXIX. As a result, it happens that for all the planets, the stations and the returns, whether towards the preceding zodiac signs or the following zodiac signs, do not occur in a similar manner. One observes the phenomenon for the five planets, but in a manner which is not absolutely similar. For the sun and the moon, it does not occur at all; indeed these two never appear to advance, nor to remain stationary, nor to retrogress. As we have said, the sun appears to be

carried on its own circle in the same time as the epicycle on the concentric circle, whereas the epicycle of the moon is carried more rapidly on the concentric circle through the zodiac, than it itself travels the epicycle.

XXX. It is clear that it matters little for interpreting the phenomena, whether one says, as it has been explained, that the planets move on circles or whether the circles which carry these stars move around their own centers. I understand that the concentric circles, carrying the centers of the epicycles, move around their own centers in the direction contrary to the universe, and that the epicycles carrying the planets also move around their own centers. Thus I understand that the concentric circle MNVW moves around O, (fig. 10) which is its own center and that of the universe, in the opposite direction from the universe. I understand in addition that the concentric circle carries on its circumference the center M of the epicycle EFGH and that this epicycle which carries the planet to point E, turns around the center M in the same direction as the universe, if it is a question of the sun and the moon, or in the opposite direction if one considers the other planets. In this way we can safely arrive at an explanation of these phenomena.

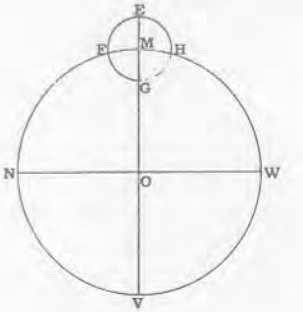

Fig 10

According to the other interpretation, we have the eccentric circle ENiW which has point H for its center. Considered in relation to the sun, this circle ENiW, moving uniformly in the space of one year around the center H, and carrying the sun fixed at point E, explains the phenomena, if the center H moves by itself, not in the opposite direction from the universe, but carried in the same direc-