

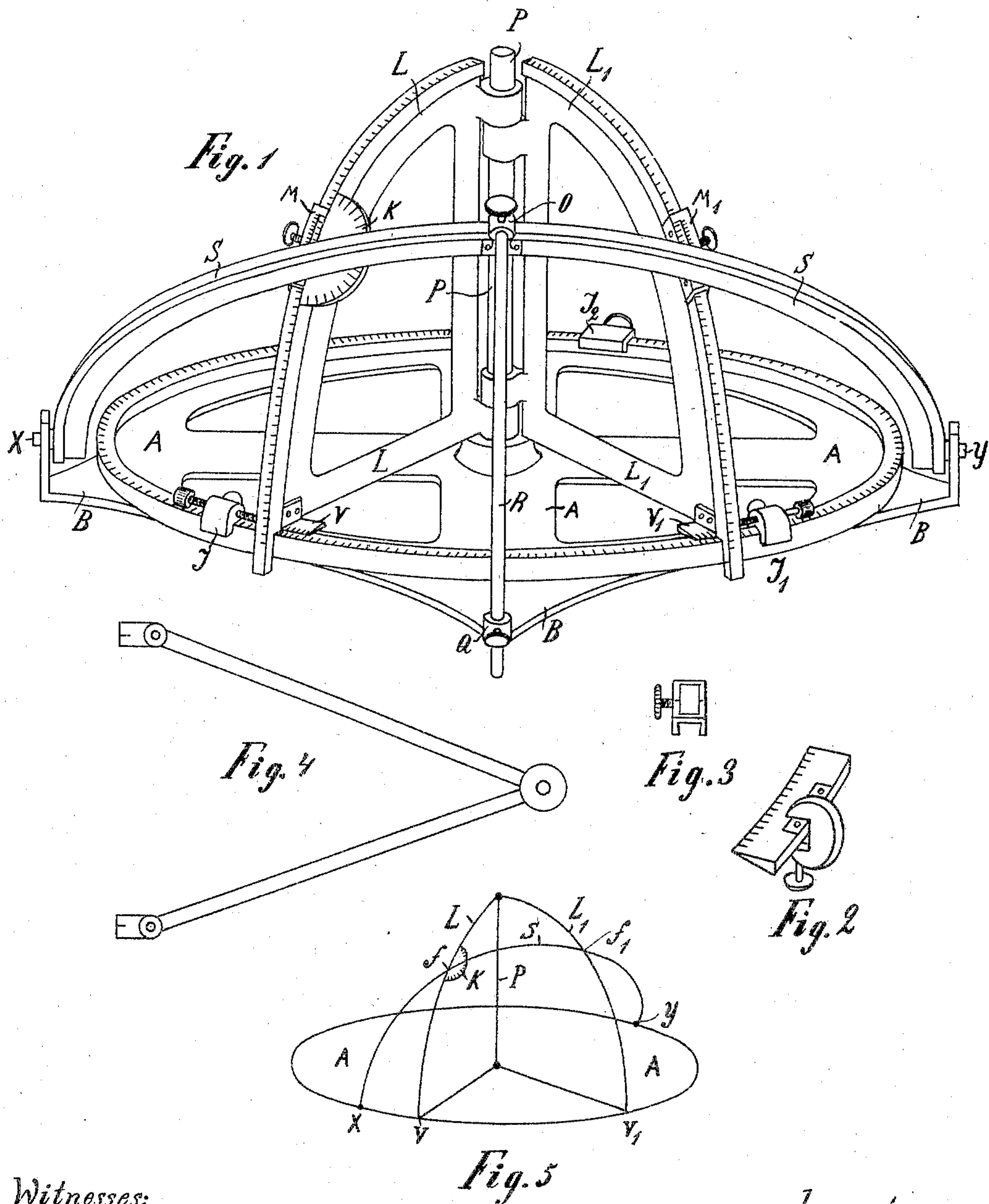
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G. PELLEHN.

MEASURING APPARATUS FOR SPHERICAL TRIGONOMETRY.

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MEASURING APPARATUS FOR SPHERICAL TRIGONOMETRY.

SPECIFICATION forming part of Letters Patent No. 780,225, dated January 17, 1905.

Application filed April 16, 1904. Serial No. 203,479.

To all whom it may concern:

Be it known that I, GUSTAV PELLEHN, map designer, a subject of the German Emperor, residing at 29 Scharrenstrasse, in the city of Charlottenburg, near Berlin, Kingdom of Prussia, and German Empire, have invented a certain new and useful Measuring Apparatus for Spherical Trigonometry, of which the following is a specification.

10 This invention has reference to an apparatus by means of which it is possible to solve all the problems of spherical trigonometry, as well as to effect the different mensurations required for mathematical astronomy and nau-
15 tics, as far as these can be effected by the aid of the spherical triangle. Besides, my new apparatus is a suitable means for initiating people in the essence of the problems referred to.

20 The principle of the new apparatus resides in arranging two graduated staples or bails, representing quadrants of a circle, upon a circular disk, so as to be rotatable on an axis passing vertically through the center of the
25 said graduated circular disk, the graduated circular disk being also rotatable on the same axis, while the said bails may be secured in position after adjustment. I also arrange a semicircular bail or staple, which is rotatable
30 on two studs and may be secured in any suitable adjusted position by suitable means and the axis of rotation of which is situated in a plane which intersects the diameter of the horizontal rotatable circular disk.

35 The construction and the purpose accomplished by the novel apparatus will be herein-after described and illustrated in detail.

On the accompanying drawings, Figure 1 represents the complete apparatus in perspective view. Figs. 2, 3, and 4 are details and accessories of the new apparatus, and Fig. 5 is a diagrammatic representation of the arrangement of the apparatus.

Referring particularly to Fig. 1, B is the
45 base or bed plate, upon which the entire apparatus is to be supported and which is fastened to a table or to a bracket secured in the wall or otherwise. In the said base or bed

plate a vertical axis P is rigidly secured by a screw-threaded section or in any other suitable manner. At the bottom part of the said axis P a disk A, the edge of which is provided with suitable recesses and on which there is a circular graduation, is arranged. This disk may be retained in any suitable position by means of a clamp J². The two graduated sector-disks L and L', which are rotatable on the axis P, are provided with graduated vernier-scales V and V', sliding on the rim of the horizontal circular disk A. These circular sectors, quadrants, or circular strips or bails L L', which are rotatable on the axis P, may be adjusted at any desired angle in relation to each other along the circular disk A and may be accurately secured in the adjusted position by means of the clamps J J', arranged on the rim of the horizontal circular disk A and, if desired, also by the aid of micrometer-screws. M and M' are graduated indicating-clamps or verniers, which are displaceable and which may be secured after adjustment along the rim of the circular sectors L and L', respectively. K is a half-spherically-vaulted segment or calotte, with compass graduation, which can be secured in position both on the rim of the circular sector L, as well as upon the circular sector L' and on the vernier-scales M and M' respectively, the vaulting of the said spherical segment being exactly corresponding to the circular curvature of the circular sectors. The meridian of the compass of this semicalotte is in the plane of the meridian which is placed in the zero-point of the graduation of the verniers V and V', respectively. S is a semicircle which is rotatably secured to suitable projections of the base-plate B by means of studs X Y. The center lines of the pivotal studs X Y are so arranged that if extended their extensions would intersect in the center of the vertical axis P, and they are situated in a plane which passes vertically to axis P through the zero-points of the graduations of the quadrants L and L'. The inner edge of the rotatable semicircular bail S is shaped so that it will make contact in any position of the bail S with the

verniers M and M' on the bails L and L' and with the surface of the calotte or spherical segment K and so that the said inner edge will show such a sharply-brought-out line on the said compass to read off or set to any angle between zero and one hundred and eighty degrees with great exactness. The semicircular bail or curved strip S may be secured in any position between zero and ninety degrees by means of a curved rod R, which is guided partly along the semicircular bail S itself and within a clamp O and, on the other hand, on the base or bed plate B within a clamp Q. The fixed end of said rod R may be in either one of these clamps. Instead of the said curved rod R, I may also use any other suitable clamping device. Fig. 2 is an illustration of an indicating-clamp which can be mounted upon the semicircular bail S for the purpose of marking former positions of the zero-points of the verniers M and M'. Fig. 3 shows a clamp which is in certain cases to be mounted on the quadrant L or L', as the case may be, in order to indicate the zero-point of the division. Fig. 4 is an illustration of a measuring pair of compasses for transferring a given measure of arc from the graduation on L or L' on to the semicircular bail S, or inversely to measure a given arc taken from the bail S. For these purposes the clamp shown in Fig. 3 is used to give zero of the aforesaid graduation in the same spherical surface as inner edge of bail S. The said clamp, however, can also be dispensed with in case the semicircular bail S is provided with circular graduation.

For the purpose of explaining the different modes of application of the new apparatus the diagram shown in Fig. 5 may be consulted, in which A represents the rotatable equator-disk, the rim of which is provided with circular graduation. P is the vertical axis of rotation. L and L' are the quadrants with circular graduation rotatable on P, and S represents the semicircular bail, which can be turned around the axis X Y and can be locked in the adjusted position.

Hereinafter some of the modes of applications of my invention will be described by way of example.

The instrument serves particularly for the purpose of sailing in a great circle in the following manner: Place of departure and place of destination may be called, respectively, f and f' . Of both these places the geographical longitudes are laid off at V and V' and also the geographical latitudes at M and M'. The compass K is secured at M at the place of departure f . The equator-clamp J² and the rod-clamps of R are loosened. Then the equatorial disk A is turned and the curved strip S is raised until the inner edge of the strip S coincides with zero-point of M and M' or center of compass K, respectively. Now the plate A and the rod R are secured in po-

sition. The reading on K' indicates the first true course on the orthodrome. The indicating-clamp, Fig. 2, is then fastened at M upon the strip S. Thereupon the micrometer-screws at M and J are actuated until the way of the ship has changed, according to requirements for the value of one or two degrees or, respectively, for the amount of a quarter ($\frac{1}{4}$) point. The reading of the latitude at M, as well as the reading of the longitude at V, gives the geographical position where the second course is to be taken up by the ship. The piece of arc on the strip or bail S between the indicating-pointer and the new location of the ship expressed in minutes at the same time indicates how many nautical miles are to be sailed on the first course of the ship.

In the case of latitudes of different names both latitudes are regarded as of the same name and are laid off; but one hundred and eighty degrees are added to the longitude of the place of destination, and then the procedure is the same as hereinbefore described until the semicircular bail S is adjusted. Then the meridian of the place of destination is swung away, and the way of the ship is then followed up along the great circle down to the equator, and thence the same way is followed up back to the place of destination.

For astronomical problems, f represents the zenith of the location of the ship, with approximate latitude and longitude, while at f' the declination of the celestial body in question is used as latitude. The difference between right ascension and sidereal time at ship are used to obtain the setting at V'. Thus in this case the real azimuth may be read off directly on K. Then the piece of the arc between f and f' on the bail S is the complement of the altitude, so that for night observations the angle of altitude can be obtained to act sextant accordingly beforehand.

With some practice and care in the adjusting operation the chronometrical longitude can quickly be obtained in a similar manner with sufficient accuracy for practical purposes. If after some days of bad weather a single star becomes visible occasionally, which disappears again after its altitude and its bearing by compass have scarcely been ascertained, the time being noted as well, then the name, or, which means the same, the astronomical dates of the star, are wanted to be used in getting the longitude. From the description hereinbefore given it follows that in this case also the instrument allows of obtaining the required data directly in a few minutes and with such accuracy that by their aid the exact data of the star can be found in the nautical almanac. The instrument while thus solving in a rapid and easy manner all the problems pertaining thereto may also be employed on all occasions where computations of this kind have to be effected from any reasons whatever—such as in schools, for instance, or where the problems

to be treated are very complicated—where by aid of this instrument a clear illustration may readily be obtained.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In an apparatus to aid in effecting navigation by spherical trigonometry, two bails with circular graduations and constituting circular sector-disks, a vertical axis on which the said bails are rotatable, the said bails being adjustable in relation to each other, a horizontal circular graduated disk mounted on the said axis and perpendicularly arranged in relation to the said circular sector-disks and being rotatable, and means to secure the disks in position, a bail constituting a semicircle and rotatable on two studs outside of the above-mentioned systems, the rotating axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned vertical axis in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, substantially as and for the purpose set forth.

2. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said bails are rotatable, the said bails being adjustable in relation to each other, a horizontal circular graduated disk mounted on the said axis and vertically arranged in relation to the said circular sector-disks and being rotatable and means to secure the disk in position, a bail constituting a semicircle and rotatable on two studs outside of the above-mentioned system, the rotating axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, substantially as and for the purpose set forth.

3. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said bails are rotatable, the bails being adjustable in relation to each other, a horizontal circular graduated disk rotatably mounted on the said axis and vertically arranged in relation to the said circular sector-disks and means to secure the disk in position, a bail constituting a semicircle and rotatable on two studs outside of the above-mentioned system, the rotating axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the diameter, the bail being adjustable in any desired position between zero and ninety degrees, two clamping-pieces displaceably arranged upon the circular sector-disks, the said clamping-pieces being provided with vernier-scales and clamping means, the said semicircular bail having its inner edge slidingly arranged in relation to the said clamping-pieces, substantially as and for the purpose set forth.

eter, the bail being adjustable in any desired position between zero and ninety degrees, substantially as and for the purpose set forth.

4. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said bails are rotatable, the bails being adjustable in relation to each other, a horizontal circular graduated disk rotatably mounted on the said axis and vertically arranged in relation to the said circular sector-disks and means to secure the disk in position, a semicircular bail rotatable on two studs outside of the above-mentioned system, the rotary axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the diameter, the bail being adjustable in any desired position between zero and ninety degrees, two clamping-pieces displaceably arranged upon the circular sector-disks, the said clamping-pieces being provided with vernier-scales and clamping means, the said semicircular bail having its inner edge slidingly arranged in relation to the said clamping-pieces, substantially as and for the purpose set forth.

5. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis on which the said bails are rotatable, the bails being adjustable in relation to each other, a horizontal circular graduated disk, rotatably mounted on the said axis and vertically arranged in relation to the said circular sector-disks and means to secure the disk in position, a semicircular bail, rotatable on two studs outside of the above-mentioned system, the rotary axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the diameter, the bail being adjustable in any desired position between zero and ninety degrees, two clamping-pieces displaceably arranged upon the circular sector-disks, the said clamping-pieces being provided with vernier-scales and clamping means, the said semicircular bail having its inner edge slidingly arranged in relation to the said clamping-pieces, a semiglobular calotte or spherical segment with circular graduation and compass-card division, capable of attachment at the said clamping-pieces at a level with the same and upon the circular sector-disks, substantially as and for the purpose set forth.

6. In an apparatus for effecting mensura-

tions by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said bails are rotatable, the bails being adjustable
 5 in relation to each other, a horizontal circular graduated disk rotatably mounted on the said axis and vertically arranged in relation to the said circular sector-disks and means to secure the disk in position, a semicircular bail, ro-
 10 tatable on two studs outside of the above-mentioned system, the rotating axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged
 15 in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the diameter, the bail being adjustable in
 20 any desired position between zero and ninety degrees, an arc-shaped curved rod on the said semicircular bail and displaceable along the same and along a rigid clamp and means to secure the said rod in position, substantially as
 25 and for the purpose described.

7. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said
 30 bails are rotatable, the bails being adjustable in relation to each other, a horizontal circular graduated disk rotatably mounted on the said axis and vertically arranged in relation to the said circular disks and means to secure the
 35 disk in position, a semicircular bail, rotatable on two studs outside of the above-mentioned system, the rotary axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis
 40 in the center and being arranged in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the
 45 diameter, the bail being adjustable in any de-

sired position from zero to ninety degrees, a separate, rigidly-secured bail with clamping device for securing the said semicircular bail in any desired position, substantially as and for the purpose set forth.

8. In an apparatus for effecting mensurations by spherical trigonometry, two bails with circular graduation and constituting circular sector-disks, a vertical axis, on which the said bails are rotatable, the bails being adjustable
 55 in relation to each other, a horizontal circular graduated disk rotatably mounted on the said axis and vertically arranged in relation to the said circular sector-disks and means to secure the disk in position, a semicircular bail, rota-
 60 table on two studs outside of the above-mentioned system, the rotating axis constituting at the same time the diameter of the semicircular bail and intersecting the above-mentioned axis in the center and being arranged
 65 in the same plane with the two zero-points of the circular graduation of the circular sector-disks, the upper edge of the semicircular bail being situated in a plane which is intersected by the diameter, the bail being adjustable in
 70 any desired position from zero to ninety degrees, means for securing the said semicircular bail in any desired position, one clamping-piece each for the circular sector-disks and displaceable and capable of attachment to the
 75 same, the inner edge of the said semicircular bail having a sliding movement on the said clamping-pieces, a half-globular calotte or spherical segment with circular graduation and compass-card division, capable of attach-
 80 ment to the clamping-pieces upon the said circular sector-disks, a base-plate, upon which the said vertical axis is fastened, substantially as and for the purpose described.

The foregoing specification signed at Berlin, Germany, this 28th day of March, 1904.

GUSTAV PELLEHN.

In presence of—

V. LE COMTE OURDAN,
 OSKAR ARENDT.