(No Model.) 3 Sheets—Sheet 1.

J. A. BOORMAN.

APPARATUS FOR PLOTTING ANGLES FOR BEVEL GEAR.

No. 400,737. Patented Apr. 2, 1889.

FIG. 1.

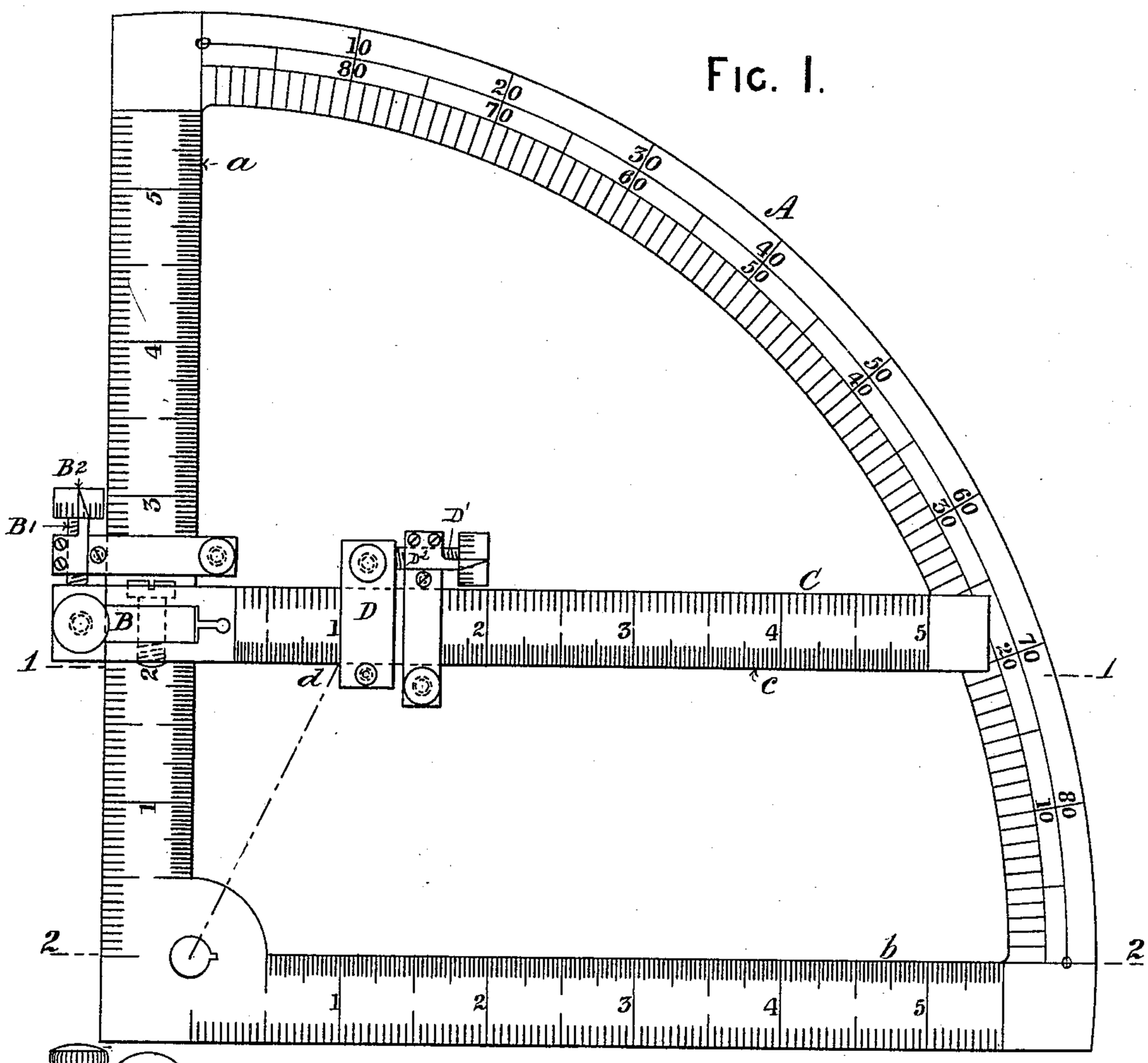

FIG. 2.

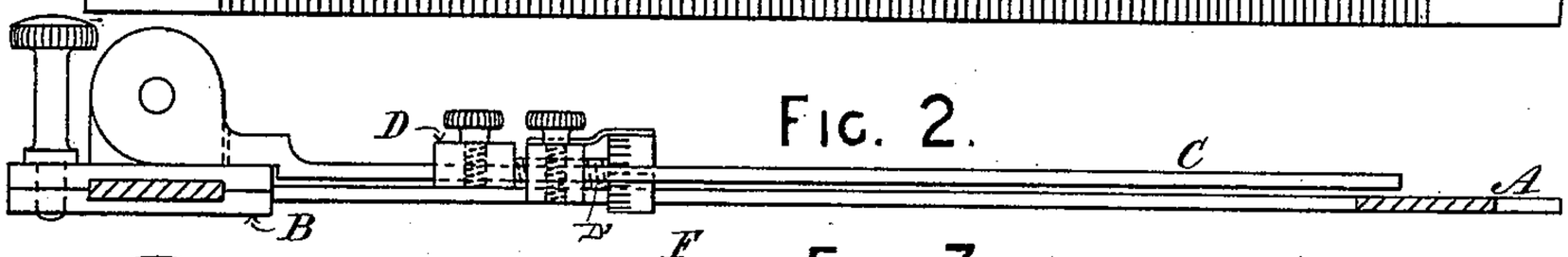

FIG. 3.

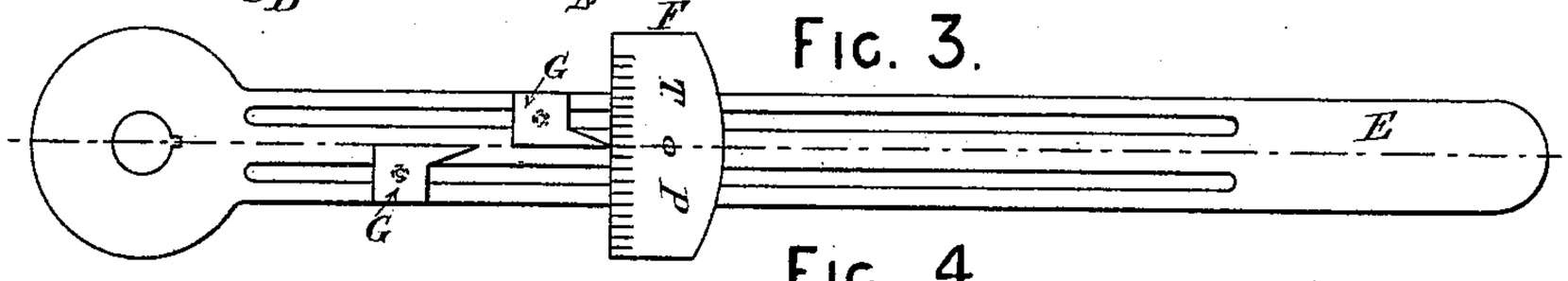

FIG. 4.

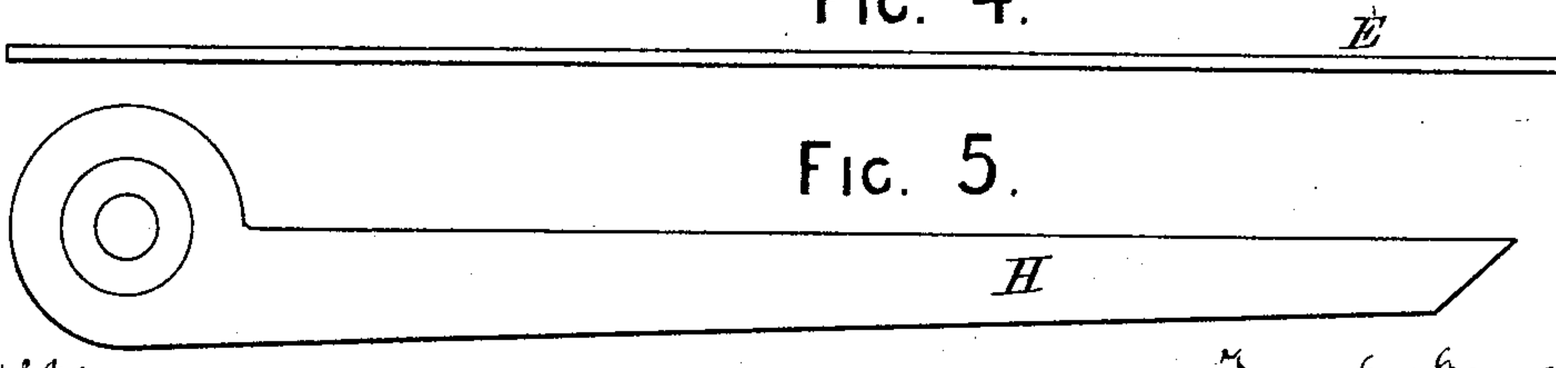

FIG. 5.

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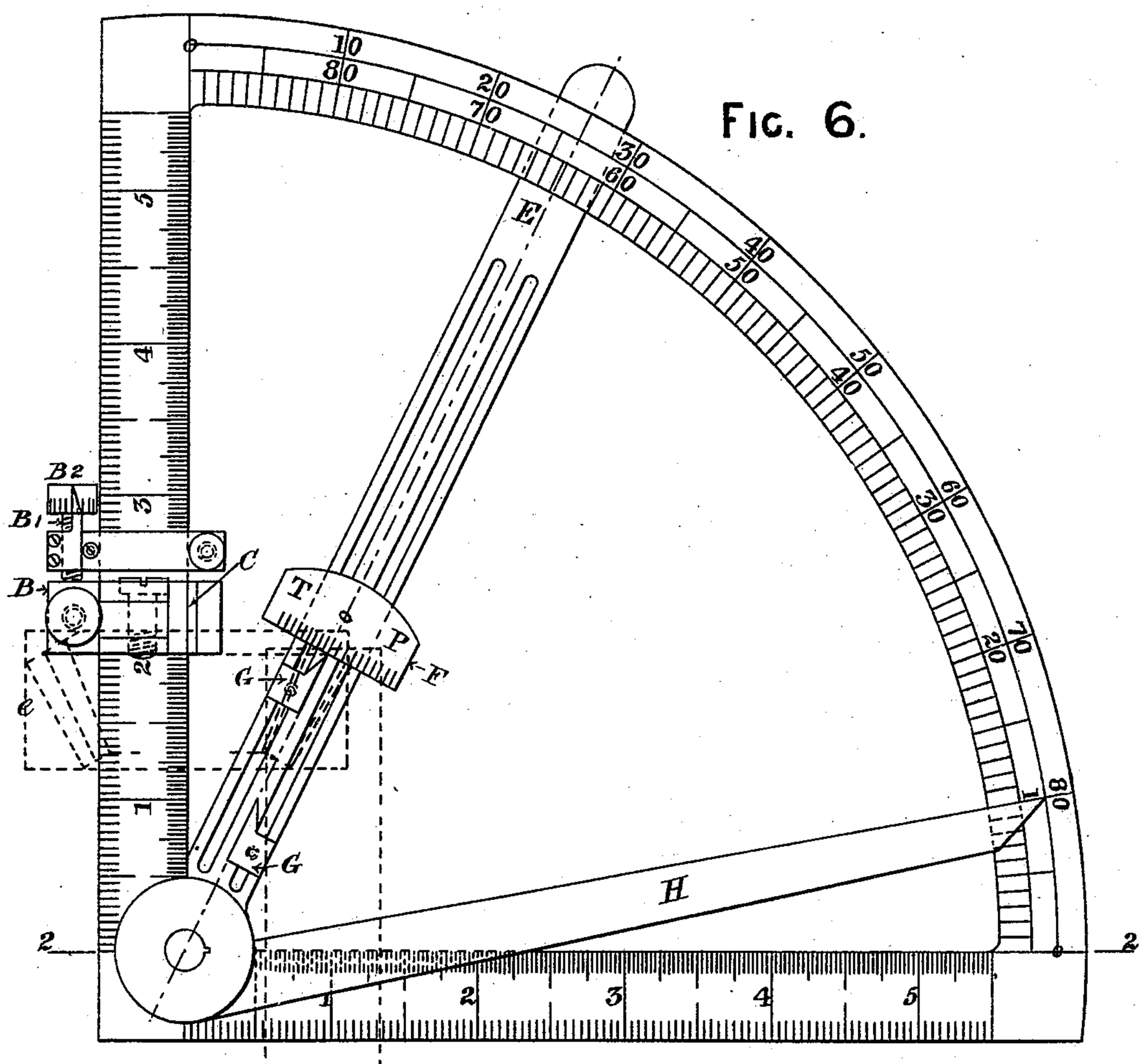

FIG. 6.

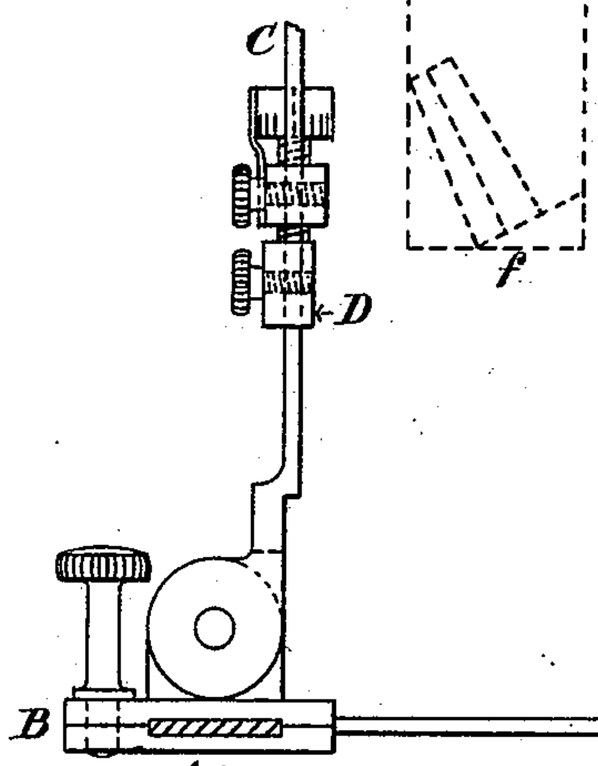

FIG. 8.

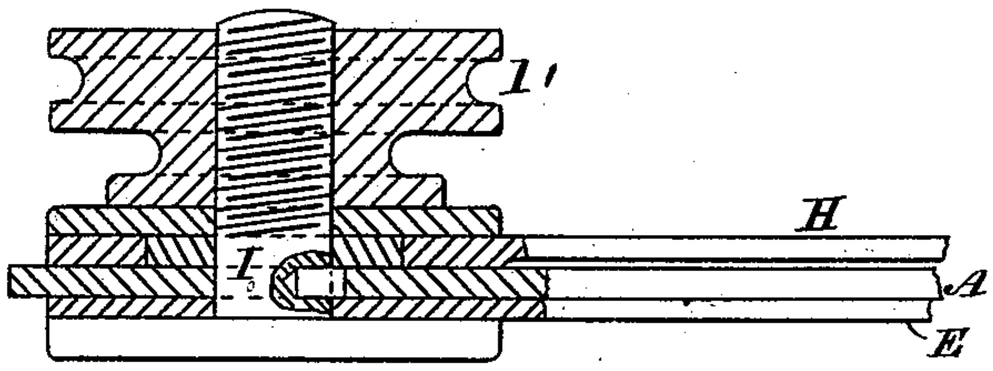

FIG. 7.

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FIG. 9.

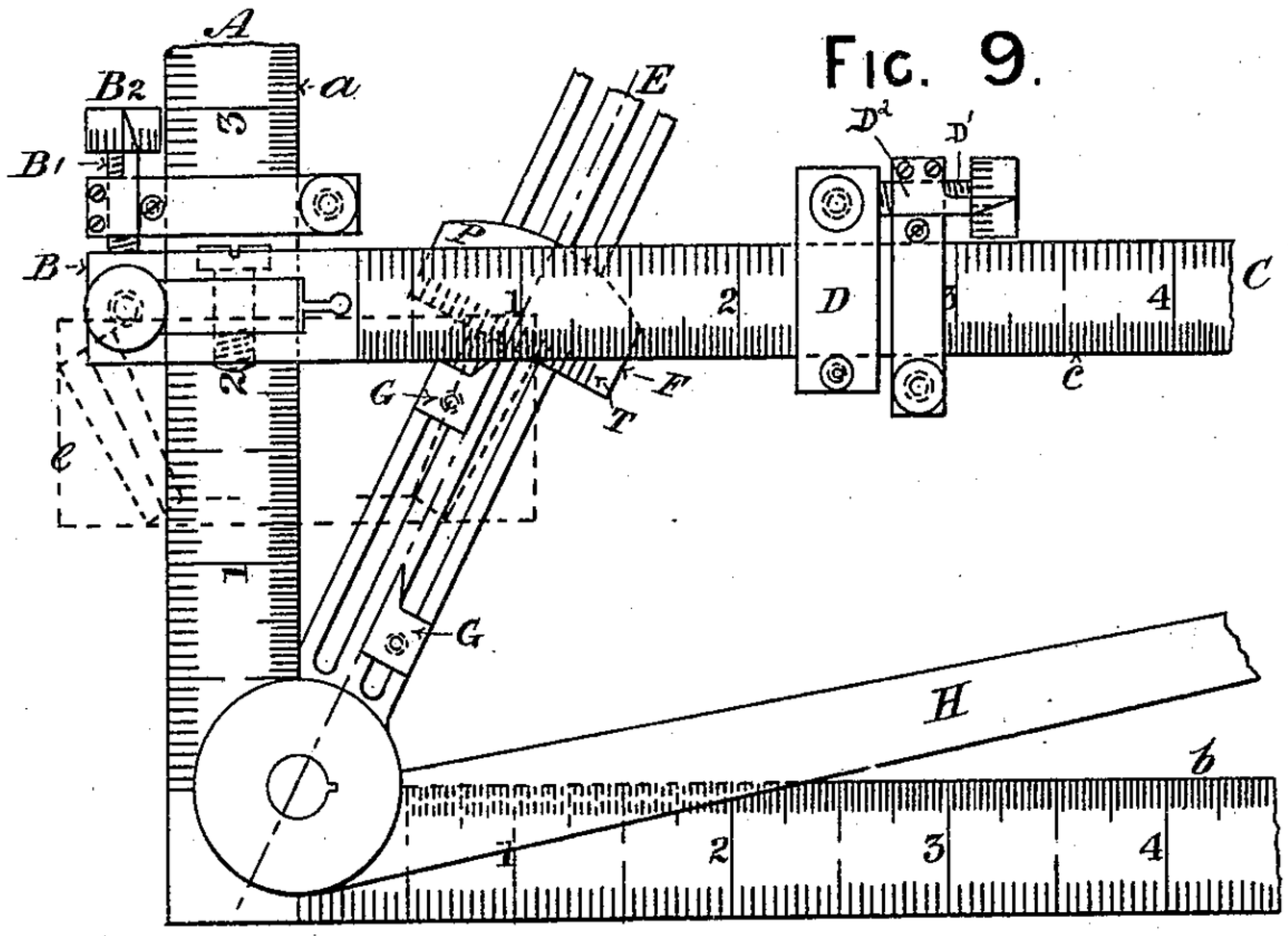


FIG. 10.

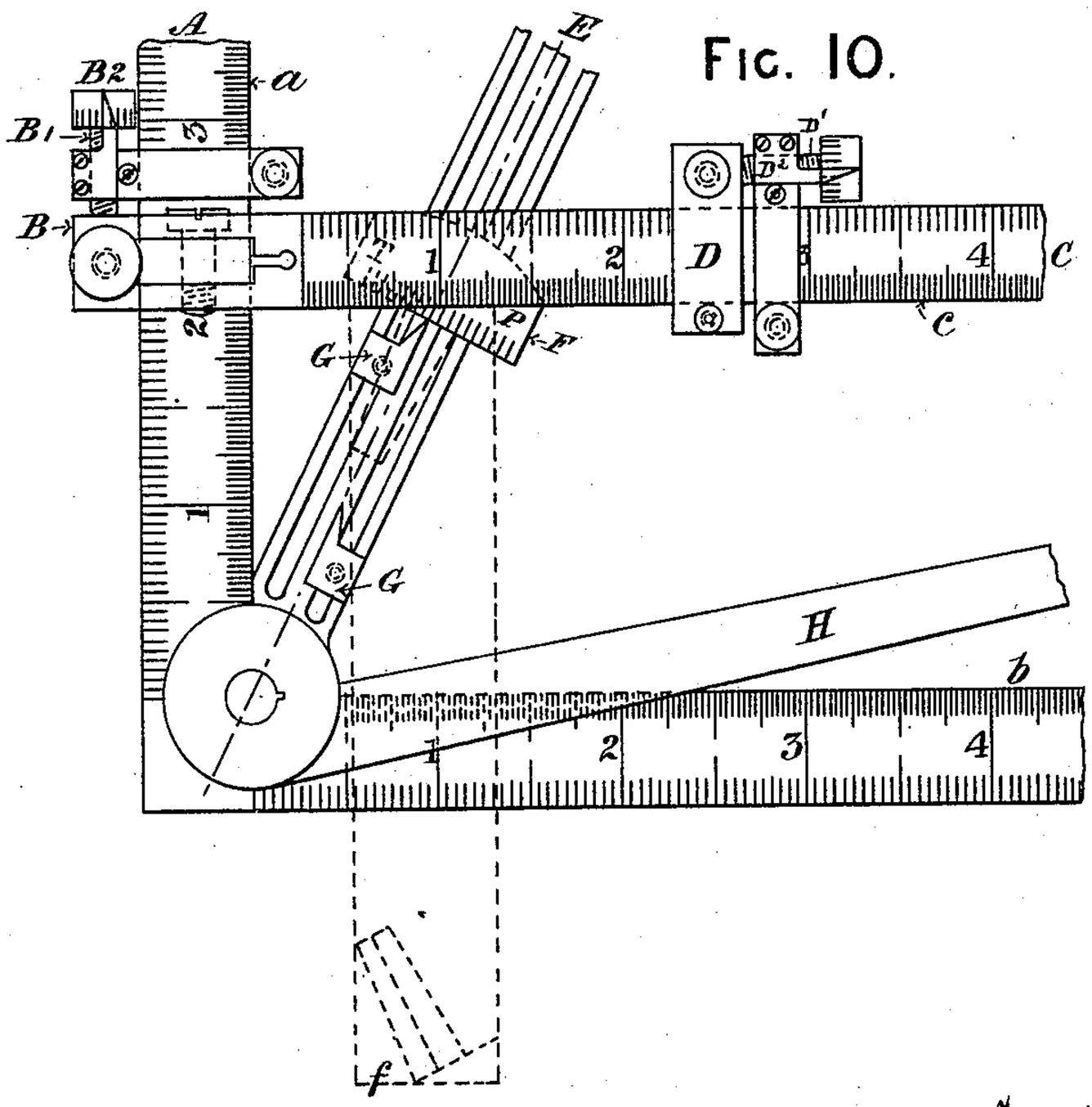
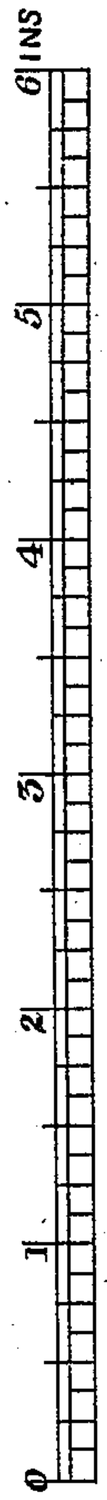


FIG. 11.



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UNITED STATES PATENT OFFICE.

JOSEPH ASHWORTH BOORMAN, OF LEEDS, COUNTY OF YORK, ENGLAND.

APPARATUS FOR PLOTTING ANGLES FOR BEVEL-GEAR.

SPECIFICATION forming part of Letters Patent No. 400,737, dated April 2, 1889.

Application filed August 25, 1888. Serial No. 283,803. (No model.) Patented in England October 1, 1887, No. 13,313.

To all whom it may concern:

Be it known that I, JOSEPH ASHWORTH BOORMAN, a subject of the Queen of Great Britain and Ireland, residing at Leeds, in the county of York, Kingdom of Great Britain and Ireland, have invented a new and useful anglegraph or apparatus for ascertaining the correct angles of bevel and miter wheels, also the angle of a line passing through a point at a given distance from vertical and horizontal planes, (for which I have obtained a patent in Great Britain, No. 13,313, bearing date October 1, 1887,) of which the following is a specification.

In constructing bevel and miter wheels, (especially bevel-wheels,) either in the wooden pattern form or in the metallic blank form, it has heretofore been usual to first make a drawing of the same. The angles of miter-wheels when once found may be taken to be constant. From the above-mentioned drawing templets or gages are made which are handed to a workman (a turner) in wood or metal, as the case may be, upon whose skill and the correct application of the said templets depends the accurate production of the pattern or blank forms previous to the operation of cutting or forming the teeth, and it often happens that some inaccuracy is discovered after a considerable amount of labor has been expended on the work.

Now, my invention has for its object the dispensing with the cost of making drawings and templets and the supposed skill of the workman in applying the same, and has reference to the use for this purpose of an instrument or apparatus, hereinafter described, whereby all the required angles can be ascertained with the greatest facility, after which, by the use of such tools as are generally to be found in first-class engineering establishments, no difficulty will arise in producing the required angles either in wooden patterns or metallic blanks ready for the operation of cutting or shaping the teeth. The angle of the bottoms of the spaces being accurately determined by my invention, a properly-constructed wheel-cutting machine can readily be adjusted thereto.

The objects of my invention are attained by the use of the instrument or apparatus illustrated in the accompanying drawings, in which—

Figure 1 is a plan of the apparatus entire according to my invention; Fig. 2, a section at the line 1 1 of Fig. 1, showing in detail a movable graduated arm or blade. Fig. 3 shows in detail a radial arm with transverse graduated scale and indices thereon; Fig. 4, an edge view of the radial arm shown in Fig. 3. Fig. 5 is an index for pointing out degrees on the quadrant. Fig. 6 is a plan of the apparatus, showing its application. Fig. 7 shows the quadrant in section on the line 2 2, Fig. 6, showing the graduated arm referred to in Fig. 2 turned up after having been used. Fig. 8 is a section to an enlarged scale on line 2, Figs. 1 and 6. Fig. 9 is a plan in part, illustrating its application. Fig. 10 is a plan in part, also illustrating its application. Fig. 11 is a scale of inches to which the apparatus is drawn.

Similar letters refer to similar parts throughout the several views.

A is a quadrant having the inside edges of its right-angled sides *a* and *b* radial and similarly graduated into equal parts of any suitable denomination, the segmental part being graduated into degrees.

B is a sliding part upon the side *a* of the quadrant, or it may, if desired, be used on the side *b*. The accurate adjustment of this slide is effected by means of the micrometer-screw B′, having a graduated head and index, B^2, and bearing upon the slide B and preferably carried by a separate sleeve embracing the side of the quadrant.

C is an arm or blade, at its inner end hinged or otherwise connected to the slide B, so that its free end will extend at right angles to the side *a* and over the side *b*, so that the free end can be swung laterally out of the way when desired, and this arm C is graduated in a similar manner to the sides *a* and *b*. The zero-point on this arm coincides with the radial side of the part *a*, and is provided with a sliding part, D, the inner part (or that side next to zero) of which is for setting to the radius of one of a pair of wheels required, and the adjustment of the said sliding part is effected in a similar manner to that of the part B, above mentioned.

Instead of the arm or blade C, a separate square may be used, having its blade graduated and provided with a sliding part, such as D; but I prefer the apparatus in the form illustrated.

E is a radial arm with its center line radial to the axis of the quadrant, on which it is loosely mounted and around which it is capable of being moved.

F is a slide or scale upon the arm E, having its inner side at right angles to its center line and graduated in either direction from the said center line, as follows: Each division on the part T gives the length of tooth from the pitch line to the point or end, and each division on the part P gives the depth of the spaces or the roots of the teeth, also from the pitch line, in both cases counting from the center of F or zero.

One each of the above divisions represents those respective parts of the teeth or spaces for each eighth of an inch in the pitch of the teeth. Thus, for three-eighths of an inch pitch (as in the example hereinafter referred to) three each of the said divisions are taken to represent those respective parts from the pitch line. The graduations on the scale F range from one-eighth of an inch pitch to one and one-eighth-inch pitch, but may be extended so as to represent greater pitches, if desired. In addition to the scale F, the arm E is also provided with two indices, G G, each with its point coinciding with the center line of the arm and with zero on F, and capable of being adjusted and fixed in any required position and as either of which may be found to be convenient for use.

H is an arm or indicator for pointing to the degrees on the segmental part of the quadrant, is free to turn on the axis thereof, and has one of its sides radial thereto.

I is a bolt and I′ a nut at the axis of the quadrant for fixing the arm E in any required position. The arm H is free to move at all times.

The application of the instrument or apparatus is shown in Figs. 6, 9, and 10.

The quadrant A, as seen in Fig. 7 in cross-section at the line 2 2, Figs. 1 and 6, shows the arm or blade C (after having served the purpose of determining the angular position of the arm E) turned out of the way, as hereinafter referred to.

The slides B and D loosely embrace the parts to which they are applied, and are so constructed that they can be clamped rigidly to the same by screws, as seen, and the slide or scale F loosely embraces the arm E and freely slides on or can be slipped off or on the same. The opposite sides of the scale F are graduated from opposite ends, as will be seen by comparing the same, as seen in Figs. 9 and 10, in which the scale is shown from opposite sides.

The slide D on the arm C is accurately adjusted by means of micrometer-screw D′, carried by a sliding collar on the arm C and having an index, D^2, the device being similar to that for adjusting the sleeve B on the side *a*.

The method of applying the instrument or apparatus is as follows: Say, for example, it is required to produce a pair of metallic blanks for "cut bevel-gears" of thirty-two and sixteen teeth, respectively, by three-eighths of an inch pitch. The half diameters or radii of these at their pitch lines, as may be found from a table of factors for diameters or radii supplied with the instrument, or by other means, are 1.91 inch and 0.955 inch, respectively. Set the slide B, with the graduated arm C on the side *a* of the quadrant, say, for the thirty-second wheel, equal to 1.91 inch, and the slide D on the arm C for the sixteenth wheel, equal to 0.955 inch. Then move the arm E and one of the indices G until the latter coincides with or points to the number 0.955 on the arm C. This will be known by the point of the index G taking fairly into the internal angle, *d*, formed by the slide D with the arm C. This position is ascertained by the sense of feeling that the point of the index G is fairly in the said internal angle, *d;* or the position may be determined by "seeing" that the index points to the required graduation. The center line of the arm E will then point to the number of degrees representing the angles of the pitch lines of both wheels in relation to their respective axes, and the angles of the outer and inner ends of the teeth or blanks will at all times be ninety degrees from or with the pitch-line angles just found. Next fix the arm E by the bolt I at the axis of the quadrant, turn up the arm C, as shown in Fig. 7, and move the transverse slide F on the arm E so that its zero touches the index G. Then move the swiveling arm H until its radial side coincides with the third division from zero on the part T of the transverse scale F. This will give the required angle for the points or face of the teeth of one of the wheels. Next move the said arm H to the third division from zero on the part P of the scale F, and this will give the angle for the roots of the teeth or bottoms of the spaces between the teeth. Then remove the scale F from the arm E and replace it thereon with the contrary side uppermost, on which the graduations are arranged in a contrary direction to those on the other side, placing it so as to touch the index G, as before, and apply the swiveling arm H to corresponding divisions thereon, and the angles for the points and roots of the teeth or bottoms of the spaces will be given for the other wheel.

All the angles of the pair of wheels having now been recorded, it remains to find the radii of the respective blanks in the cylindrical form, as shown by the dotted lines *e* and *f*—that is, the extreme points of the teeth to which it will be advantageous to turn them previous to forming the required angles as recorded by the instrument and hereinbefore described—say, first, for the wheel to have sixteen teeth, as the scale F as last used is in

position for this. In order to ascertain these radii, first remove the slide or part D and its vernier to the end of the arm C, so that they will not interfere with the reading of the scale F. Then set side *c* of the arm C, Fig. 9, so that it coincides with the third division on the part T of the scale F, and on the said side *c* of arm C will be recorded the radius required. Then, for the wheel to have thirty-two teeth, again reverse the scale F on the arm E, placing it so as to touch the index G as before, and set side *c* of the arm C to the third division from zero on part T of the scale F, and the radius required will be recorded on the side *a* of the quadrant, as shown in Fig. 10.

In cases where the required wheels are too large to come within the scope of an instrument or apparatus of the size shown in the drawings, which is made to the scale Fig. 11, such wheels may be reduced by scale to such a size as to be embraced by it—as for example, suppose it is required to construct a bevel-wheel of three feet diameter of any required pitch, (such wheel may be assumed to be four and a half inches diameter,) the pitch of the teeth being proportionately reduced, the angles will be those of the full-sized wheel, as also other dimensions measured by the scale to which the wheel was reduced.

The instrument or apparatus is also applicable to the finding of the angle of a line passing through a point at a given distance from vertical and horizontal planes.

What I claim as my invention is—

1. The combination, with a graduated quadrant, of a slide movable upon one arm of the same, a graduated arm hinged to the slide and extending at right angles to the side upon which the slide is located, and an adjustable slide upon said arm, for the purpose set forth.

2. An instrument for ascertaining the correct angles of bevel and miter wheels and the angle of a line passing through a point at given distances from vertical and horizontal planes, comprising a graduated quadrant, a radial arm pivoted to the quadrant capable of adjustment around the axis of the same and adapted to be clamped in the desired adjustment, and a transverse adjustable slide upon the radial arm, for the purpose set forth.

3. The combination of a graduated quadrant, an adjustable slide upon one arm of the same, a graduated arm hinged to the slide and provided with an adjustable slide, a radial arm pivoted to the axis of the quadrant and capable of adjustment around the same, a transverse reversible and adjustable slide upon the radial arm, and indices for the same, for the purpose set forth.

4. An instrument for ascertaining the correct angles of bevel and miter wheels and the angle of a line passing through a point at given distances from vertical and horizontal planes, comprising a graduated quadrant and an adjustable arm pivoted to the same at its axis and adapted to be clamped at the desired angle, an adjustable transverse slide upon this arm, and a radial index or arm loosely pivoted to the axis of the quadrant, all arranged for the purpose set forth.

5. An anglegraph comprising a graduated quadrant, a slide upon an arm of the same provided with a graduated arm, an adjustable radial arm pivoted to the axis of the quadrant and adapted to be clamped at the desired ascertained angle, a transverse reversible and adjustable slide upon the radial arm, a pair of indices upon the radial arm, and an index mounted upon the axis to freely turn upon the same, for the purpose set forth.

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