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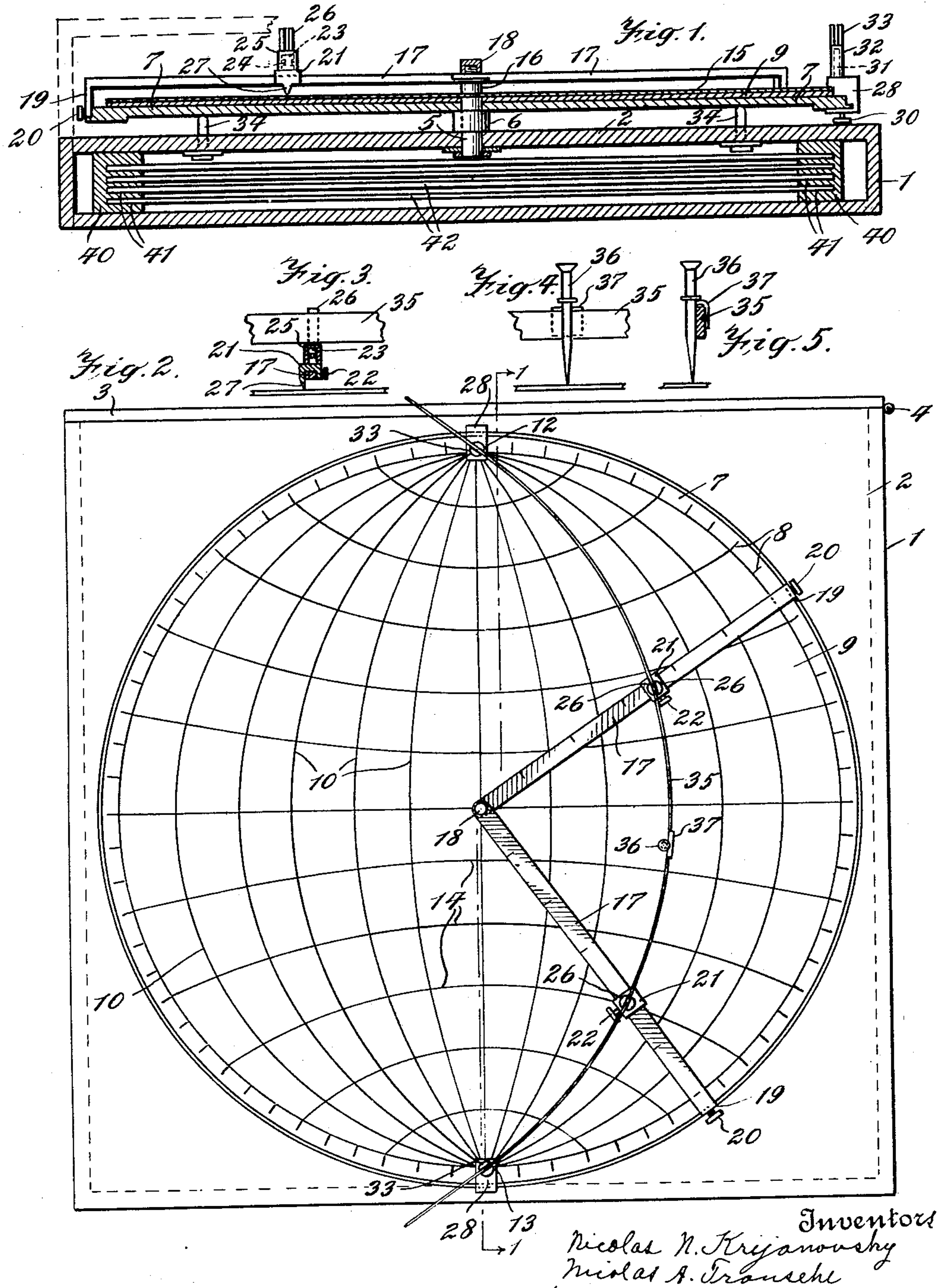

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NOMOGRAPH OR DEVICE FOR SOLVING PROBLEMS IN SPHERICAL TRIGONOMETRY

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This invention relates to a device by means of which problems in spherical trigonometry, such as problems in astronomy, aero-navigation, geography, crystallography, etc., can be quickly solved without complicated calculations in such a manner that the results can be obtained with a reasonable degree of accuracy. Nomograms or discs on which maps are provided with lines representing meridians and lines of latitude on the sphere may be used upon which the measurements are taken and the problems solved.

The invention will be understood from the description in connection with the accompanying drawing in which Fig. 1 indicates a vertical section through the device taken along the line 1—1 of Fig. 2; Fig. 2 is a plan view of the same; and Figs. 3, 4 and 5 are views on an enlarged scale showing some of the details.

In the drawing, reference character 1 indicates a box upon the top cover 2 of which the device may be mounted. The box may be provided with a front door 3 hinged as indicated at 4 for ready access to the interior of the box.

A central shaft 5 is rigidly mounted upon the cover 2 and a spacing sleeve 6 on the shaft rests upon the top of the cover 2. A disc 7 is provided with a central hole which fits over the shaft 5 and this disc rests upon the spacing sleeve 6. The edge of the disc 7 may be graduated or divided by means of lines one half of a degree apart, more or less. A second disc 9 is stationary on the shaft 5 and is slightly smaller than the disc 7. It is provided with a central hole that fits over the shaft 5 so that the disc 9 lies in contact with the upper surface of the disc 7. The disc 9 is preferably made of transparent material, but may be made of aluminum or other material.

Nomograms or maps may be provided on the disc 9. The nomograms are made up of meridian lines passing from poles at points 180 degrees apart at the edge of the disc and lines corresponding to lines of latitude crossing the meridian lines at right angles. By placing geographical maps on opposite sides of the disc so that one hemisphere is on one side and the other hemisphere is on the other side, one hemisphere is superimposed on the other in a manner similar to what would be seen if the same were observed through a transparent globe. The projecting of meridian lines or arcs of great circles 15° apart upon the disc is shown by the lines 10 in Fig. 2, which extend from one pole 12 to the opposite pole 13. Lines of latitude also 15° apart are shown by the lines 14 in Fig. 2 crossing the meridian lines at right angles.

A third disc 15 of the same size as the disc 9 and made of transparent material is provided with a central hole that fits over the shaft 5. The discs 7 and 15 are both revoluble around the shaft 5 with respect to each other and also with respect to the disc 9, which is not revoluble. A spacer sleeve 16 is provided above the disc 15 and hands 17 are pivoted on the shaft 5 above the spacer sleeve 16. A nut 18 may be screwed upon the upper threaded end of the shaft 5 to keep the parts in position. The outer ends of the hands 17 extend downwardly and are provided with set screws 20 so that the ends of the hands can be clamped into any adjusted position along the edge of the disc 7.

The hands 17 are marked off or graduated in degrees and a sliding block 21 is provided on each hand. A set screw 22 extends through the side of the block 21 so that the block can be adjusted to any position on the hand and kept in place. The block 21 is provided with an upward extension 23 that has a groove 24 around it. A revoluble cap 25 fits over the extension 23 and is provided with a pin or set screw, the end of which extends into the groove 24 to prevent the cap from becoming displaced and still permit the cap to turn with respect to the extension 23. The cap 25 is provided with two spaced parallel prongs 26 to form a passageway for a flexible strip to be described below. Each block 21 is also provided with a pointer 27 that extends into proximity to the upper surface of the disc 15, or the disc 9 when the disc 15 is not used.

Two blocks 28 are provided with set screws 30 by means of which the same may be clamped in any adjusted position around the periphery of the disc 7. Each block 28 is provided with an extension 31 similar to the extensions 23 already described, and caps 32 provided with parallel spaced prongs 33 are revolubly mounted upon the extensions 31. In addition to the spacer sleeve 6 at the center of the disc 7, supports 34 may be located between the top 2 of the box 1 and the disc 7.

A thin band of flexible material 35, such as steel for example, passes through the spaces between the prongs 33 on the blocks 28 and the prongs 26 on the blocks 21, as most clearly shown in Fig. 2. A pencil or stylus 36 is slidable along the band 35, being retained in place by means of the clamp 37 that is attached to the pencil and extends over the band.

The box 1 may be provided with strips 40 with slots or grooves 41 along the facing edges of the strips so that the discs 42 similar to the disc 9 described above can be slipped in place for safe keeping.

The following examples of solutions of actual problems are given to illustrate the operation of the device:

(*a*) A spherical triangle having one side *s* of 100° 30′, another side *t* of 40° 20′, and the included angle U of 46° 40′, is given to find the other side *u* and the other angles S and T.

The disc 9 with the nomogram on the upper surface thereof is placed upon the disc 7. The point of the angle U is placed at either pole of the lower disc 7, as indicated in Fig. 2, and a distance of 100° 30′ is laid off on the outer meridian, thus determining the point T. An angle TUS which is equal to the angle U of 46° 40′, is laid off on any convenient parallel of latitude to find the appropriate meridian and a distance of 40° 20′ is laid off on that meridian from the point U to find the point S. One of the hands 17 is turned to such a position that the pointer 27 of the sliding block 21 touches at the point S and the hand is then clamped to the disc 7 in that position by means of the set screw 22. The lower disc 7 is then revolved with the clamped hand, while the nomogram is kept fixed until the point T reaches the north pole where the point U was at first. The point U will thereby be carried around on the circumference a corresponding distance to the position U′ and the point S correspondingly to a new position S′. The side *u* is read off along the meridian in degrees from the north pole to the point S′ and is found to be 72° 40′. The angle T is read off between the side *u* and the outer meridian and is found to be 29° 30′. It only remains to find the value of the angle TS′U′ or the angle S. This angle can be read off of the nomogram directly simply by manipulating the device so that this angle is brought to the north pole with one side of the triangle lying along the outer meridian. In order to do this, the point S′ is moved along its parallel of latitude to the point S″ on the outer meridian and the point U′ is moved along its parallel a corresponding angle causing it to reach the point U″. The other arm 17 is moved into such a position that the point 27 of its sliding block 21 touches the point U″ and the hand is clamped to the disc 7. The disc 7 is then revolved until the point S″ reaches the pole. The point U″ or the pointer 27 will thereby be caused to reach the position U‴, whereupon the desired angle S is read off between two lines, namely, the meridian passing through U‴ and the line along the outer meridian toward the left from the pole, and is found to be 131° 30′.

In many of the problems that are to be solved with this device, it is not necessary to have both the disc 15 and the hands 17 because the disc 15 can be used in lieu of the hands 17, or vice versa, in many instances.

(*b*) A geographical problem combined with an aero-navigation problem will now be solved.

Two places on the earth's surface whose latitudes and longitudes are known will be taken and we will find (A) the measurement and plotting of the shortest distance between the two, which will, of course, lie on the arc of a great circle; (B) the position of an aeroplane at any moment on the flight, the speed of the plane being known; and (C) the course of the aeroplane at any point desired. We will take, for example, San Francisco in latitude 37° 48′ north, longitude 122° 26′ west; and Fayal Island, latitude 38° 32′ north, longitude 28° 38′ west. Pick out on a nomogram or a nomogram with a geographical map the point for San Francisco as determined by its latitude and longitude and do the same thing for Fayal Island. This can be done by marking the two points on a transparent disc 15, being guided by the nomogram on the disc 9, or this can be done by setting the hands 17 with the points 27 at the corresponding points, in which case the disc 15 could be dispensed with. The hands being clamped in position, the disc 7 is revolved until both points designated as above represented by the pointers 27 lie upon a common meridian. The distance along this meridian can be readily measured and will be found to be 70° 5′. This can be converted into miles by multiplying by 60 and is 4205 miles.

In order to plot the shortest distance between the two points, the spring or band 35 is inserted between the prongs 26 of the sliding blocks 21 and the prongs 33 on the blocks 28, the blocks 28 being placed at the poles and the adjustment of the band being made so that it lies exactly along the meridian. The band is frictionally held between the prongs sufficiently tight to retain it in the positions into which it is adjusted. When the band has been placed along the meridian, the disc 7 is again revolved to bring the points back to their original places, whereupon the course can be readily plotted, simply by following the position of the band. This may be done by having a special pencil similar to the one indicated in Fig. 5 for marking the line.

If it is desired to find the position of an aeroplane flying 80 miles an hour, 18 hours after it has left San Francisco, this can be done as follows: When the disc is in the position so that the pointers 27 lie upon a common meridian, as described above, the number of miles, namely, 80 x 18, is converted into degrees by dividing by 60, thus giving 24°, which can be easily measured on the nomogram when the disc 7 is in this position thus locating the point P. The disc 7 is again revolved to the original position and the point P along the course which the aeroplane has reached at the end of 18 hours will be the location on the map where the aeroplane is at that moment, and the latitude and longitude can be read off directly from the nomogram. They will be found to be 47° 40′ north latitude and 92° 0′ west longitude. The course at any point, for example, the point at the end of 18 hours flight, can be determined as follows: The band 35 is removed and the point P is moved along its parallel to the outer meridian to the point P′ and the point FI is moved along its parallel a corresponding number of degrees to reach the point F′I′. One of the hands 17 is set so that the pointer 27 of its sliding block 21 coincides with the point F′I′, and the disc 7 is then revolved until the point P′ reaches the north pole. The pointer 27 will then be at the point F″I′. The angle between the meridian from F″I′ and P′ and the outer meridian, can then be read off of the nomogram, which will be found to be about 77°, which means that the course is north 77° east at that moment.

It is not thought to be necessary to describe in detail how other problems of spherical trigonometry can be solved with this device. The solutions of the problems are quite accurate and are very much more rapid than can be done mathematically.

We claim:

1. In a device of the character described, a disc with a graduated periphery, a superposed

disc carrying a nomogram, a flexible strip, and means associated with said discs to hold said strip in predetermined positions along arcs of great circles above said discs.

2. In a device for solving problems in spherical trigonometry and the like, a disc carrying a nomogram, means whereby elements of a spherical triangle can be laid off on said nomogram, said means comprising a circular graduated member concentric with said disc and revoluble relative thereto, arms revolving around the same center, a slidable block carrying a pointer and revoluble prongs, located on each arm.

3. In a device for solving problems in spherical trigonometry and the like, a disc carrying a nomogram, means whereby elements of a spherical triangle can be laid off on said nomogram, said means comprising a circular graduated member concentric with said disc and revoluble relative thereto, arms revolving around the same center, a slidable block carrying a pointer and revoluble prongs, located on each arm, blocks having prongs thereon carried by said circular member, and a flexible guide strip held in position by said prongs.

4. In a device for solving problems in spherical trigonometry and the like, a disc carrying a nomogram, and means comprising a flexible strip and guides through which said strip slides whereby elements of a spherical triangle can be laid off on said nomogram, two of said guides being located on said disc at the respective poles of said nomogram.

5. In a device for solving problems in spherical trigonometry and the like, a disc carrying a nomogram, and means comprising a flexible strip and guides through which said strip slides whereby elements of a spherical triangle can be laid off on said nomogram, a hand pivoted at the center of said disc, two of said guides being located on said disc at the pole of said nomogram and another one of said guides being carried by said hand.

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