April 3, 1934. G. B. HAYES 1,953,804

DIVIDING ENGINE

Filed June 6, 1932 2 Sheets-Sheet 1

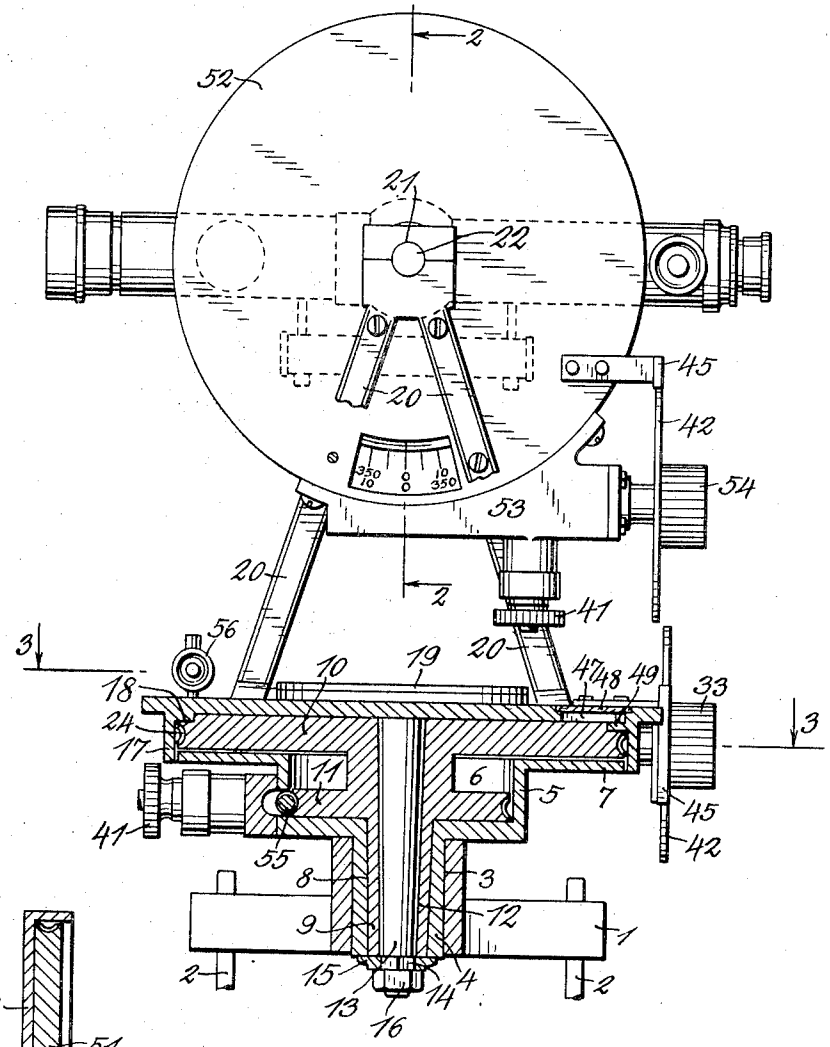

Fig. 1.

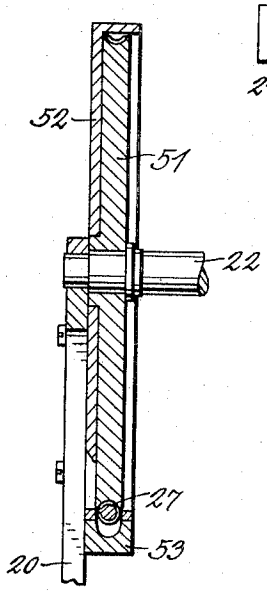

Fig. 2.

Inventor

George B. Hayes.

By A. J. O'Brian

Attorney

April 3, 1934. G. B. HAYES 1,953,804

DIVIDING ENGINE

Filed June 6, 1932 2 Sheets-Sheet 2

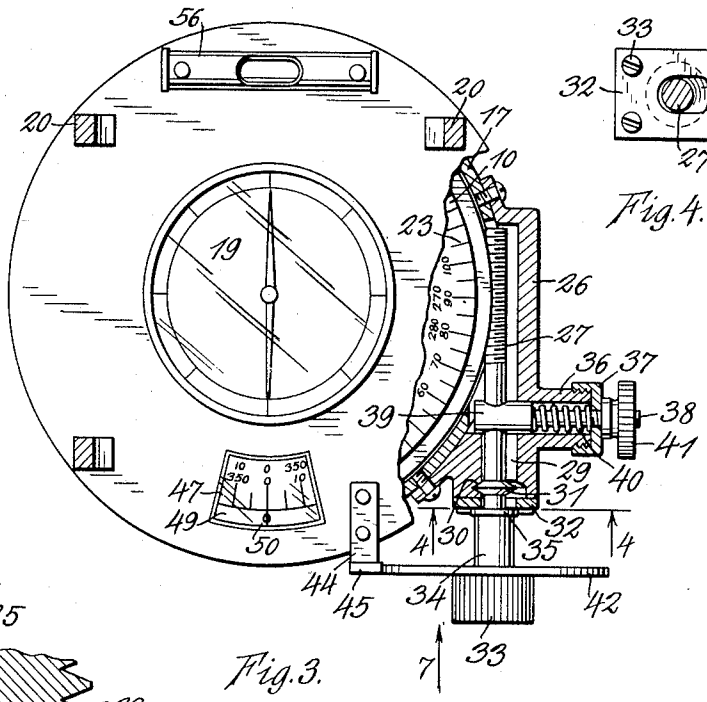

Fig.3.

Fig.4.

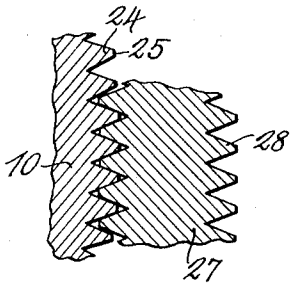

Fig.5.

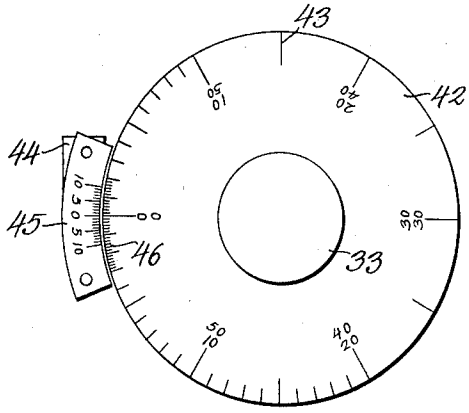

Fig.7.

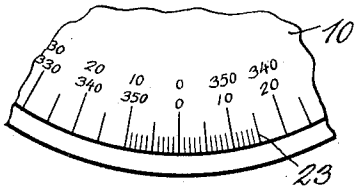

Fig.6.

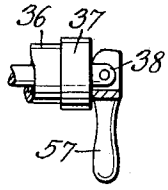

Fig.8.

Inventor

George B. Hayes.

By A. J. O'Brien

Attorney

Patented Apr. 3, 1934 1,953,804

UNITED STATES PATENT OFFICE

1,953,804

DIVIDING ENGINE

George B. Hayes, Denver, Colo.

Application June 6, 1932, Serial No. 615,607

4 Claims. (Cl. 33—69)

This invention relates to improvements in dividing engines of the type employed for dividing circles into any number of parts as when laying out gears or for use with transits and other measuring instruments.

It is an object of this invention to produce a mechanism suitable for general use and by means of which the parts operated thereby can be given a positive movement and the extent of this movement directly determined by means of the moving mechanism.

Another object of this invention is to apply to a transit or other similar mechanism the well known worm gear drive for moving the parts so that the movements of the parts can be effected by a micrometer mechanism in such a way that the angles can be read directly in degrees, minutes and seconds without the use of verniers.

A further object of this invention is to produce a worm gear mechanism in which there will be no lost motion and which has a gear ratio of 1 to 360, whereby the degree disk will be rotated to one degree for every complete turn of the worm which can therefore be provided with a minute disk divided into sixty parts whereby the movement of one space on the minute disk indicates a movement of one-sixtieth of a degree of the main disk.

A still further object of this invention is to produce a worm gear drive mechanism for transits and other dividing engines which can be readily disconnected so that large adjustments can be made without utilizing the worm gear drive.

The above and other objects that may become apparent as this description proceeds are attained by means of a construction and an arrangement of parts that will now be described in detail, and for this purpose reference will be had to the accompanying drawings in which:

Fig. 1 is a view partly in section and partly in side elevation of a transit constructed in accordance with this invention;

Fig. 2 is a section taken on line 2—2, Fig. 1;

Fig. 3 is a section taken on line 3—3, Fig. 1, and shows the upper surface of the alidade and parts broken away so as to better disclose the construction;

Fig. 4 is a section taken on line 4—4, Fig. 3;

Fig. 5 is a section through the worm gear showing the interlocking of the teeth;

Fig. 6 is a fragmentary view of the upper surface of the degree circle showing the scale, the graduations and the manner in which the numbers are placed;

Fig. 7 is a view of the minute circle looking in the direction of the arrow 7 in Fig. 3, showing its relation to the vernier segment by means of which the seconds are determined; and

Fig. 8 is a fragmentary view showing a cam that can be substituted for the screw device shown in Fig. 3 for the purpose of disconnecting the worm gear drive.

In the drawings the invention has been shown as applied to a transit of otherwise ordinary construction. The leveling head has been indicated by reference numeral 1 and this is supported in the usual manner by the leveling screws 2. The leveling head is provided with a socket 3 in which the spindle 4 of the horizontal limb 5 is non-rotatably mounted. The socket and spindle are preferably provided with a slight taper so as to assure that there will be no lost motion. The spindle has a central cylindrical recess 6 and at the top of this recess there is an outwardly extending flange 7. The spindle 4 is provided with a socket 8 for the reception of the spindle 9 of the circle plate 10. The circle plate has formed integral with it and the spindle 9 a worm gear 11, which rests on the bottom of the recess 6 in the spindle 4. The bottom of the circle plate is located a short distance above the top of the flange 7. The center of the circle plate and the spindle 9 are provided with a tapered socket 12 for the reception of the alidade spindle 13. This spindle extends completely through the different sockets and spindles and is provided at its lower end with a square section 14 to which a washer 15 is secured. A nut 16 is threadedly connected with the lower end of the spindle and serves to hold the parts in assembled relation. The washer can be made larger than shown in the drawings so as to project over the lower edge of the leveling head socket. The alidade has a downwardly extending flange 17, whose lower edge is on the level with the lower surface of flange 7. The circle plate has a cut-out or rabbet 18 in its upper outer edge and the under surface of the alidade is so formed that it will fit snugly against the upper surface of the circle plate. Located centrally of the alidade is a compass 19. Brackets 20 extend upwardly from the upper surface of the alidade and are provided with bearings 21 for the trunnions 22 of the telescope; since there is no novelty in the construction of the telescope or the brackets, these will not be described in detail. Plate 10 has its upper surface provided with a scale 23 which is graduated into 360 equal divisions, each of which represents one degree. This scale has been shown in Fig. 3 and in greater detail in Fig. 6. From the latter, it will be seen

that the graduations have been numbered from 1 to 360, but in opposite directions from the zero mark. One set of these numbers is in black and the other in red, so that they can be readily distinguished one from the other. The edge of the horizontal scale plate 10 is provided with worm gear teeth 24, whose sides are inclined at 60 degrees to each other. Although the angular inclination just mentioned is preferable, the exact degree of inclination is not material. The ends of the teeth are truncated as indicated by reference numeral 25. Secured to the circular flange 17 of the alidade is a housing 26 which contains a screw 27 that is provided with truncated V-shaped threads 28 of the proper size and shape to fit the spaces between the teeth 24. Housing 26 is held in place by means of screws and has an opening at one end which has been designated by reference numeral 29. This opening is preferably elongated or is of larger diameter than the screw 27 that extends through it and will be referred to as the bearing. The inner surface of the bearing 29 has a V-shaped groove 30 and the screw 27 has an outwardly extending V-shaped flange 31. A removable plate 32 is secured to the outer end of member 26 by means of screws 33 as indicated in Fig. 4 and prevents the screw from being accidentally removed from the housing 26. A knurled wheel 33 is secured to the outer end of the screw 27 and has a sleeve 34 that is provided at its inner end with a flange 35 that covers the opening in plate 32. The worm housing 26 has a tubular extension 36 provided with a removable cap 37. A screw 38 extends through the cap and has its inner end provided with an enlarged cylindrical portion 39 having an opening through which the screw 27 passes. A spring 40 surrounds the screw 38 between the outer end of the cylindrical portion 39 and the inside of the cap and is under compression so as to normally move the worm inwardly for the purpose of forcing the threads on the worm against the teeth on the circle plates 10 and the flange 31 into the groove 30. A knurled nut 41 is secured to the screw 38 and by rotating this nut the screw can be moved outwardly out of engagement with the threads on the circle plate so that the latter can rotate freely with respect to the alidade. Secured to the sleeve 34 is a circular plate 42 that has been shown in elevation in Fig. 7. This plate is divided into 60 equal spaces by means of short radial lines 43 and these are numbered from zero to 60. The numbering is in opposite directions so that there are two sets of numbers, each running from zero to 60 and the two sets are of different color, one preferably being black and the other red to correspond with the correspondingly colored numbers on the horizontal circle plate. As has been mentioned before, the outer periphery of the horizontal circle plate has 360 teeth and the pitch of the threads on the screw 27 is so calculated that one complete turn of this screw will turn the plate 10 one degree and since the plate 42 that is secured to the screw 27 has 60 divisions, each division represents one minute and the rotation of the plate 10 can therefore be read directly in minutes by means of the plate 42. A bracket 44 is secured to the upper surface of the alidade and extends downwardly, and has attached to it a segment plate 45 which is a vernier plate cooperating with the graduations on the plate 42 so as to read movements of one second of the plate 10. Each division on the plate 42 is divided into six by short radial lines 46 and the distance between each of these lines will therefore represent ten seconds and the vernier is so designed that it will divide these short spaces into tenths so that each reading of the vernier will indicate a movement of one second of the circle plate.

The upper surface of the alidade is provided with an opening 47 that is preferably covered with a plate 48 and the ledge or flange 49 has a line 50 indicated by zero which is used in the reading of the degrees indicated by the scale 23. If the horizontal circle plate is set at zero as shown in Fig. 1, one complete revolution of the screw 27 will rotate it one degree, and in one direction the readings are made by the black figures and if it is rotated in the opposite direction by the red figures, so that the angles can be readily determined directly from reading the scale that is visible through the opening 47 and the scale on the plate 42.

Secured to one end of trunnion 22 is a vertical circle disk 51. This disk is partially enclosed in a housing 52 that carries a removable housing 53 that contains a worm of substantially the same construction as that shown in Fig. 3 and whose knurled head has been indicated by reference numeral 54. The disk 51 is graduated into degrees in the same manner as the disk 10 and the graduations are numbered from zero to 360 in both directions from the zero mark, one set of figures being in black and the other in red in the manner already described in connection with the horizontal circle disk. The worm gear drive is constructed exactly the same as the one already described and therefore a detailed explanation will not be given, but the same reference numerals will be applied to the parts that correspond to those already shown and described.

The horizontal circle disk 10 has formed integral with it a worm gear 11 that is operated by means of a worm 55 of the same construction as worm 27 already described. By means of the worm 55 the horizontal circle disk 10 can be slowly rotated with respect to the horizontal limb 5 and is used for pointing the telescope without changing the setting of the horizontal circle disk 10 with respect to the alidade.

In operation, when an angle in a horizontal plane is to be measured, the parts are leveled by means of the leveling screws 2 and for this purpose two levels located at right angles have been provided, one of which is shown and which is indicated by reference numeral 56. After the alidade has been brought into a horizontal plane, it is adjusted so as to bring the zero mark in line with the line 50 on the flange 49, after which the telescope is rotated by means of the screw 55 so as to point it at the object from which measurements are to be made. If the angle that is to be measured is comparatively small, the alidade is rotated on the horizontal circle plate by means of the worm 27 until it points at the other objects, after which readings are taken in the manner above indicated, the number of degrees being read directly on plate 10, while the minutes and seconds are read from the plate 42 and vernier 45. If the angle to be measured is large, then the worm 27 is disconnected from plate 10 by means of the nut 41, whereupon the alidade can be freely rotated into a position approximately that which is desired after which the worm is again moved into operative relation with the plate 10, and the fine adjustments effected by means of the micrometer adjustment of worm 27. Owing to the fact that the plate 10 has 360 teeth, it will always

register with the threads on the worm at points spaced an even degree from the starting point and if the parts are set at zero before this movement is made, the movement will be a whole number of degrees after which the finer adjustments are made by the worm mechanism as described thereupon the exact angle can be read by reading the degrees from the scale on plate 10 and the minutes and seconds from plate 42.

The vertical circle plate 51 is operated in the same way as the horizontal plate and no explanation needs to be given because of this.

Instead of using the screw 41 for moving the worm out of contact with the worm gear, a cam like that shown in Fig. 8 can be used. This cam is pivoted to the end of the rod 38 and has a handle portion 57 that is normally in the position shown, but by rotating this into a horizontal position, the parts will be moved outwardly sufficient to disconnect the worm from the worm gear and in this way the operation of disconnecting and connecting the parts can be quickly made.

I have already called attention to the fact that it is very essential that no lost motion is present between the several parts because if the parts could move without moving the indicator, the readings would not be reliable. For the purpose of assuring that no lost motion can take place, the worm teeth on the several disks have been made V-shaped as shown in Fig. 5 and their ends have been truncated while the threads on the worms that cooperate with the worm teeth are also inclined in the same manner as the worm gear teeth, and have their ends truncated so that when the parts are pushed together by the action of spring 40, the worm and worm gear teeth will be in close contact so that there will be no lost motion present at the same time any wear that takes place will not effect the adjustment because the sides of the teeth will still contact on account of their V-shaped form.

To prevent the worms from moving in their bearings, the V-shaped flanges 31 engage V-shaped grooves 30 and when these parts are held together by the action of the spring 40, there is no chance for the plates to move endwise and therefore the readings will always be reliable, since no lost motion between the parts can take place.

The invention has been shown as used in connection with a transit but can be used wherever it is necessary to divide a circle into any number of equal parts, and is especially well adapted for use on gear cutting machines where an accurate division is necessary. The two uses pointed out are believed to be typical but applicant, of course, wants protection to any use to which this device can be put and the two examples mentioned are merely illustrative and are not intended as limiting the invention in any way.

Since the reading of verniers and similar scales is well understood by those versed in these arts, a detailed explanation of this will not be given as the general explanation given above is believed to be sufficient to enable any one skilled in this art to understand how to use this invention.

Having described the invention what is claimed as new is:

1. A dividing engine comprising, in combination, a horizontal limb, having a socket or bearing, a circle plate having a centrally located journal of the proper size to fit the bearing, one side of the circle plate having a circular scale graduated in degrees, an alidade having a graduation that cooperates with those on the scale, the outer edge of the circle plate having 360 worm gear teeth, the alidade having a bearing whose axis is parallel to a tangent of the circle plate, the surface of the bearing nearest the circle plate having a V-shaped groove which lies in a plane perpendicular to the axis of the bearing, a shaft having a V-shaped circular, flange whose sides are inclined to fit the sides of the groove, the worm gear teeth on the circle plate being V-shape, one end of the worm shaft having V-shaped, threads adapted to fit and cooperate with the teeth on the circle plate, resilient means for simultaneously urging the shaft towards the bearing and towards the edge of the circle plate, means for moving the threaded end of the worm shaft out of contact with the teeth on the circle plate whereby the latter can be freely rotated, a minute circle carried by the shaft, and an indicator associated with the minute circle whereby the degrees and minutes can be read directly from the disk and minute circle.

2. A dividing engine reading directly in degrees and minutes and in seconds by means comprising, a supporting horizontal limb, a circle plate mounted for rotation about a central axis perpendicular to the plane of the circle plate, one side of the circle plate having a circular scale concentric therewith, and which is graduated in degrees, the edge of the circle plate having three hundred and sixty V-shaped teeth, an alidade having a bearing for a worm shaft, the axis of the bearing being parallel to a tangent of the periphery of the circle plate, a shaft journaled in the bearing, the bearing and the shaft having a cooperating V-shaped groove and a correspondingly shaped flange for engaging the walls of the groove for preventing relative movement in the direction of the axis of the shaft, one end of the shaft having threads that engage the worm gear teeth on the disk and which have a pitch that turns the circle plate through an angle of one degree when the shaft makes one complete revolution, resilient means for simultaneously urging the shaft towards the bearing and towards the circle plate, means for moving the threaded end of the shaft away from the circle plate against the resilient means whereby the circle plate can rotate freely, a minute circle carried by the shaft and an indicator associated with the minutes circle.

3. A dividing engine comprising, in combination, a supporting horizontal limb having a socket, a circle plate having a central journal whose axis coincides with a line passing through the center of the circle plate and perpendicular to the plane thereof, the journal conforming in size and shape to the bearing, the edge of the circle plate having three hundred sixty teeth, the base having a worm housing provided with a bearing whose axis is parallel with a tangent to the circle plate, the surface of the bearing nearest the circle plate having a V-shaped groove whose sides are frusto conical surfaces whose common axis is the axis of the bearing, a worm shaft journaled in the bearing, the surface of the shaft having an outwardly extending V-shaped flange whose surfaces conform in size and inclination with the surfaces of the groove into which the flange is adapted to fit, the inner end of the worm shaft having threads adapted to cooperate with the teeth on the edge of the circle plate, the gear teeth and the threads on the worm shaft being V-shaped, the pitch of

the threads being such that one turn of the worm shaft will turn the circle plate through an arc of one degree, resilient means associated with the shaft for moving it towards the bearing so as to force the flange into the groove and the threads into engagement with the teeth on the circle plate, a disk graduated into sixty equal spaces secured to the end of the worm shaft, an indicator attached to the supporting base for cooperating with the graduated circle on the shaft, and means for moving the shaft to disconnect the threads on the shaft from the teeth on the circle plate to permit the latter to be turned freely with respect to the support.

4. A device for obtaining accurate adjustments of one member with respect to another comprising, in combination, a circle plate mounted for rotation in its own plane and about its center, the outer edge of the plate having a number of worm gear teeth of substantially V-shape, a support mounted for rotation relative to the circle plate and about the axis of the latter, the support having a bearing whose axis is parallel to a tangent of the circle plate, the surface of the bearing adjacent the circle plate having a V-shaped groove which lies in a plane perpendicular to the axis of the bearing, a worm shaft having a V-shaped circular flange whose sides are inclined to fit the sides of the groove, one end of the worm shaft being provided with V-shaped threads adapted to fit and cooperate with the teeth on the circle plate, and means for simultaneously urging the shaft towards the bearing and towards the edge of the circle plate.

GEORGE B. HAYES.