2 Sheets—Sheet 1.

# F. M. PANNETRAT.

## Time Instrument.

No. 106,718. Patented Aug. 23, 1870.

Fig. 1.

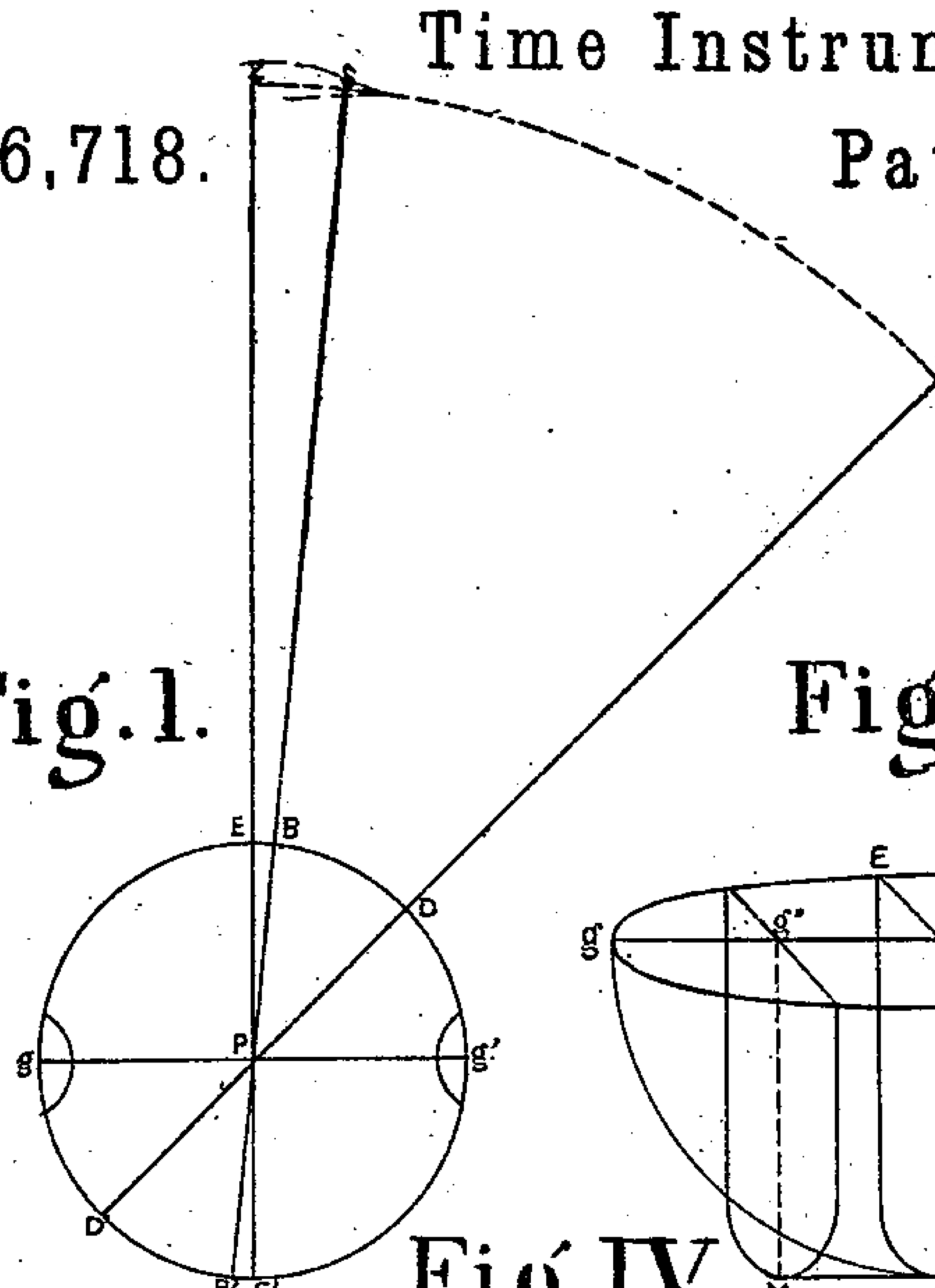



Fig. II.

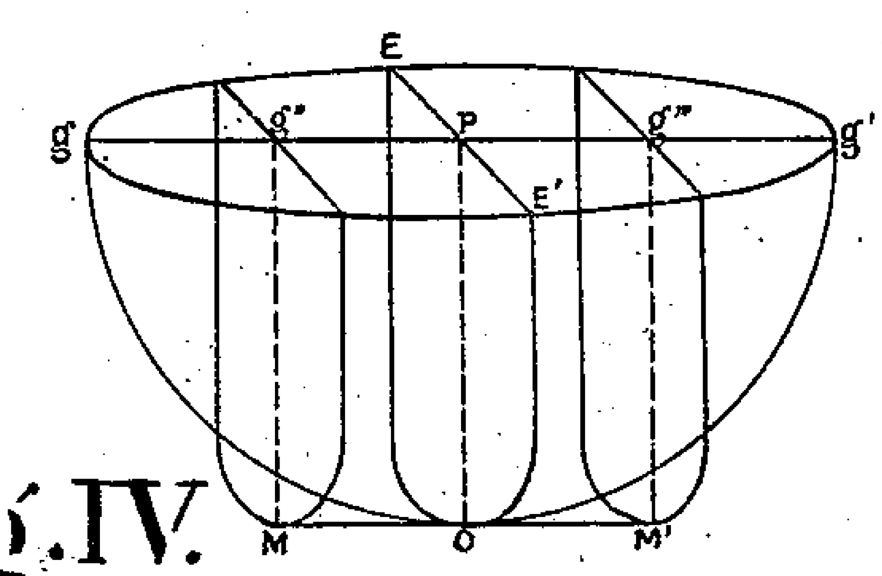



Fig. III.

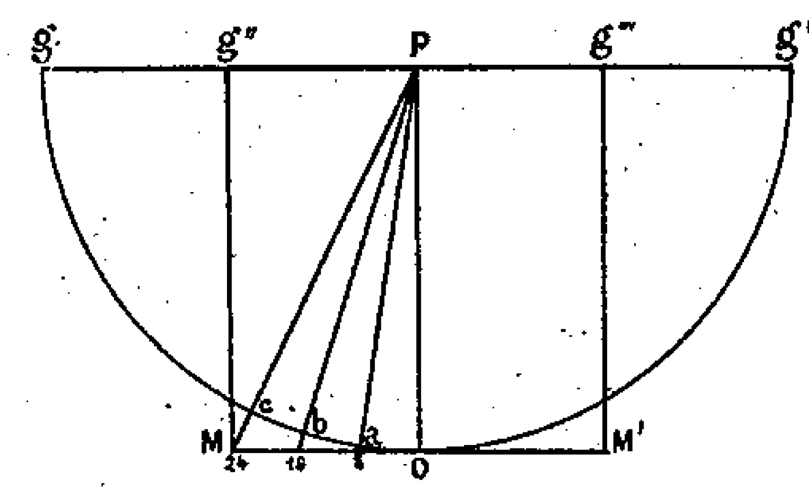



Fig. IV.

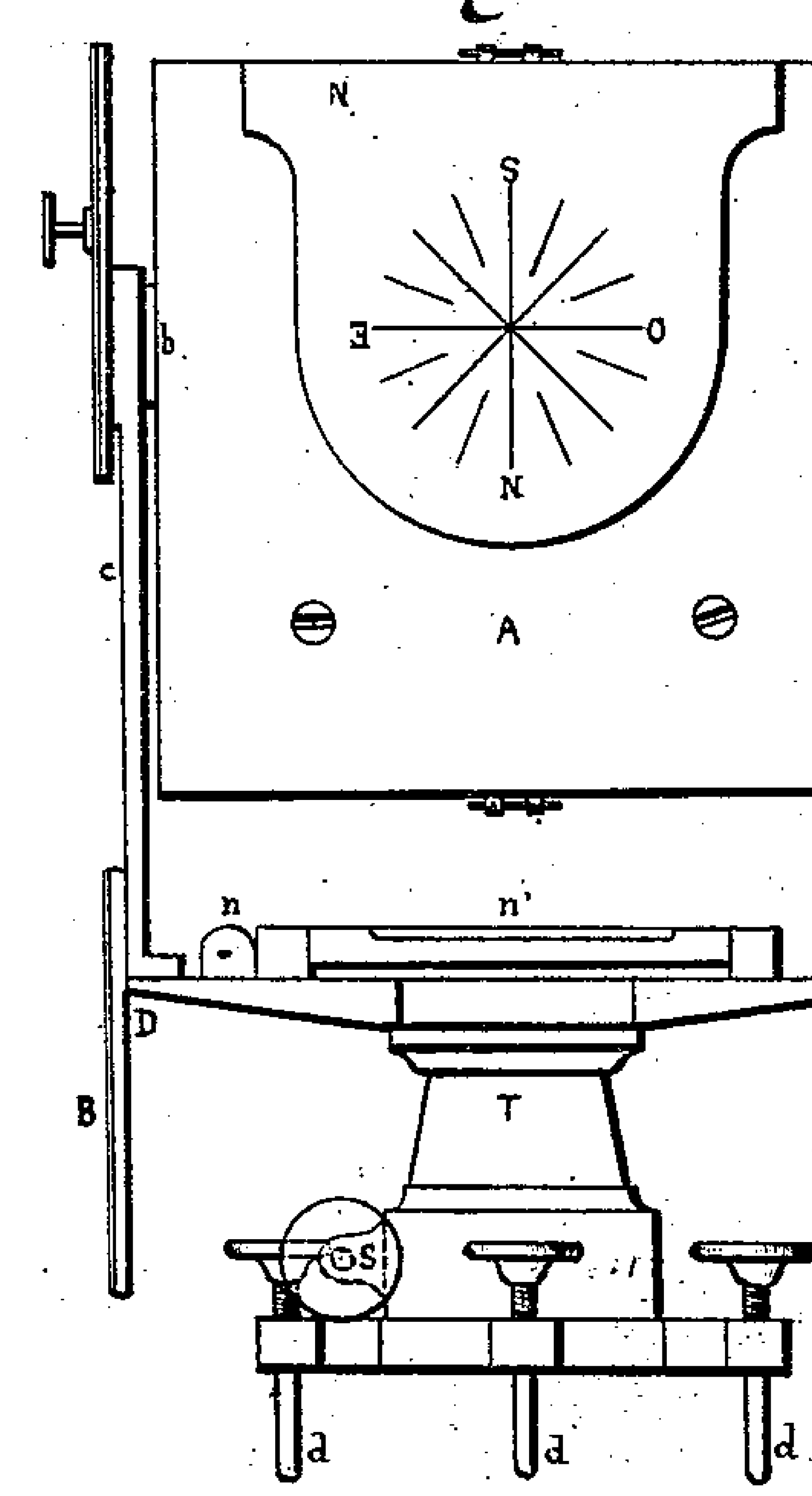



Fig. V.

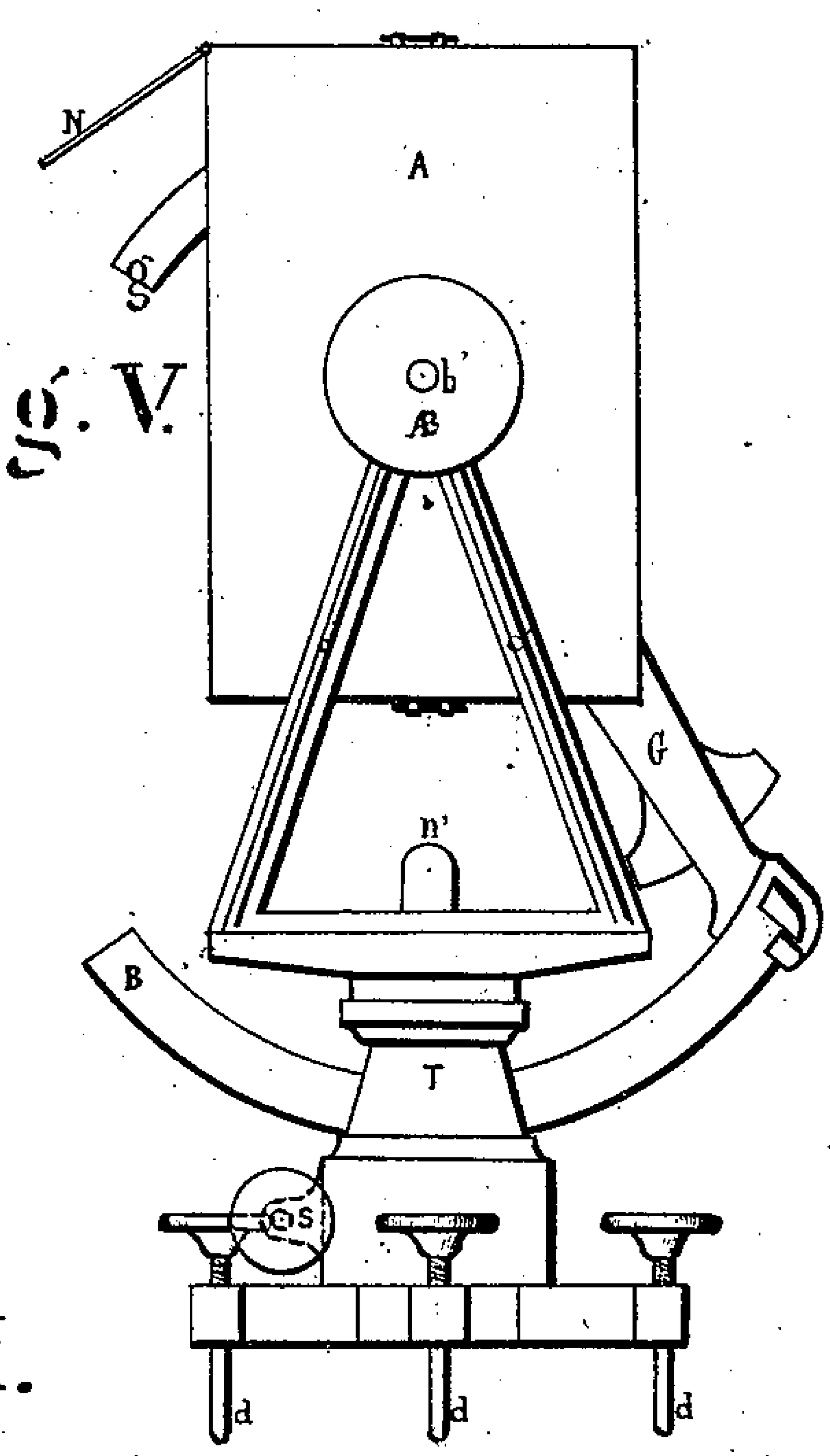
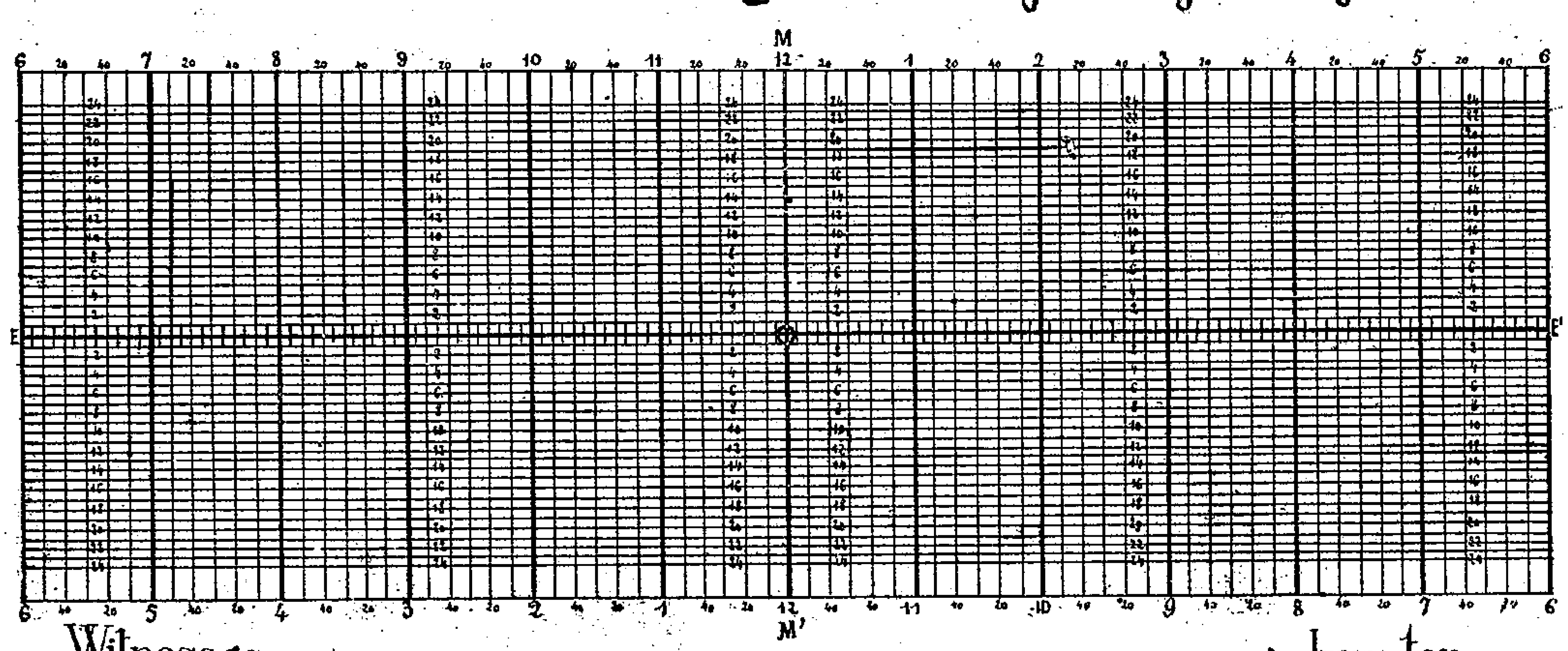



Fig. VI.




Witnesses

Inventor

N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

2 Sheets—Sheet 2.

F. M. PANNETRAT.

Time Instrument.

No. 106,718. Patented Aug. 23, 1870.

Fig.VII.

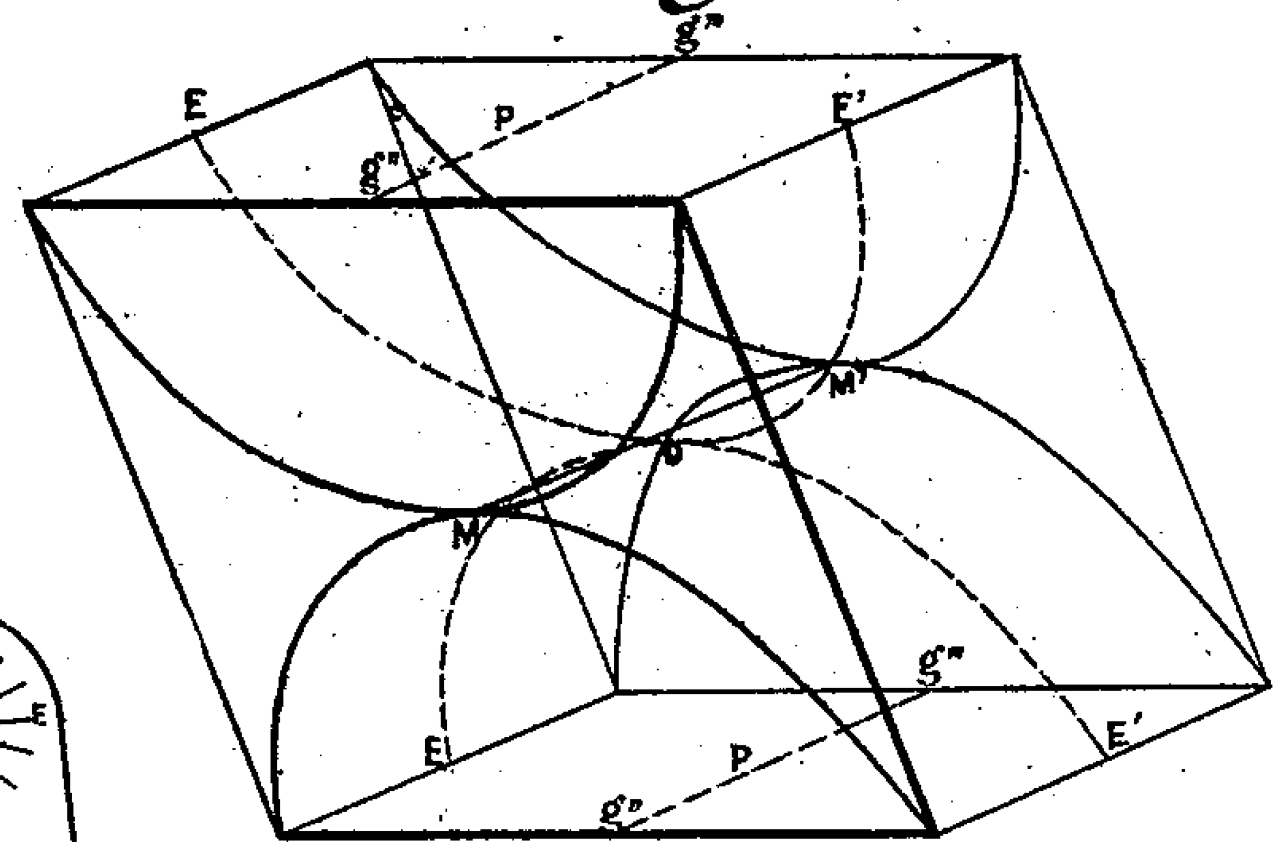


Fig.VIII

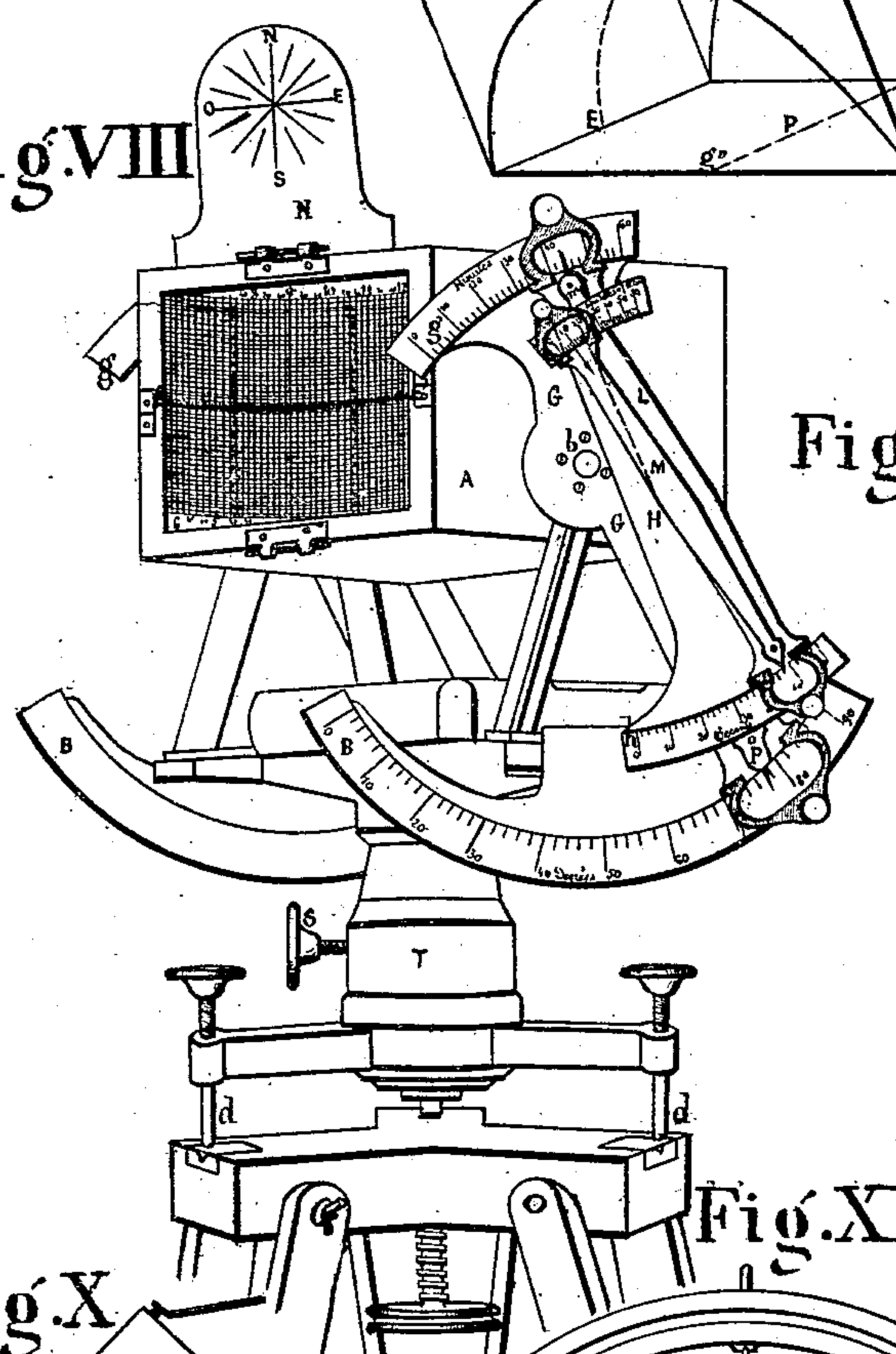


Fig.IX

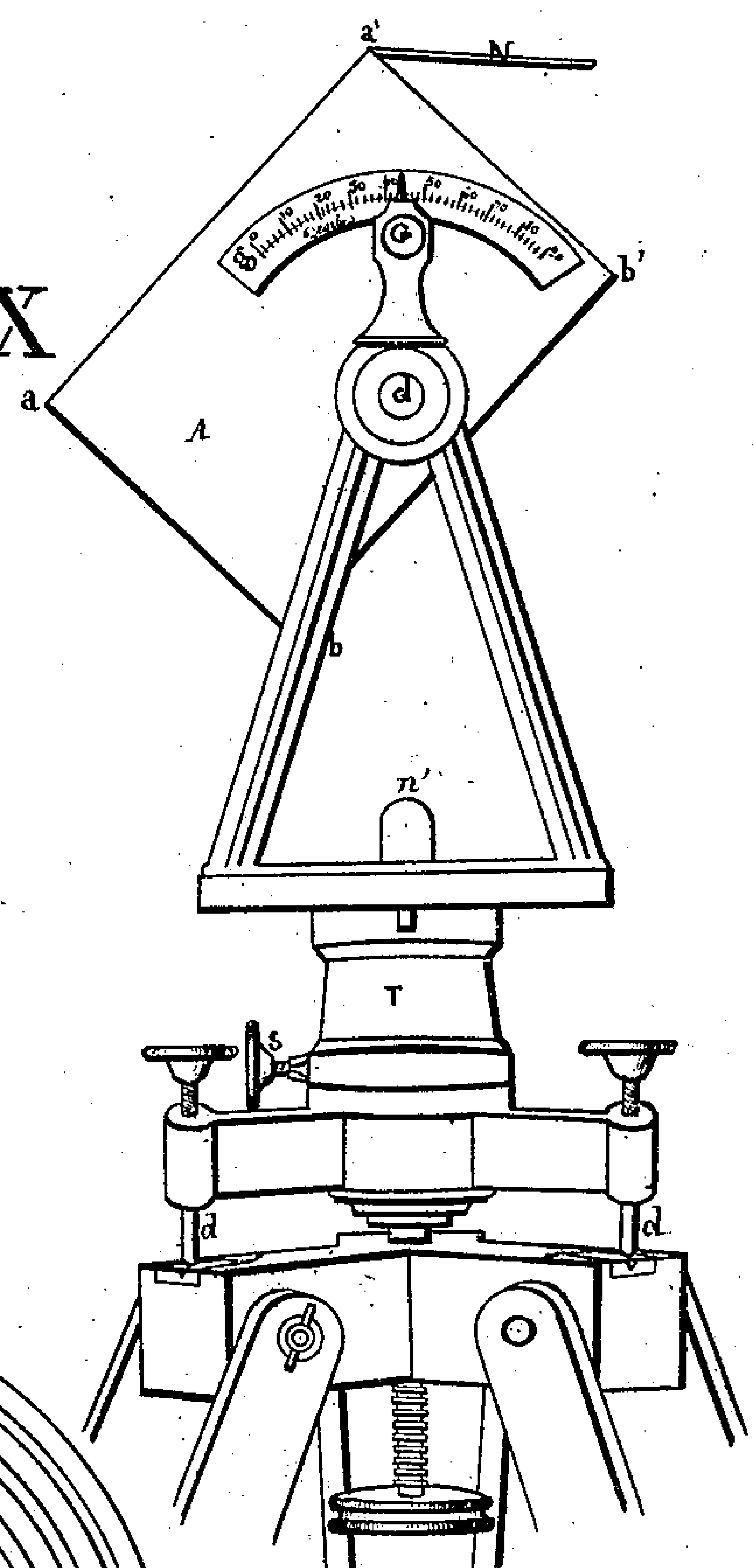


Fig.X

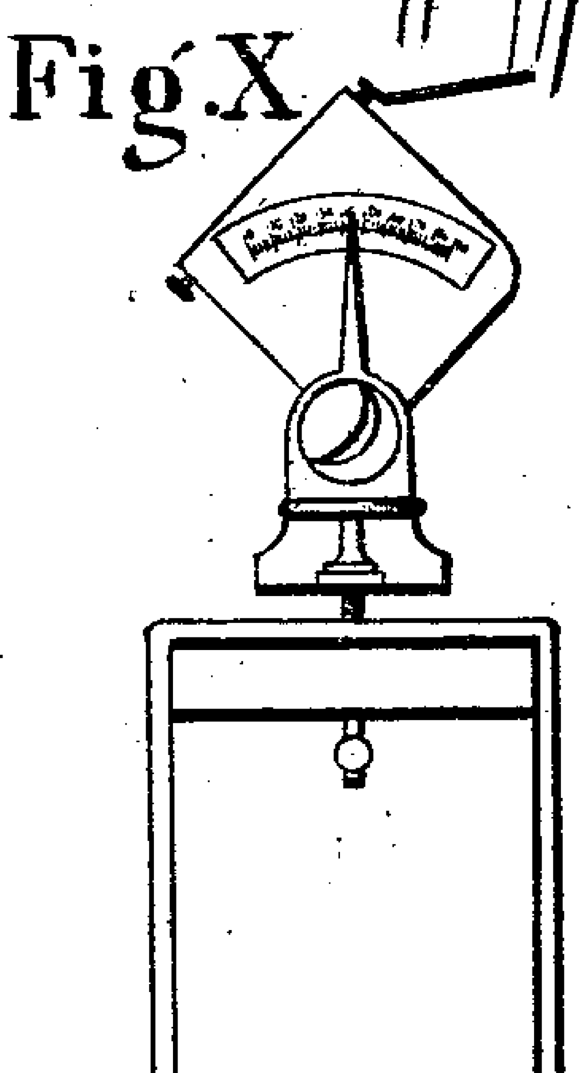


Fig.XI.

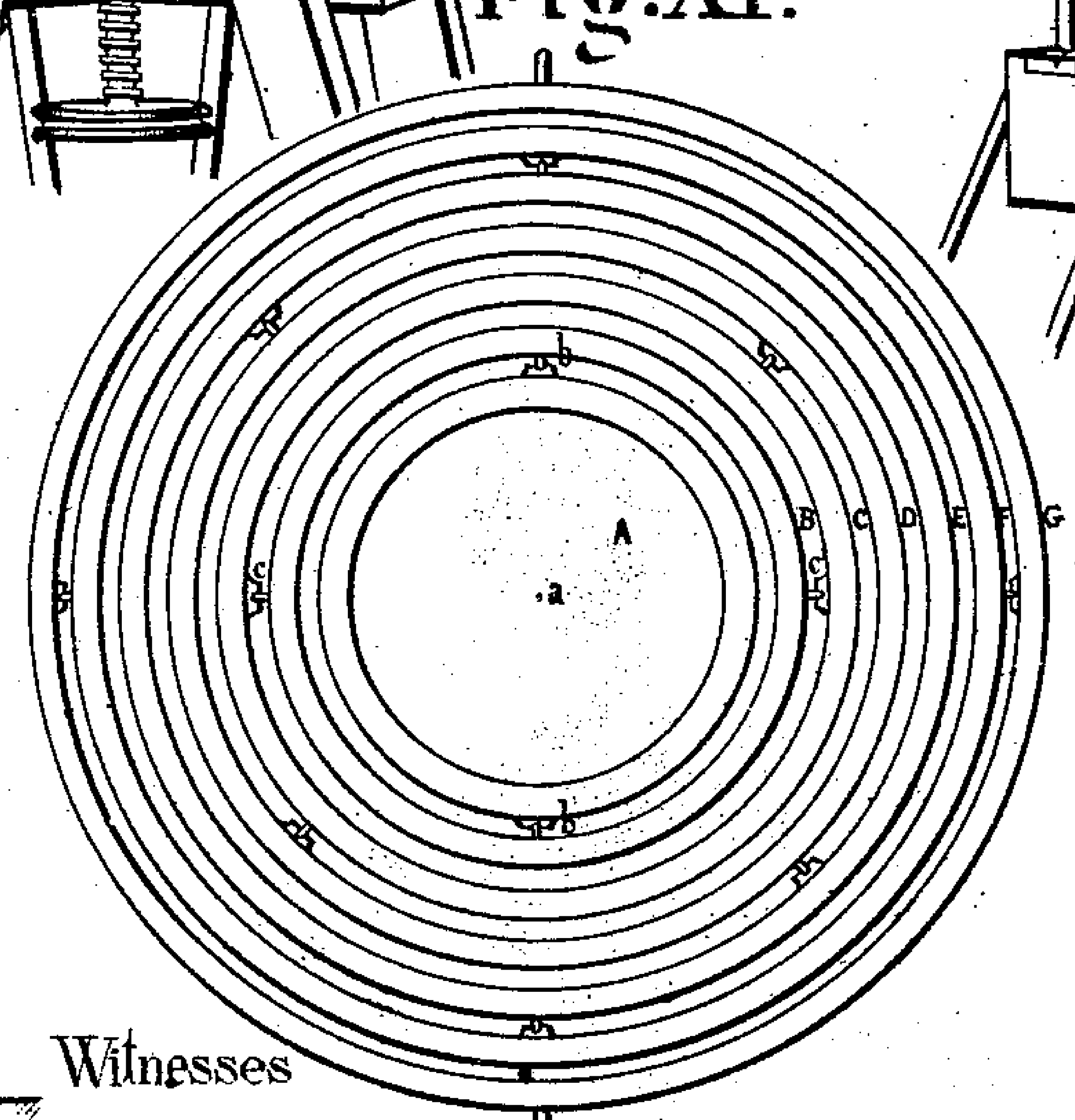
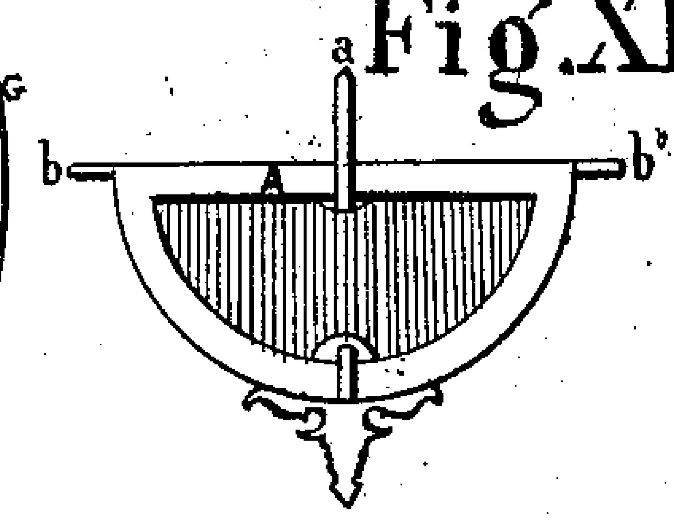


Fig.XII.



Witnesses

H. Bonneville

H. Norton

Inventor

F. M. Pannetrat

N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

# United States Patent Office.

FRANÇOIS MARTIN PANNETRAT, OF PARIS, FRANCE.

*Letters Patent No.* 106,718, *dated August* 23, 1870.

## IMPROVEMENT IN SOLAR-TIME INSTRUMENT.

The Schedule referred to in these Letters Patent and making part of the same.

*To all to whom it may concern:*

Be it known that I, FRANÇOIS MARTIN PANNETRAT, of Paris, in the Empire of France, have invented a new and improved Astronomical Instrument called the Heliade, by means of which is obtained the true time at mid-day, or at any other moment of the day, the latitude, the longitude, and the meridian-line; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawing and to the letters of reference marked thereon.

In these drawing—

Figures I, II, III serve to demonstrate the principle on which this instrument is based.

Figure IV is a front view, and

Figure V, a side view of the said instrument, with a series of alidades and dials on one side, and on the other a metal disk, B, to counterbalance the weight of the alidades and dials.

Figure VI is the developed plan of the interior of the box making part of this instrument.

Figure VII is a graphical view of the said interior undeveloped.

Figure VIII is an oblique view of the instrument, with a series of alidades and dials on each side of the box.

Figure IX is a side view of an instrument, with a single demi-cylinder.

Figure X is a small pocket instrument, its case serving as its support.

Figures XI and XII are, the former a plan of a balance doubled and multiplied; the latter a vertical section of the leg of the same, for maintaining the equilibrium of the instrument.

This invention relates to an instrument intended to measure, with the help of the sun, in all places in the world, on land or on sea, first, the true time of mid-day, or, in other words, the moment of the passage of the sun over the meridian; second, the latitude at all times of the day, as long as the sun is above the horizon, the true time being known; third, the true time of the place where one may be at every instant of the day, the latitude being known, approximatively; fourth, the longitude of the place where one may be; fifth, the meridian-line, or true north and south line, and, consequently, the declination of the compass, or the variation.

If this instrument does not lead to the complete suppression of the sextant and other reflecting-instruments, of the chronometer, and of the compass, at least it will be found indispensable for controlling and regulating with nicety these different instruments and the operations effected with them. It dispenses almost entirely with all calculations, and reduces the observations to a great simplicity, and, at the same time, insures an exactitude almost mechanical. It does not, consequently, demand any deep theoretical study. It is independent of atmospheric influence. Finally, it has the advantage of being capable, if necessary, of replacing, alone, all the other instruments, viz., sextant, chronometer, and compass.

The size of this instrument is variable. It may be reduced to the size of a large snuff-box, and thus carried in the pocket; or, if great exactitude and precision are required, this size may be proportionately increased.

It is important, before entering into the explanation, to give an idea of the problem to be solved. This will be done by referring to Fig. I of the accompanying drawing, which also sets forth the relations between the instrument and the terrestrial globe.

Suppose D the place whose position is to be determined on the sphere represented by the circumference E *g′* E′ *g*, and whose axis from one pole to the other is shown by the line *g g′*, and the line E E′ indicates the equatorial plan, it is required to find what distance separates the point D from the point E, or, in other words, from the equatorial line, that which is effected by astronomically measuring the distance from the point Z′, zenith of the observer, to the point Z, equatorial zenith, by drawing from the points Z and Z′ the lines Z E E′ and Z′ D D′, which meet at the point P, the center of the sphere; we have the two angles E P D and D′ P E′, equal to one another, as also the arcs E D and D′ E′, both similar to the arc Z Z′. Consequently, if a method of any description enables one to measure the arc D′ E′, the measure of the arc Z Z′ will be obtained, also, and, therefore, that of the arc E D. It is precisely this that this instrument is intended to effect.

This instrument consists of a rectangular box, A, hung so as to turn on two pins, *b b′*, and whose axis passes through the center of the volume of the box in the direction of its length.

The axis of the two standards *c c′* is perpendicular to the base D D′, which pivots horizontally, at T, on a support, whose legs, *d d d*, are composed of screws, by means of which the base may be maintained in a perfectly horizontal position, which forms an essential condition for the exactitude of the observations.

This true horizontal position is ascertained by means of two water-levels, *n n′*, fixed, at right angles, on the base.

A screw-nut, *s*, serves to arrest the pivoting movement when the box is in the desired position.

Inside the box are two hollow demi-cylinders, with their convex parts standing back to back at the center of the volume of the box, (see Fig. VII.) Their bases form exact half circles.

These cylinders are graduated in their concave part by means of lines parallel with the hemicycle of the base, and of others perpendicular to the first, and parallel with the generating-line of the cylinder. Fig. VI represents these graduations developed in a plan.

Thus arranged, these two demi-cylinders represent exactly, each of them, the section of a part of one of the hemispheres included between the two tropics, (see Fig. II,) graduated in its concave, instead of in its convex part.

The line E E', (Figs. II, VI, and VII,) which divides the longitudinal lines into equal parts, represents the equator; the others, above and beneath, marked 0 to 24, represent the degrees of boreal and austral declination of the sun from one tropic to the other. The distance intervening between said lines increases gradually from the first (the nearest to E E', which is marked zero) to the last, according to the principle demonstrated, Fig. III. Thus, by taking the line *g g'* as the axis of the earth, the point P as the center of the sphere, the arc *g* 0 *g'* as a meridian, the point 0 as one of the points of the equatorial line, the points *a b c* as degrees of intertropical latitude, and then if from the center P two radii are drawn, which, after cutting the circumference at the points *a b c*, extend far enough to meet the tangent M M', it is clear that the divisions 8, 16, and 24 increase in proportion as they depart from 0, in a progression of which it is important to take account, for the greater precision of the observations.

The other lines, perpendicular to the former, and equidistant from one another, are the meridians. The middle one, M M', marked 12, (see Fig. VI,) being the generating-line of the cylinder, represents the midday of the place, and the other to the right and to the left, marked 1 to 6, and 6 to 11, the horary lines of the diurnal arc, with subdivisions, by fractions, of 2° 30', say ten minutes of time.

A thread, *g'' g'''*, Fig. VII, perpendicular to the long sides of the box, and corresponding exactly to the line M M', serves as axis to each of the demi-cylinders.

At the center of this thread is a knot, P, which should correspond with the point 0 or ⊕ of the line M M'.

In order to obtain this precision, the thread is retained in *g'' g'''* by screws, which enable one to bring back the knot to the center, which is determined by placing a second thread in the length of the box from E to E', the extreme points of the equatorial line. The place where this second thread will cut the first will be the precise center sought for. The thread *g'' g'''* thus represents the axis of the earth, of which the knot is the true center, (see Figs. II and III.)

On a board, N, attached, by hinges, to one of the large sides of the box, so as to remain applied, or to be withdrawn, at will, exists a compass-card, whose north and south line is precisely in the plane of the thread *g'' g'''*, and of the line M M'.

This board may be equally well placed on either side of the box, provided that, whatever be the slope of this latter, the said board be held horizontally. It could also be so arranged as to act, at the same time, as cover or lid to the box.

The upper demi-cylinder serves for the observations from 6 a. m. to 6 p. m., the lower one before 6 a. m., and after 6 p. m., in high latitudes, or when the sun is continually at the edge of the horizon, that is to say, in the polar regions. And, as this latter is very rarely used, it could, with a view of simplification and economy, be suppressed, as shown in Fig. IX.

At the foot of one of the vertical standards is fitted a quarter circle, B, graduated from 0 to 90.

An alidade, G, is fixed to rest at the axis *b* of the box, which axis is the center of the circle of which the dial B is an arc, so that, by running the alidade on the dial, a rotating motion is imparted to the box, which slopes, and describes, on the plan E' P E O, (see Figs. II and VII,) an arc exactly similar to that described by the alidade on the dial.

This dial could rigorously suffice if the alidade were furnished, like those of sextants, with a vernier or nonius giving the minutes and the seconds, and, according to the size of the instruments and the degree of precision required, the observation may be arrested here. Nevertheless, to attain a higher degree of exactitude, it will be better to apply the following improvement to the instrument:

At the top of the alidade G a second dial, *g*, will be seen. A second alidade, H, is attached by a pin onto the first, at the point *p*, which is the center of the circle of which the dial *g* is an arc; this latter alidade plays in the contrary direction to the first, G. At the head of this second one, that is to say, on the prolongation of the radius under the center, *p*, and forming with it a broken line, exists a little hand, which exactly covers the indicating stroke of the alidade G. The indicator of the alidade H is then, at the extreme left of the dial *g*, destined to give the fractions of degrees in minutes. To divide this dial, the alidade H is first placed in this position, and in front of the indicating stroke on the alidade, on the dial *g*, is traced a line which is the prolongation of said stroke, and marked O. The indicator G being then placed in front of any degree-line but zero on the dial B, the alidade H is run out until its head hand, changing from right to left, has measured, backward on the dial B, the space of a degree, that is to say, until its point is found exactly in front of the division which precedes that marked by the indicator G. The indicator H has then passed to the extreme right of the dial *g*, on which is traced a stroke marked 60, which is the prolongation of the stroke of the indicator of the alidade, and the arc intercepted by the two points 0 and 60, similar to the arc described by the hand, is divided into sixty sections, equivalent to as many minutes.

In order to obtain the complement of fractions a third dial and alidade are required. This third dial, *h*, is on the pin of the alidade H, upon which the third alidade, L, is fixed by a pin at *m*. This latter is the radius of the circumference, of which the dial *h* is an arc. Its head has a hand which fulfills, in relation to the divisions of the dial *g*, the same functions as the one placed at the head of the alidade H in relation to the divisions of the dial B. To the extreme left of the dial *h* the line O is traced, being a prolongation of the stroke of the indicator L, and the same proceeding is effected as before, dividing into sixty parts, which will represent seconds, the space run over by this indicator on the dial *h*, while its hand will have measured backward one of the divisions of the dial *g*. By this means, if it is judged necessary, fractions of one-third may be taken into account; for this purpose a fourth alidade, M, being pinned to the end of the alidade L, indicator of seconds, whose indicating stroke, at its point, is run on a fourth dial, placed on the pin of the alidade L, which dial has been divided into sixty parts, which are thirds of seconds, in the same way as the others, by means of the hand at the head of the alidade M.

It will be understood that a number of combinations could be included in the construction of an instrument on this principle, each of which would be preferable according to the requirements of the accompanying circumstances, that is to say, according to the importance, more or less considerable, of the questions of weight, volume, and delicate nature of such an instrument.

Fig. VIII represents the same, with a double play of alidades and dials, one on each side of the box—

an improvement which not only affords greater convenience, but is also an extra guarantee for evenness and for precise solutions.

In Fig. IX, which represents, as above described, an instrument with but one demi-cylinder, viz., the upper one, the axis of suspension and rotation of the box, instead of passing through the center of the volume, is lowered, so as to pass continually through the point O, (see Figs. II, III, and VII,) which, in this case, lies directly on the bottom, being intended specially to realize a reduction in the general proportions of the instrument, principally in the height, and thus necessitates certain modifications in the measuring apparatus. Consequently a single dial, *g*, is fixed, not to the foot of one of the standards, but to the right-hand corner of one of the small sides of the box itself, so that the first stroke of this dial to the left, marked zero, is entirely included in the supposed plan, E P E′ O, Figs. II and VII. A single alidade, G, which is firmly connected to, and extends in a vertical direction from, the corresponding standard on the axis of the pin *d*, serves to mark the divisions of the dial, which are only degrees. To trace these divisions the box is caused to turn in such a way that the sides *a b a′ b′* change the vertical position they occupy for a perfectly horizontal one. This results in the supposed plan E P E′ O, also changing from vertical to horizontal, after having run over an arc of ninety degrees, which the indicator of the alidade will have duly registered on the dial. In coincidence with this indicator another line is then traced to the right of the dial, which is marked 90, and the space included between these two extreme lines is divided into ninety fractions, each representing one degree.

Fig. X is a small pocket instrument, its case serving as its support.

To effect an operation, that is to say, an observation, all the indicators should be brought onto the zeros, commencing with the indicator of the thirds, if the instrument has one; otherwise by the one denoting seconds, then the minutes, and finally the degree. For this purpose the box should be perfectly perpendicular; in other words, the supposed plane which passes in E O E′ P, Fig. II and Fig. VII, ought to be quite vertical. The line Z′ D P D′, Fig. I, that is to say, the terrestrial ray, in its prolongation as far as the zenith of the observer, passes infallibly through the points O P of the Figs. II, III, and VII, inasmuch as the graduated demi-cylinder represents the lower hemisphere *g* E′ *g′*, Fig. I, of the planet. This condition of verticalness is simply a question of level.

To find the exact time of mid-day with this instrument, (this problem being in relation and essential for the solution of all others,) and without the aid of any other, the observations should commence at the moment that the sun is approximately judged to be on the point of reaching its greatest height, that is to say, of passing over the meridian. The operation is then pursued as follows:

The base being perpendicular, and the indicators on the zeros, the instrument is so placed that the box, in turning on the axis *b b′*, slopes toward the sun, that is to say, toward the south, if the observer is in the boreal hemisphere, and toward the north if in the austral hemisphere.

We shall only speak of the observations made in the boreal hemisphere, and of those with the upper demi-cylinder, as all the other observations are identical.

The instrument is then set by turning the base horizontally from right to left, or from left to right, on the point T, until the shadow of the thread *g″ g‴* exactly covers the line of the meridian M M, Figs. VI and VII; then, still maintaining it thus, the box is turned vertically, by pushing the alidade G on the dial B, until the shadow of the knot reaches the intersection of the line M M′, and of the longitudinal line, which represents the declination of the sun calculated for the day, (for this, a knowledge of the time-tables, or, at least, of ephemeris giving the equation of time and the declination of the sun, is requisite.) It is evident that if the declination is boreal, the observer being in the boreal hemisphere, the shadow of the knot will fall below the line E E′; if, on the other hand, the declination is austral, it will fall above the same.

Suppose the first hypothesis. The shadow of the knot is thus below the line E E′, as long as the sun rises this shadow will incline to descend, which will necessitate the prolongation of the vertical movement of the box, so as to maintain this shadow on the desired line. A fugitive but appreciable moment will at last arrive when this shadow will become stationary before inclining to reascend; it is this passing but appreciable moment that must be arrested to rapidly fix the box by the screw of the alidade G which will be the precise time of mid-day, in other words, the precise instant the sun passes over the meridian and inclines to redescend.

Observation being then taken of the figure of the divisions marked by the alidade G on the dial B, the exact latitude of the place is obtained; this alidade, which, as previously mentioned, pivots on the same axis, and, at the same time as the box, having described on this dial an arc similar to that described by the box in its revolution toward the sun. Under this new condition the line E′ P E Z, Fig. I, that is to say, the terrestrial radius, in its prolongation to the equatorial zenith, passes through the points O P, Fig. II, III, and VII, instead of the line D′ P D Z′, and the arc Z Z′ is measured.

It is now that the lines of declination present their great importance. If the terrestrial axis were unchangeably perpendicular to the plane of the ecliptic the sun would be continually at Z at mid-day with regard to the observer D; but it is not so, and, for example, if it be supposed at any other point S of the intertropical zone, Fig. I, it is evident that by inclining the box representing the lower hemisphere *g* E′ *g′*, so that the shadow of the knot may fall on the central point ⊕, the arc Z′ S will alone have been really measured, and, to the measure found, it will be necessary to add the known measure of the arc S Z. (If the sun was in the other hemisphere it would have to be deducted.) This work is avoided by this instrument, which, itself, takes account of the declination. Nevertheless, a small calculation of this nature will become necessary whenever the calculated declination presents fractions. As, in consequence of the size of the instrument, the divisions representing the degrees of declination are always too near to one another to admit of subdivisions, the fractions must at first be neglected, that is to say, the shadow of the knot must be made to coincide with the line to which it is nearest, which will of necessity give a few minutes and seconds more or less. Suppose, for example, the declination of the day to be 19° 16′, the shadow of the knot must be made to coincide with the line 19, save to add the 16′ to the figure, read on the dial after the operation. Let this figure be 45° 44′, the latitude of the place will be 46°. If the declination had been 19° 44′ the shadow of the knot would have been made to coincide with the line 20, and 16′ would have to be deducted from 45° 44′ which leaves 45° 28′.

If the indicator does not correspond exactly to a degree line on the dial B, but gives a fraction, for example, 48° and a fraction, in order to know what this fraction represents in minutes and seconds, the following operation must be observed:

The alidade H must be moved, so as to bring the hand on its head round onto the line 48 of the dial B, and the space run over in the contrary direction by the indicator on the dial *g* will determine the number of minutes. This number may itself have a fraction, suppose this number to be 34+X. To determine this fraction the same proceeding must be executed with the alidade L, the hand on the head being brought round onto the line 34 of the dial *g*; its indicator will then mark the complement of seconds on the dial *h*; suppose these seconds to be 25, the latitude found will be at half a second, nearer 48° 34′ 25″.

To find the latitude at any other time of the day not mid-day, the true time must be known, being obtained by the ordinary observations and instruments.

The box is placed in such a position that the shadow of the thread covers the horary line corresponding to the known time, and it is inclined at the same time until the shadow of the knot falls on the line of the declination, as calculated. The arc run over by the indicator to arrive at these coincidences measures, necessarily, the latitude of the place.

To find the true time at any other moment of the day than at mid-day it, is requisite to know, at least approximately, the latitude of the place where the observation is to be made. The morning and the evening a slight difference in latitude is of little importance. The indicators are arranged so as to mark the latitude, say, for example, 48° 34′ 25″. To begin, the indicator of seconds is placed on 25 of the dial *h*. It is then observed that the needle at its head has measured in the contrary direction, backward from the zero of the dial *g*, a fraction necessarily equivalent to these 25″; consequently, the alidade H has only to be run out until this hand be on the division 34 of the dial *g*, for the indicator H to measure thereon forward the 25″. In this movement the alidade's hand measures downward, backward from the zero of the dial B, the fraction equivalent to 34′ 25″, and the alidade G has only to be pushed until this hand arrives at 48 for the indicator to be in advance between 48 and 49 in the exact proportion of these 34′ 25″. The box will thus have the inclination necessary to measure the horary angle. The base is then made to pivot horizontally, so that the shadow of the knot falls on the line of declination of the day, and remains on this line. During this time the shadow of the thread is projected parallel with the horary lines to the right and left of the line M M′, Figs. VI and VII, according to whether it is before or after noon, and it passes, necessarily, from one to the other every ten minutes. As soon as it covers one of the lines the true time is obtained.

At whatever time of the day the observation is made the true time has only to be reduced to the mean time, (by the equation of time, furnished in any little work on ephemeris,) and this mean time to be compared with that of the first meridian, to have the exact longitude of the place.

During the observation of mid-day the north and south line of the compass-face, traced on the board N, is directed in the exact direction of the meridian, and, by placing a compass at the side, the variation of the compass is obtained.

To obtain on board a ship a stability sufficient to assure the constant horizontal position of the base of the instrument, in short, to neutralize the effect of the movements of the ship, recourse has been had to the double balance multiplied and combined, (see Fig. XI,) which, however, does not make a part of the instrument.

A is a board with tail-piece, and tolerably heavy, (shown Fig. XII.)

*a* is a pin, upon which the instrument can be fixed at will by means of a hole pierced in the base for this purpose.

At the center of gravity of the instrument *b b′* are pins, upon which rests and pivots the board.

B is a circle of metal which surrounds the board; inside it is provided at *b b′* with two fixed notches to receive the pins of the board outside with two pins, *c c′*, whose axis cuts the axis of suspension, *b b′*, of the board at right angles.

C D E F G are circles fitting into one another, their suspension play is in opposition, like the first mentioned, only that the axis of the circles D and F cutting one another at right angles, cut the others at angles of 45°, they are intended to neutralize the effects of the diagonal movements combined from side to side or from head to stern.

Having thus described the said invention and the manner of performing the same, I would have it understood I do not confine myself to the precise details herein indicated and represented in the drawing, as these may obviously be modified without departing from the principle of the said invention; but

What I claim is—

In connection with a box, A, having one or more semicylindrical graduated dials provided with indicating-wires, and a compass, N, and levels *n n*, one or more stationary or movable alidades, G H M, provided with suitable indicators and dials B *h g*, substantially as described, and for the purposes set forth.

F. M. PANNETRAT.

Witnesses:

H. BONNEVILLE,

H. NORTON.