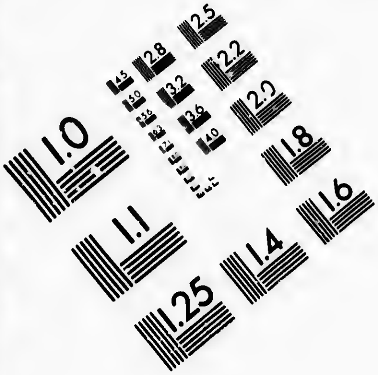

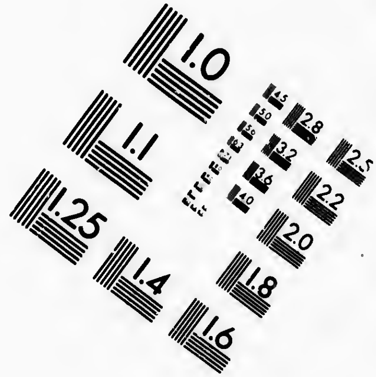

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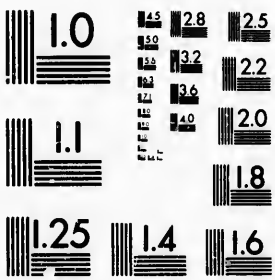

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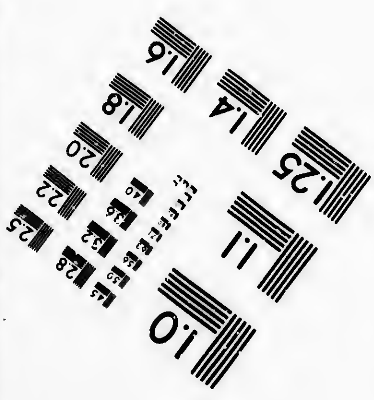

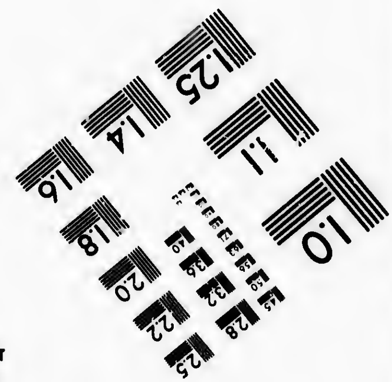

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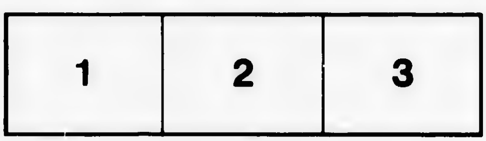
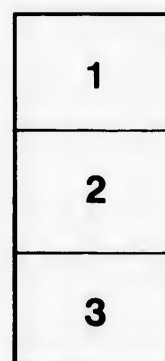
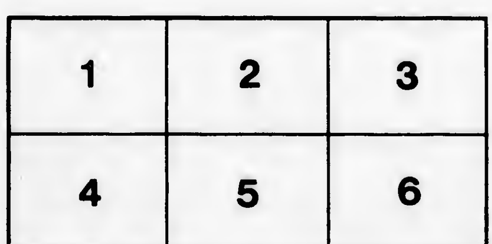






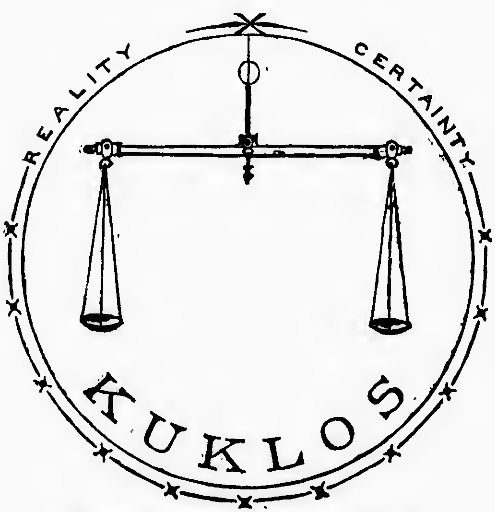
APPENDIX.

SUPPLEMENT A.

CENTRIFUGAL FORCE

AND

GRAVITATION.



APPENDIX.

SUPPLEMENT A.

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CENTRIFUGAL FORCE

AND

GRAVITATION.

A LECTURE

BY

JOHN HARRIS.

Montreal:
PRINTED BY JOHN LOVELL, ST. NICHOLAS STREET.

JUNE, 1874.

APPENDIX

TO

SUPPLEMENT A.

THE PLANETARY THEORY OF THE PERPENDICULAR AXIS OF ROTATION AND OF VERTICAL DEVIATION ABOVE AND BELOW THE SOLAR EQUATORIAL PLANE OF ORBITAL REVOLUTION.

We propose herein to put before the student a brief illustration (1) of the satisfactory and complete explanation which is afforded by this theory of (all) the observed astronomical facts belonging to the subject, and (2) that the highly complicated and artificial theory of the inclined terrestrial axis, now taught as a part of astronomical science, is irreconcilable with some of the observed and established facts thereof.

Referring to the explanations and illustrations already given in Supplements A and B, we will now consider the theory more generally in its relation to the fixed stars, *i.e.* to the constellations of the zodiac, to the apparent path of the sun amongst those constellations, and to the orbital paths of the planets considered relatively to the sun and to each other.

In Fig. 20 the earth *E.* is supposed to be at *a.* near the winter solstice, and at *b* near the summer solstice. Therefore according to the above theory (as already explained) the earth at *a* is at (about) the point of its maximum elevation above the mean orbital plane, and at *b.* is at (about) the point of its maximum depression below the mean orbital plane. Assuming, then, the earth to be situated at the elevated place *a* in the month of December, the apparent place of the sun, to a terrestrial observer, will be in the constellation at which a line drawn from the earth through the sun would if produced eventually arrive. The apparent place of the sun at that time of the year is known to be in the constellation Sagittarius.

Now the theory called the Copernican System, according to which the earth and other planets revolve around the sun, is not only accepted by astronomers as a demonstrated theorem but may be considered as the general basis of modern astronomy; it is therefore the earth and not the sun which in fact changes its position from time to time relatively to the other members of the solar system, and relatively to the independent stellar systems (fixed stars).

A question which at once proposes itself and invites a plain and intelligible reply is: what is the apparent place of the earth in the heavens viewed from the sun in the month of December, when to the terrestrial observer the sun appears to be in the constellation Sagittarius? To this question there is no difficulty in replying that the earth's apparent place is at that time, as shown in Fig. 20, in the constellation Gemini.

Let us suppose the earth now to proceed in its orbital revolution through 180°. By the theory it will, (Supp. A,) having passed the solar equatorial plane, have descended to the point of its maximum depression beneath that plane, namely 23½°, equal to its elevation above the plane when occupying the place at *a*. The apparent relative places of the sun and earth will now have become interchanged. To the terrestrial observer, in the month of June, the sun appears to be in the constellation Gemini, and (asuming our theory) to the solar observer the earth at *b* must appear to be in Sagittarius, consequently, therefore, according to the theory, the earth . latively to the equatorial plane of the sun actually describes in the heavens that (ascending and descending) oblique circle called the ecliptic, which necessarily cuts the solar equatorial plane in two places.*

Fig. 21 repeats the illustration which is amplified by the addition of a superior and an inferior planet. The

* But in the theory of the inclined axis the solar equatorial plane is the ecliptic, and which cuts the mean plane of the earths' equator in two places.

angular vertical deviation is supposed in the case of the inferior to be somewhat greater than that of the earth, and in the superior to be somewhat less than that of the earth. The neighbouring constellations above and beneath Sagittarius and Gemini are indicated for the purpose of illustrating the constant variation in the apparent paths of the several planets which thus becomes readily and satisfactorily explained.

The theory (of the perpendicular axis) may be considered to be correctly represented and illustrated by the celestial globe as constructed at the present time. The pole-star, or, more correctly speaking, the north polar axis of the celestial globe, is to be considered the pole-star of the earth and also the pole-star of the sun, because the polar axes of both are perpendiculur and therefore parallel to each other, and the distance of 95 million miles between them is, in comparison with the great distance of the fixed stars from the sun, practically inappreciable.* The point marked on the globe 'pole of the ecliptic' is the point intercepted by a straight line which passes through the centre of the compound circle described by the earth in its ascending and descending orbital path, and which line is perpendicular to the plane of that compound circle; since the plane of that circle is oblique to the solar equatorial plane and forms an angle therewith of 23½°, the point in the celestial sphere intercepted by that line is necessarily situated 23½° from the pole of the sun; which last is also the pole of the celestial sphere as viewed from the sun, and is also the pole of the mean planetary orbital plane of revolution belonging to the solar system, and may be moreover considered as practically the pole of the

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* On this point we are adopting for the moment the presently received teaching of Astronomy, but there seems to us at least a probability that a very appreciable quantity of space between the poles of the sun and earth may be hereafter ascertained and perhaps even enable an approximate measurement of the distance of the pole star from the sun to be obtained of a more reliable character than any of the estimates hitherto made.

earth, although in fact this last revolves around it at a distance of about 95 million miles in an ellipse which is a counterpart of the earth's orbit around the sun.

Let us now consider in the same manner the 'theory of the inclined terrestrial-axis' as set forth in works on astronomy.

In Fig. 22, the illustration is similar to that of Fig. 20, but adapted to the requirements of this theory. We have the earth at *a*, as before, in the month of December at about the time of winter solstice when to the terrestrial observer the sun appears in the constellation Sagittarius; and in answer to the former question, as to the apparent place of the earth viewed from the sun, the reply is the same as before . . in the constellation Gemini. When the earth is supposed to have proceeded through the one half of its revolution to the place *b*., the apparent relative positions of sun and earth are, as before, interchanged, and the sun appears in Gemini, the earth in Sagittarius.

If this theory were the new, and that of the perpendicular axis the old one, the astronomical student on looking at this Figure (Fig. 22) would be apt at the first moment to say:—'This won't do at all, things are not in their right places.' A little consideration, however, will show that we now have a very complicated and difficult case to deal with, and it will soon become apparent that if not in their right places (which we are prepared to admit) they are where the theory of the inclined terrestrial-axis as now taught, if admitted, obliges us to put them.

So long as we confine the consideration of the case simply to the sun, the earth, and those constellations which constitute the zodiac, the appearances to the terrestrial observer will be the same as in the former case. The earth, indeed, is now supposed to revolve in a horizontal plane uniformly coincident with the equatorial plane of the sun (the pole of the ecliptic being a prolongation of the sun's polar axis) and both the constellations 'Gemini' and 'Sagittarius' are now in the same horizontal plane, but the earth's equator, to which the terrestrial observer refers to determine his relative position, or which he considers as the base of his position, is now inclined at an angle of $23\frac{1}{2}°$ to the equatorial solar plane which is also the orbital plane of the earth's revolution; consequently the apparent place of the sun (viewed from the earth at *a.*) is at an angular distance of $23\frac{1}{2}°$ beneath the plane of the terrestrial equator, and so also of the constellation Sagittarius which appears at the same angular distance beneath that plane. And again, when the earth has proceeded through the half revolution and arrived at the second station *b.*, since the earth's axis, according to this theory, has uniformly the same inclination in the *same absolute* direction, or, as it is usually expressed in astronomical works, since the inclined axis of the earth remains parallel to itself throughout the orbital revolution, the sun then has an apparent elevation of $23\frac{1}{2}°$ above the terrestrial equatorial plane; and so likewise of the constellation Gemini which appears similarly elevated. With respect to the constellations, it is evident by the figure that Gemini will appear elevated and Sagittarius depressed in whatever part of its orbit the earth may be, because the earth's inclined axis remains uniformly parallel to itself throughout the annual revolution.

But what then is the ecliptic, according to this theory? The ecliptic is the (imaginary, fictitious,) path of the sun's apparent motion in the heavens, and is, also, the natural equator of the heavens (celestial sphere.) But has the sun no actual motion? Certainly not; by the Copernican theorem the sun is the fixed centre of the solar system. But does not the earth's orbit deviate from the equatorial plane? Is it not sometimes stated that the orbital plane of the earth is inclined at some angle to the equatorial plane of the sun? According to the theory no deviation in the earth's orbital plane from that of the sun's equator can take place, and any statements, if there be any, of such deviation are evidently inconsistent with the theory, for, according to the theory, the angle of obliquity of the earth's equator to that of the sun is 23½°, which inclination is retained uniformly; now if the earth, retaining that inclination, were to deviate vertically above or below the horizontal plane of the solar equator, then would the apparent depression or elevation of the sun exceed the limit of 23½°, which is well known to astronomers to be the maximum.

Therefore, according to this theory the earth revolves around the sun in an uniformly horizontal plane coincident with the equatorial plane of the sun.

Let us now amplify the illustration as before by the addition of the superior and inferior planets. Fig. 23. Here we are met by a difficulty which does not appear to be reconcilable with the recognized laws of gravitation. It is at once evident that each of the planets must have an orbital plane more or less oblique to that of the earth, for if the orbital plane of any one of the planets were coincident with that of the earth, then at each conjunction or opposition there would be either transit, occultation, or eclipse, as the case might be. Since therefore each of the planets has an orbital plane differing from that of the earth, a strong probability is suggested that each will have its own particular plane more or less oblique to each of the others. But here is the difficulty. What is there to keep a planet from vertical deviation when the earth (for example) situated in an orbital plane oblique to that of the planet's orbit is attracting it upwards; or, what prevents the earth from vertical deviation when a planet revolving in a less elevated plane is attracting it downwards?*

* It is not desirable to complicate the consideration of the subject by introducing in this place the case of a satellite, or otherwise the moon subjected at the same time to solar and terrestrial gravitation from planes not coin-

Having already mentioned this difficulty (Supp. A) in our first explanation of the new theory, we will now pass on to a more general consideration of the case.

Taking a celestial globe as at present constructed we find a point at an angular distance of 23½° from the polar axis of the globe (*i.e.* the fixed axis upon which the globe turns) 'marked pole of the ecliptic,'—and we find the pole star (Polaris) close to that fixed axis of the globe. Is this construction consistent with the theory of the inclined terrestrial axis? Certainly, the polar axis of the earth being inclined at an angle of 23½° to the polar axis of the celestial sphere, the equator of the earth is, by the theory, similarly inclined to the natural equator of the celestial sphere, and the apparent path of the sun is dependent upon the inclination of the earth's equator in such wise that it must necessarily be also oblique to the earth's equatorial plane by the same angle. Now it is true the earth is not exactly in the centre of the celestial globe, which to an inhabitant of the solar system is theoretically occupied by the sun, but the distance between the sun and earth, as already stated, when considered in reference to the place of the pole in the heavens is scarcely appreciable. Polaris, the terrestrial pole-star, which is very nearly the zenith of the earth's north pole, must be, therefore, according to this theory, always at an angular distance of about 23½° from the pole of the celestial sphere.*

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cident would furnish a pertinent example. However, it seems, to us, that in the extremely complex lunar-theory, as now taught, a vertical deviation of the moon from her orbital plane is *virtually* admitted although it is not recognized.

* Throughout these observations we assume the polar axis of the sun to necessarily coincide with the polar axis of the celestial sphere; it may be proper to remark that some astronomers appear to entertain a misgiving that the polar axis of the sun is also out of the perpendicular. Is not the sun to us as inhabitants of the solar system the centre of the celestial sphere; and is not the polar axis of the sun to us the *standard of perpendicularity?*

The difference in the relation of the ecliptic to the celestial sphere, occasioned by the substitution of the one theory for the other, may be now made readily intelligible.

In the theory, hitherto adopted, of the inclined terrestrial axis, the ecliptic is looked upon as a plane which divides equatorially the celestial sphere and is oblique to the equatorial plane of the earth. This plane (of the ecliptic) cuts through (has its centre coincident with) the centre of the sun, which to us as inhabitants of the solar system occupies the central place of the celestial sphere. But in the theory of the perpendicular axis, which we propose to substitute, the ecliptic is not considered as a simple plane,—it is a circle described by the revolving earth in descending from a higher plane to a lower plane, and again ascending from a lower to a higher, through a number of planes, all of which are parallel to each other, and of which that plane occupying the middle place, or the plane of mean elevation, is coincident with the equatorial plane of the sun and, also, with the natural equator of the heavens, which in our theory becomes a term synonymous with that of 'the equatorial plane of the sun.'*

Now the difference in this particular between the two theories being clearly understood, a test suggests itself by which the practical astronomer may determine which of the twain is truly in accordance with the facts of astronomy. If we suppose an invisible star to occupy the place in the celestial sphere intercepted by the pole of the sun, that star, according to our theory, will be so near to (Polaris) the pole star of the earth, that it may be practically considered to coincide therewith; but according to the inclined-terrestrial-axis theory it will be at an angular distance therefrom of about 23½° and in the latter case it will necessarily have an apparent diurnal revolution around (Polaris) the pole star of the earth in a circle of about 47° diameter.

* According to the present teaching the ecliptic is the natural equator of the heavens and must necessarily be coincident wirh the equatorial plane of the sun.

So far no means offers itself of testing whether the invisible pole star of the ecliptic has actually such diurnal revolution around the pole star of the earth; but, having regard to the conditions of the case, let us consider the annual revolution of the earth in its orbit; does this afford us the means of indirectly determining the fact? Yes, it appears to do so because according to our theory the pole-star of the earth is practically also the pole star of the sun and represents the place in the celestial sphere pierced by the polar axis of the heavens, consequently in the annual revolution as in the diurnal rotation the same pole star which is always over the central axis is always over the centre of revolution. But by the theory of the inclined axis the ecliptic is the natural equator of the heavens, and the pole of the ecliptic is therefore the centre of annual revolution around which the earth's pole star in common with all other stars must necessarily have an annual revolution.* It is true that the

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* We have elsewhere shown that this *corollary* to the inclined terrestrial-axis theory does not involve as a consequent that the pole star (polaris) should leave the zenith of earth's north pole; on the contrary, both are in the same case, and both (the star and zenith of the earth's pole) make the apparent revolution together.

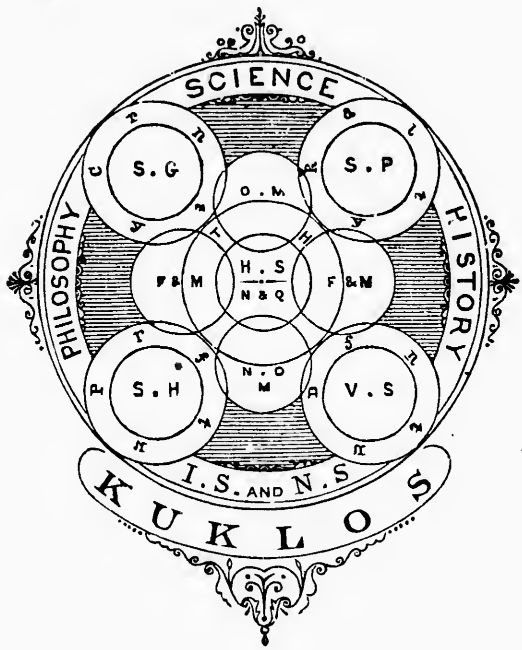
It should, moreover, be particularly noted that this apparent annual revolution of the pole-star around the pole of the ecliptic will be apparent only to a terrestrial observer who constantly retains the same position relatively to the sun, who, for example, faces the sun on each occasion of making the comparative observations from the opposite extremities of the orbit. Now by the inclined-axis theory, that axis remains constantly inclined in the same absolute direction, consequently, leaving the earth's diurnal rotation out of the case, an observer on a terrestrial station, at the opposite extremities of the earth's orbit or at various places in the orbit, will *naturally* face in the same absolute direction and in order to constantly face the sun will have to turn himself and adjust his position; therefore, *assuming the inclined-axis theory*, there will be no such apparent revolution unless the observer so adjust his position relatively to the sun.

earth's pole star will not appear to have any such annual revolution if the terrestrial observer view the heavens always with an assumption that the earth's equator is also the celestial equator, but *according to this theory*, (the theory now taught) *it is not so.*

We say it must be possible for the practical astronomer to ascertain whether there be or not actually such a centre of the celestial sphere at an angular distance of about $23\frac{1}{2}°$ from the earth's pole star. Practically it is not a distance of 190 million miles only but of 380 million miles with which the astronomer has to work, for, evidently, in this connection, if the two observations be made from the opposite extremities of the earth's orbit respectively, the diameter of that orbit is an addition to the one side of the celestial sphere, as seen from the earth, and a deduction from the other side. At the one extremity of the orbit the observer determines the place of the pole (star) of the ecliptic, and the equal or relative distances from it of certain (constellations) stars to the east, west, north and south. The earth removes to the opposite extremity of the orbit where another observation is made. The observer has therefore receded 190 million miles from certain of those constellations which were noted in the first observation, and has approached 190 million miles nearer to certain other constellations which were also noted. Practically this may be considered as giving an alteration in relative position equivalent to 380 million miles which may be made available to determine whether the fixed pole star of the celestial sphere be very nearly coincident with the pole star of the earth, or whether it be at a great angular distance of $23\frac{1}{2}°$ away from it. A more direct and simple mode of deciding the question, however, presents itself: Whenever the earth is in the line of either of its nodes it is evident that an equatorial plane passing through the centre of the earth and through the centre of the sun, must divide the celestial sphere equatorially because to the terrestrial astronomer such is the meaning of 'celestial equator,' the term cannot be defined in any other general sense than that of a plane horizontal to, or at right angles to, the perpendicular axis of the apparent heavens(of the sun). Having therefore this plane, which may be at once directly obtained by an observation of the sun at noon from any place on the equator when the earth is passing either the ascending or descending node, the problem which remains is to ascertain the point in the heavens vertically above the centre of this plane. To ascertain this we have the celestial hemisphere above us; we have, to define the base of this hemisphere, the stars or constellations to the east, west, north and south, which are intercepted by the plane (passing through the sun's centre); and we have the centres and equators of the sun and of the earth itself included in that plane which constitutes the base of the hemisphere.

Now if the place in the heavens over the centre of the celestial equatorial plane thus ascertained, be found at a great angular distance of about $23\frac{1}{2}°$ from the earth's pole star, then it will follow that the present teaching is correct; but if such place be found to nearly coincide with the place of the pole star of the earth, then must the theory of the inclined terrestrial axis be given up. Let it be observed, however, that the plane of the celestial equator is thus correctly obtainable from observation of the sun at the time of passing either of the nodes; if an observation be correctly taken at each of the nodes, the result will be the same and each will agree with the mean of the two; but a mean of several observations taken when the earth was in other places of the orbital circle would give a different result and which would not be the equatorial plane of the celestial sphere; if, for example, four observations were taken from an observatory on the equator, one at each of the nodes, one at the summer, and one at the winter solstice, the result would evidently be a plane oblique to the plane of the earth's equator.

This last proposed method of investigating the fact, taken by itself as an argument may be considered to beg the question or, in other words, it assumes the perpendicular theory to be correct and the inclined-axis theory to be incorrect; it is given here by way of illustration and as a part of the general consideration of the subject. Evidently the significance of the actual or theoretical result thus ascertained would be dependent on the fact, or on an assumption, as to the solar equator—whether its plane be coincident with that of the terrestrial equator, or whether the plane of the one be oblique to the plane of the other.



NOTE.—We have already shown by quotation from Herschel's treatise and by illustration that direct observation of the Sun's surface (solar spots) is strongly in favour of the perpendicular-axis theory.

(See Supp. A, pages 11 and 12.)

THE THEORY

OF THE

PERPENDICULAR AXIS.

Correction to page 10, Supplement B { Centrifugal Force and Gravitation.

The theory of the inclined terrestrial-axis.

On revision we find that we have inadvertently mis-stated in this place the argument which it was intended to put before the reader.

Our argument, correctly stated, is that if a diurnal revolution of the pole (star) of the ecliptic around the pole star of the earth at an angular distance of about $23\frac{1}{2}°$ is admitted, it will follow that there must be an annual revolution of the terrestrial pole star around the pole of the ecliptic at the same angular distance.

The statement made in the passages quoted from Herschel's work, that the pole of the ecliptic is a fixed point in the heavens and that the ecliptic is to be considered the natural equator of the heavens, is evidently not inconsistent with an apparently diurnal rotation of the pole of the ecliptic around the pole star of the earth; and the observations which we are desirous to correct convey the meaning that such a diurnal revolution is considered by us inconsistent with the observed facts of astronomy.

In thus mis-stating the case we overlooked in some degree the consequence of the double axis of revolution which the theory supposes.

If the statement of Sir John Herschel in the passages quoted be admitted, that the pole of the ecliptic is to be correctly considered as the fixed central axis of the celestial sphere, it would seem to follow, since the same revolving sphere cannot have two axial poles of revolution, at some distance from each other, on the same side, that 'polaris' (called the pole star) must be in the same case as the other stars, and must have an apparent annual revolution around the fixed centre of revolution which by the theory is the pole of the ecliptic; careful consideration, however, will make it apparent that the oblique position of the earth's axis, which, according to the theory, remains always inclined in the same absolute direction, so modifies the resulting motion that it becomes equivalent to a revolution around the terrestrial pole only. This may be plainly seen by contrasting Figs. 20 and 22 of the preceding Appendix, to Supp. A., when it will be found that by placing one of the figures in an oblique position the motion and revolution of the earth in both cases is alike, and, that so far as the orbital revolution only is concerned, the result apparent to the terrestrial observer according to the one theory is precisely the same as in the other.

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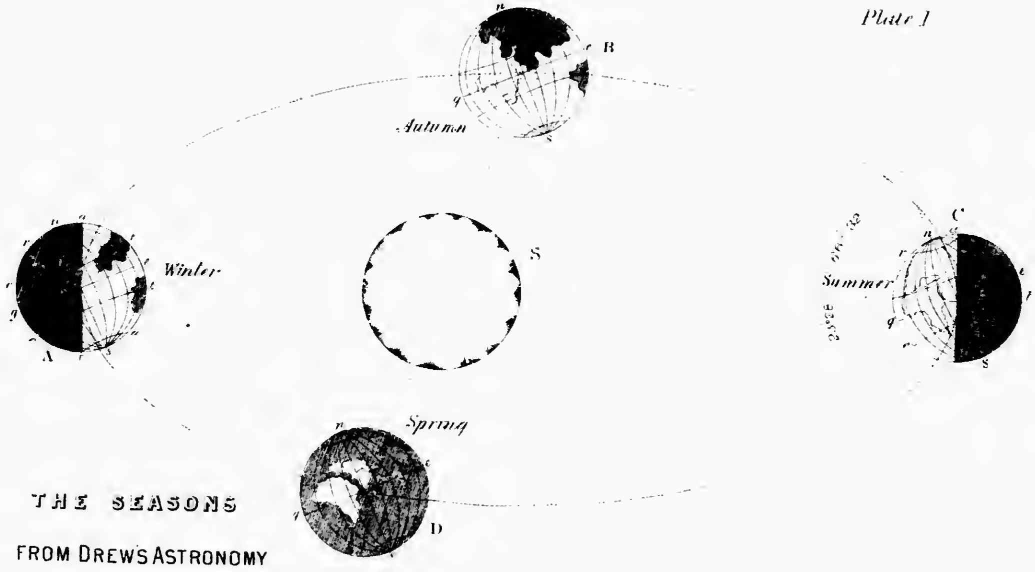
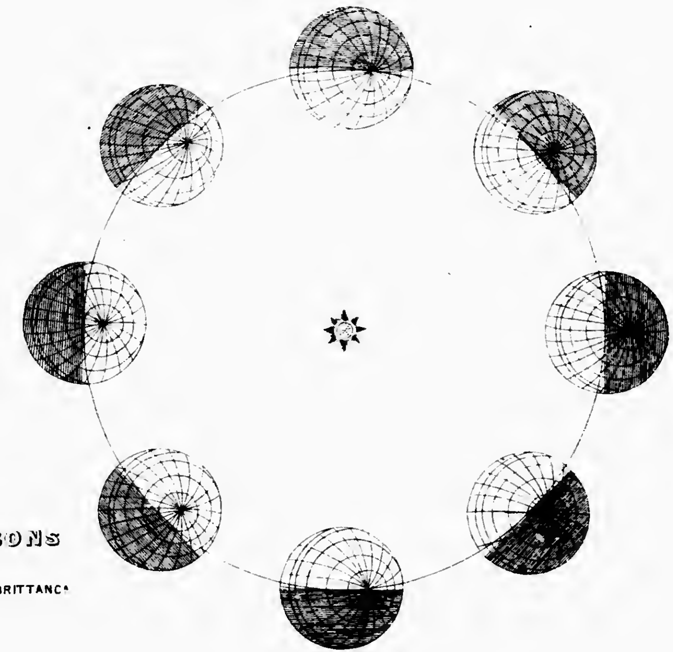
Plate 1



THE SEASONS

FROM DREW'S ASTRONOMY

Plate 2

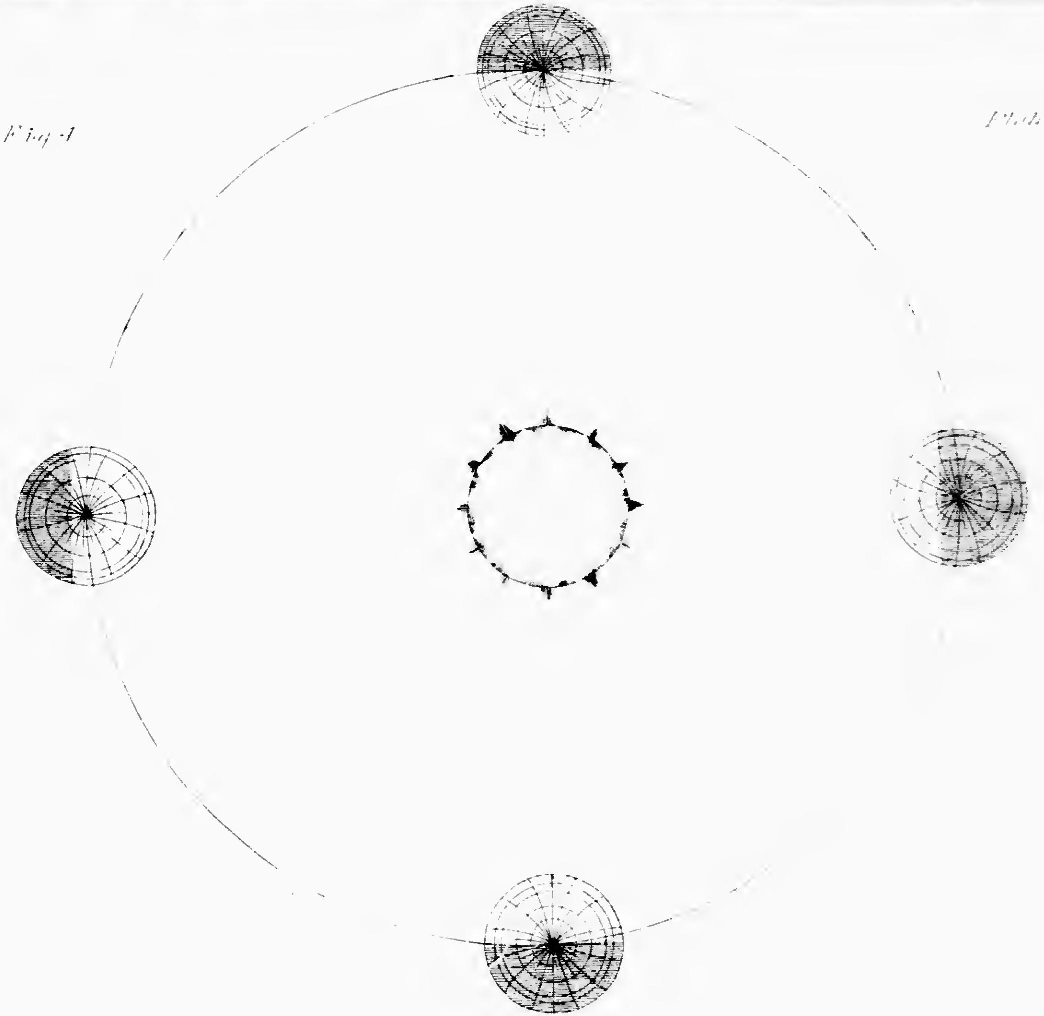


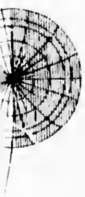
THE SEASONS

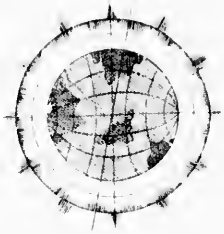
FROM THE ENCYCª BRITTANCª

Fig. 1

Plate 4







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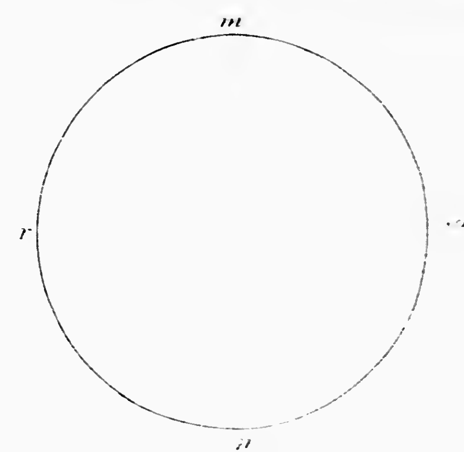


Plate 5

Fig 3

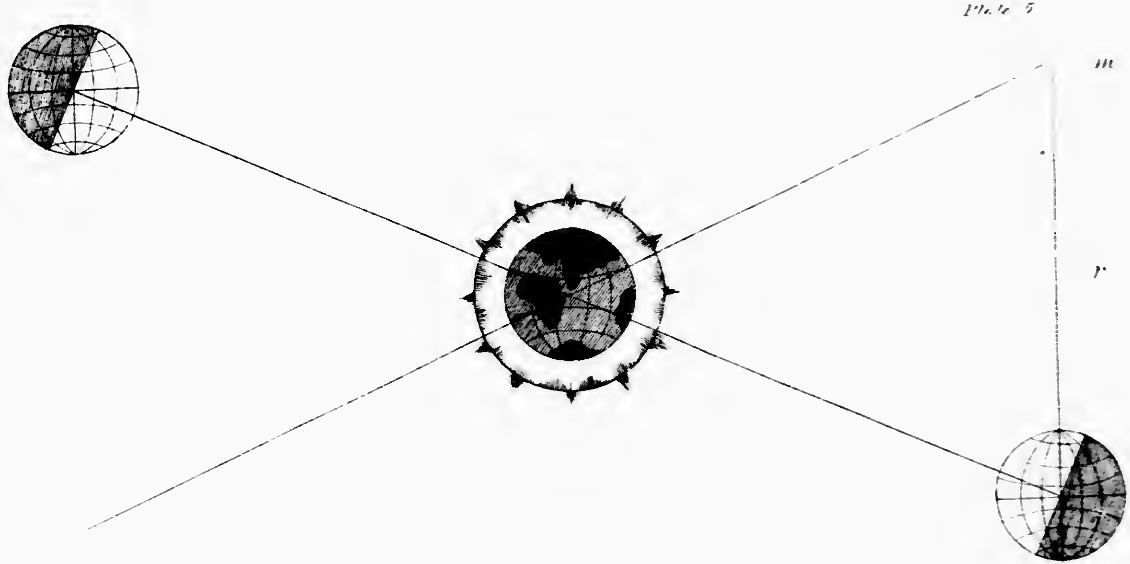
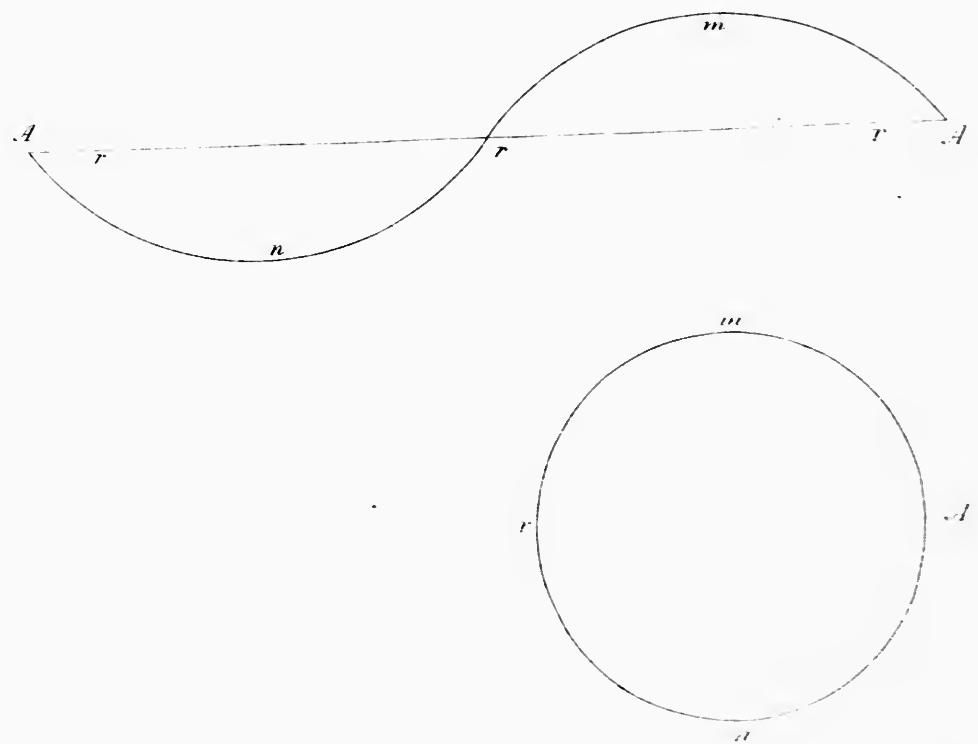
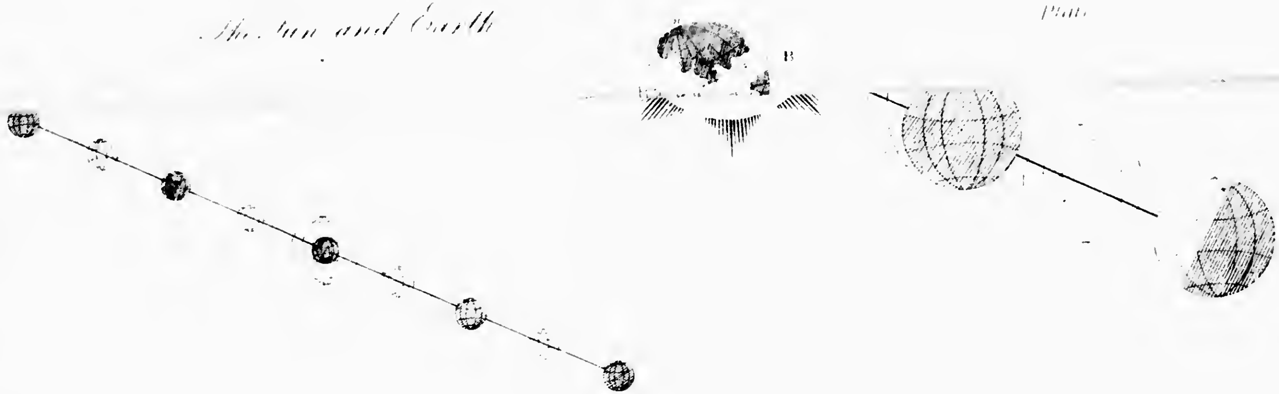


Fig 9



The Sun and Earth

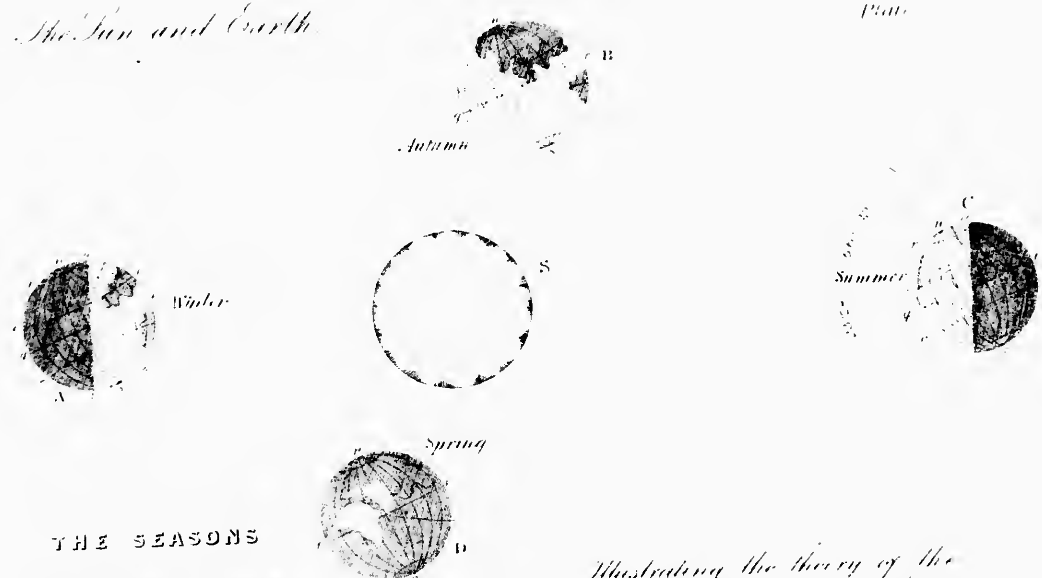
Plate



Illustrating the theory of the perpendicular axis and vertical deviation above and below the horizontal plane of the Ecliptic

The Sun and Earth

Plate



THE SEASONS

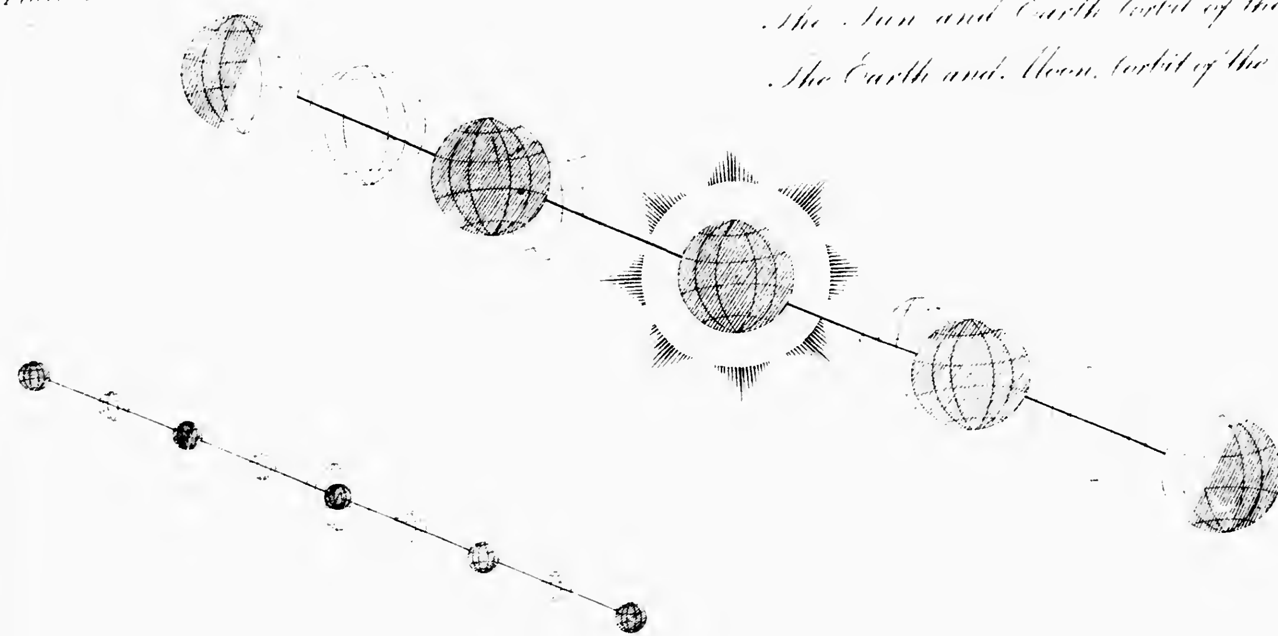
FROM DREWS ASTRONOMY

Illustrating the theory of the oblique axis and orbital plane inclined to the ecliptic

Plate 9

The Sun and Earth (orbit of the earth)

Plate 9



Illustrating the theory of the perpendicular axis
and vertical deviation above and below the
horizontal plane of the Ecliptic

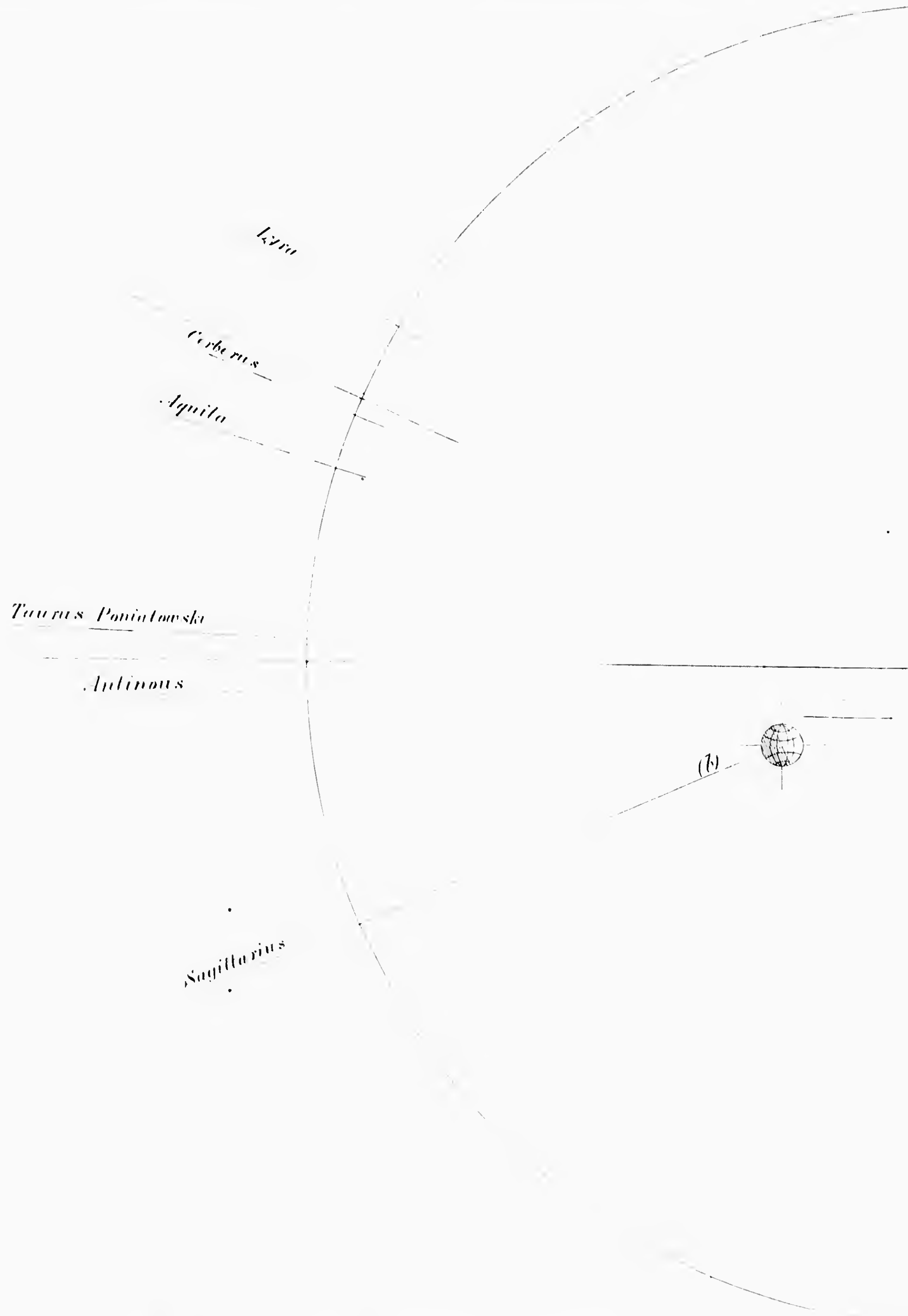


Fig. 20. The theory of the perpendicular axis.

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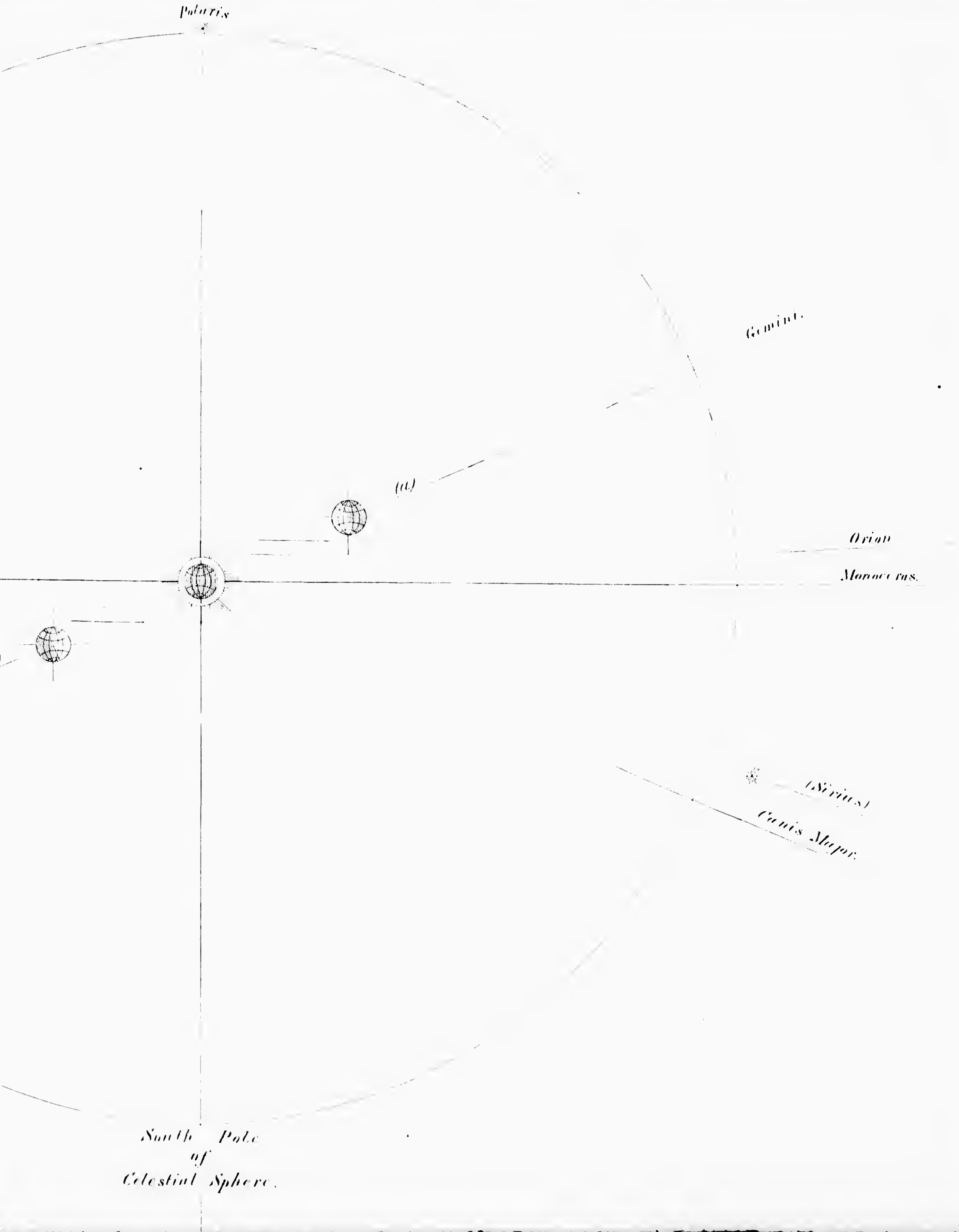


Polaris
Gemini.
(a)
Orion
Monoceros.
(Sirius)
Canis Major.
South Pole
of
Celestial Sphere.


Aquila
Taurus poniatowski
Antinous
Sagittarius
Corona Aust
Telescopium

The theory of the perpendicular axis
Fig 27.

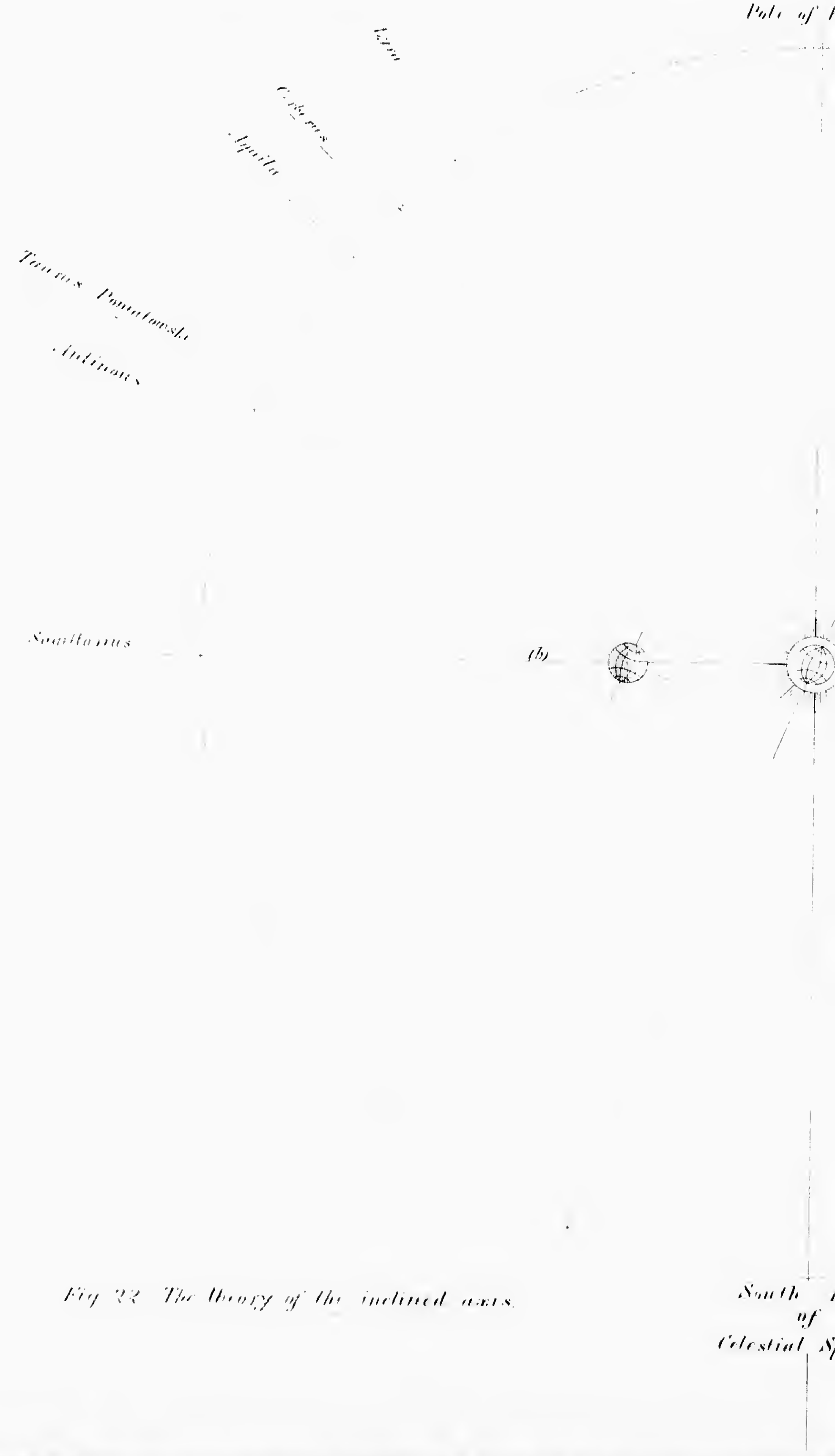
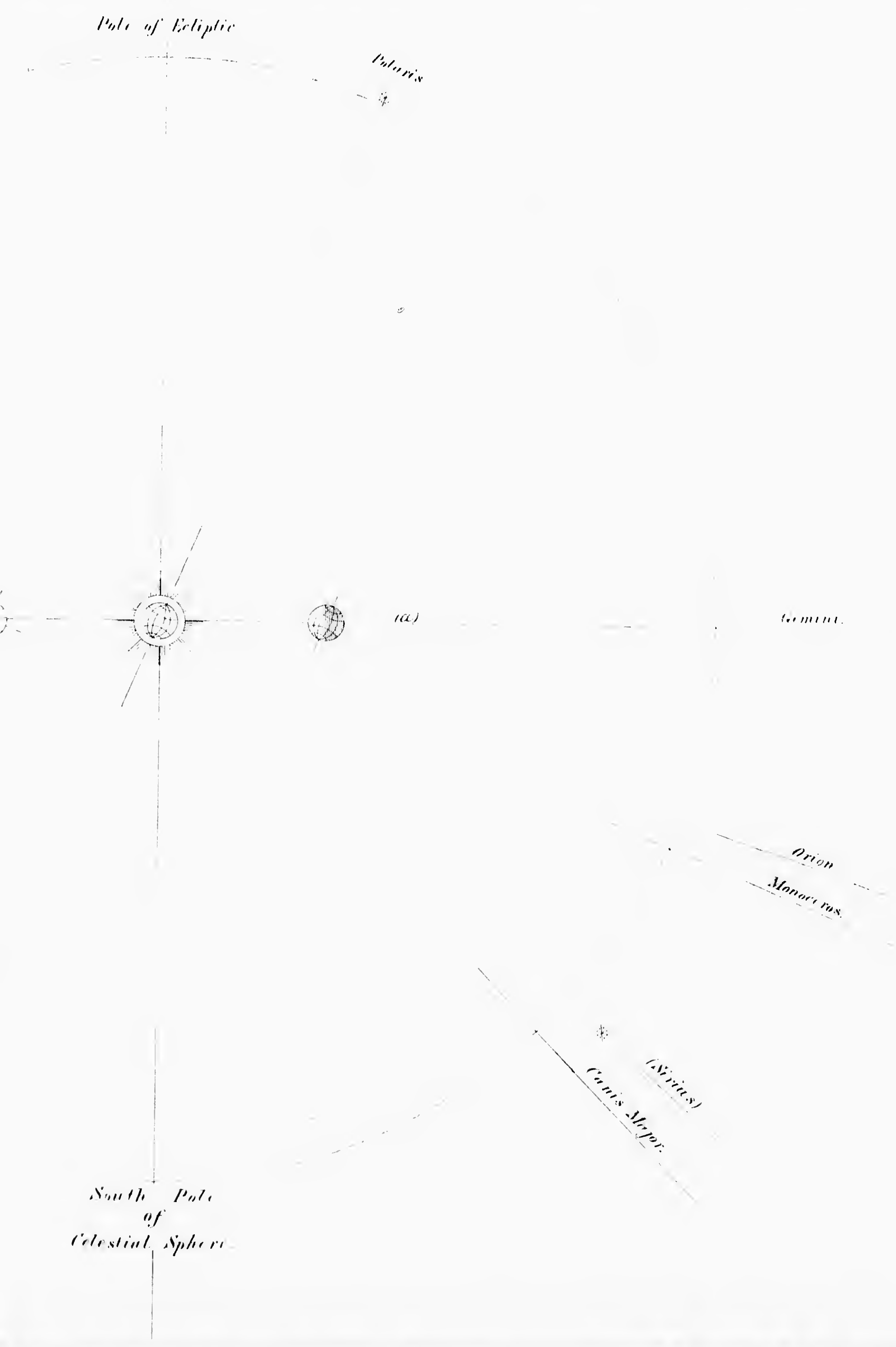
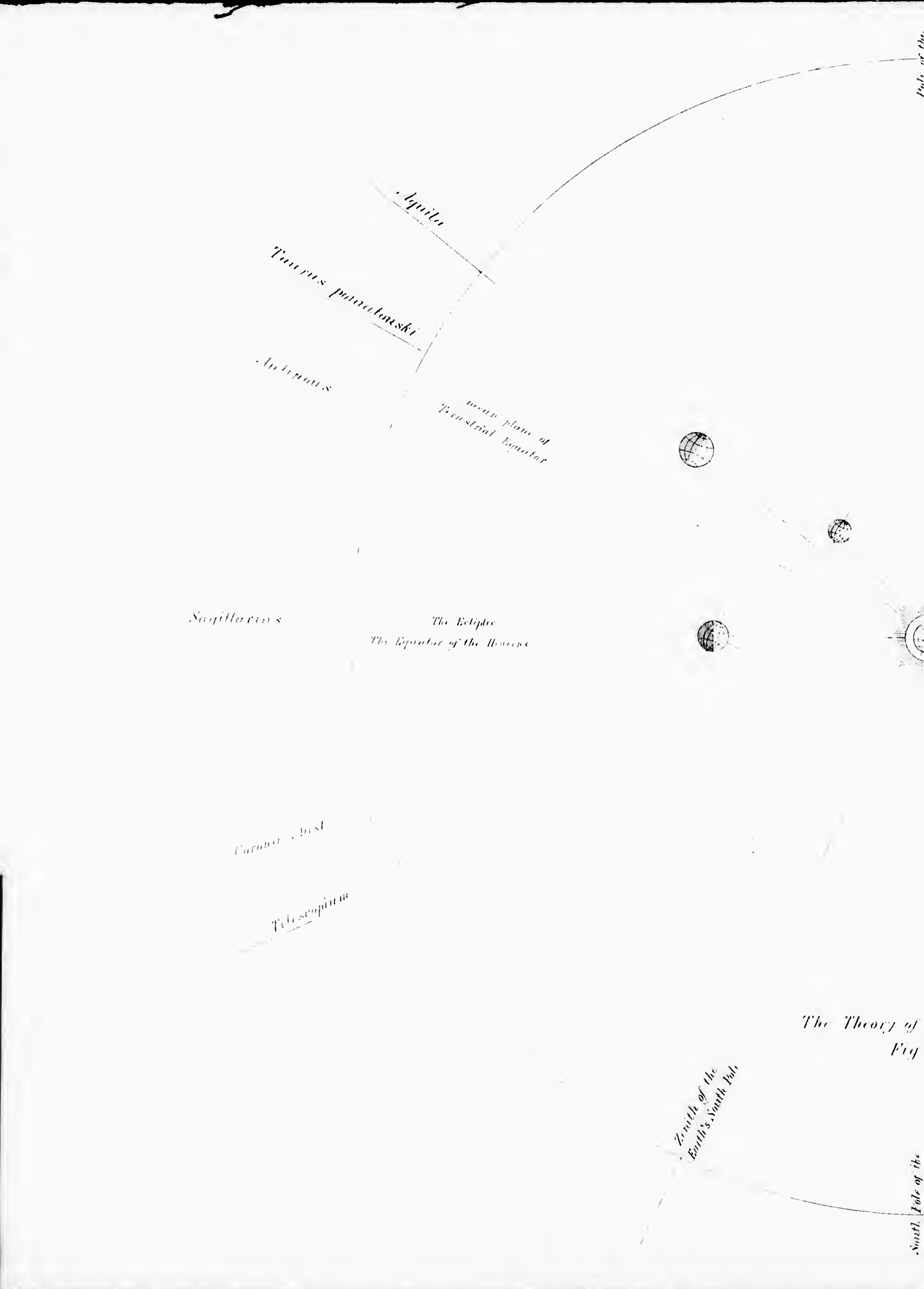
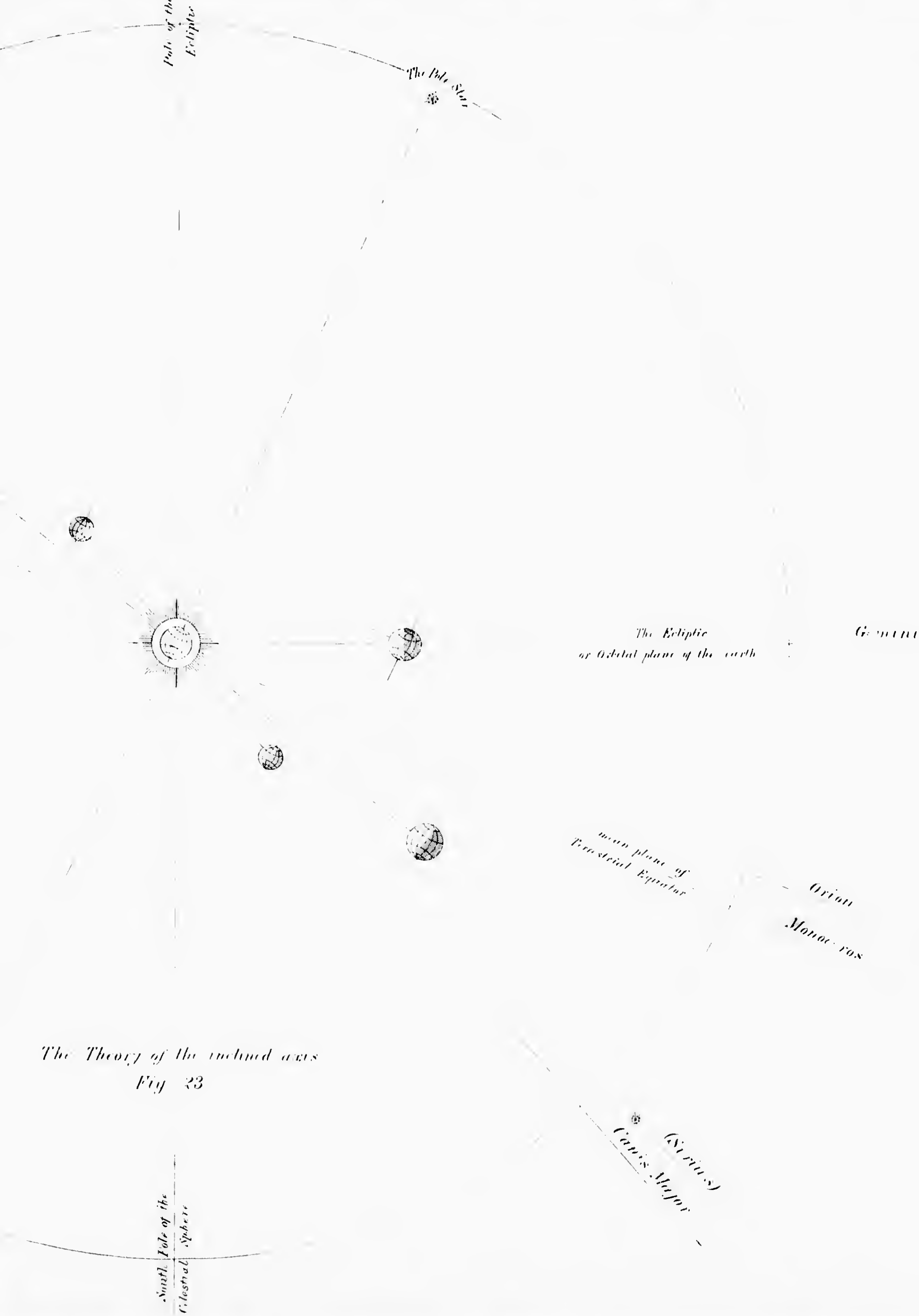


Fig. 22 The theory of the inclined axis.


Pole of Ecliptic
Polaris
(α)
Gemini.
Orion
Monoceros.
(Sirius)
Canis Major.
South Pole
of
Celestial Sphere


Pole of the
Aquila
Taurus poniatowski
Antinous
mean plane of
Terrestrial Equator
Sagittarius
The Ecliptic
The Equator of the Heavens
Corona Aust
Telescopium
The Theory of
Fig
Zenith of the
Earth's South Pole
South Pole of the



The Theory of the inclined axis
Fig 23