

No. 633,307.

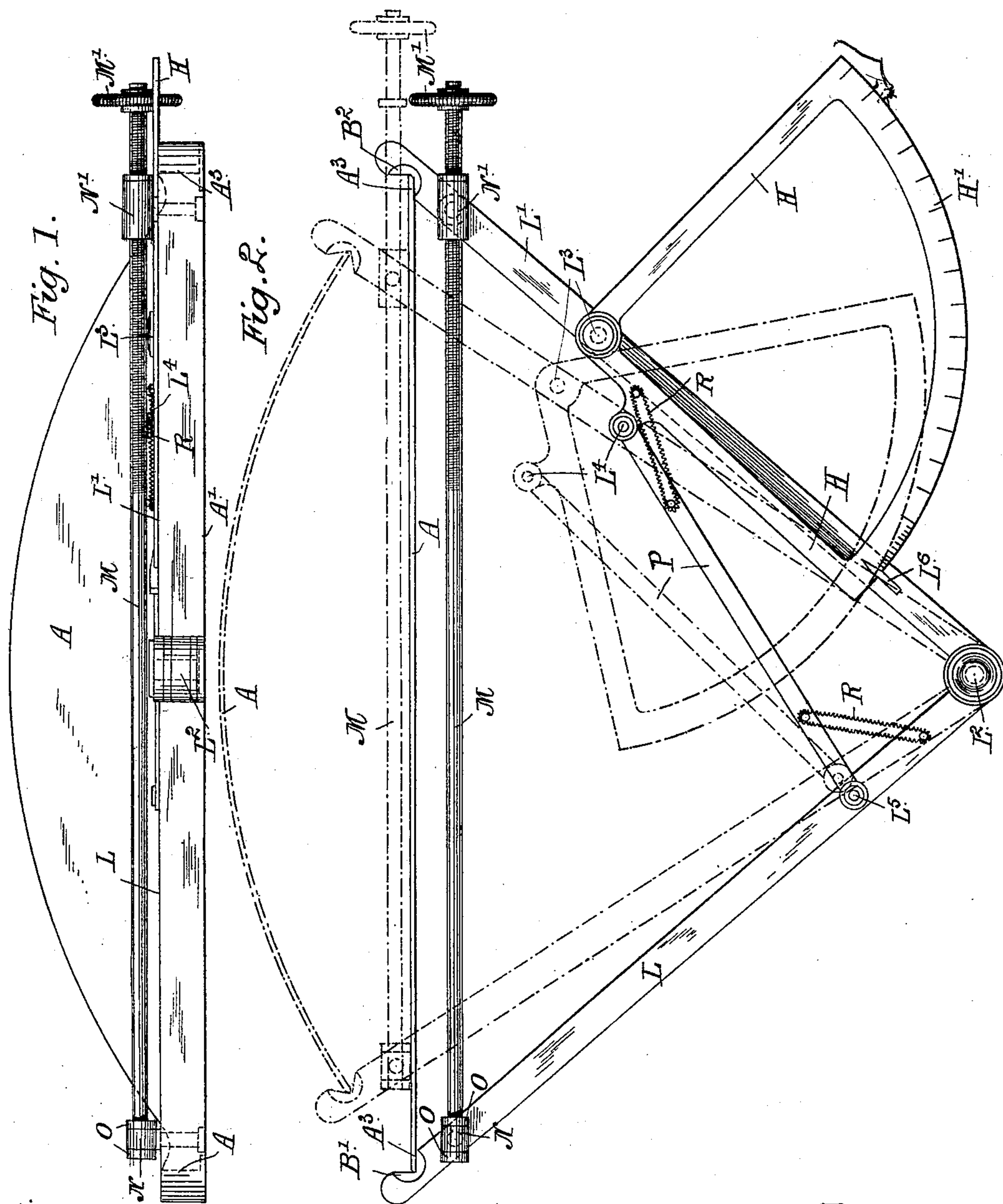
Patented Sept. 19, 1899.

T. CLARKSON.  
MATHEMATICAL INSTRUMENT.

(Application filed Mar. 5, 1897.)

(No Model.)

4 Sheets—Sheet 1.



Witnesses:

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Inventor:

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4 Sheets—Sheet 2.

Fig. 3.

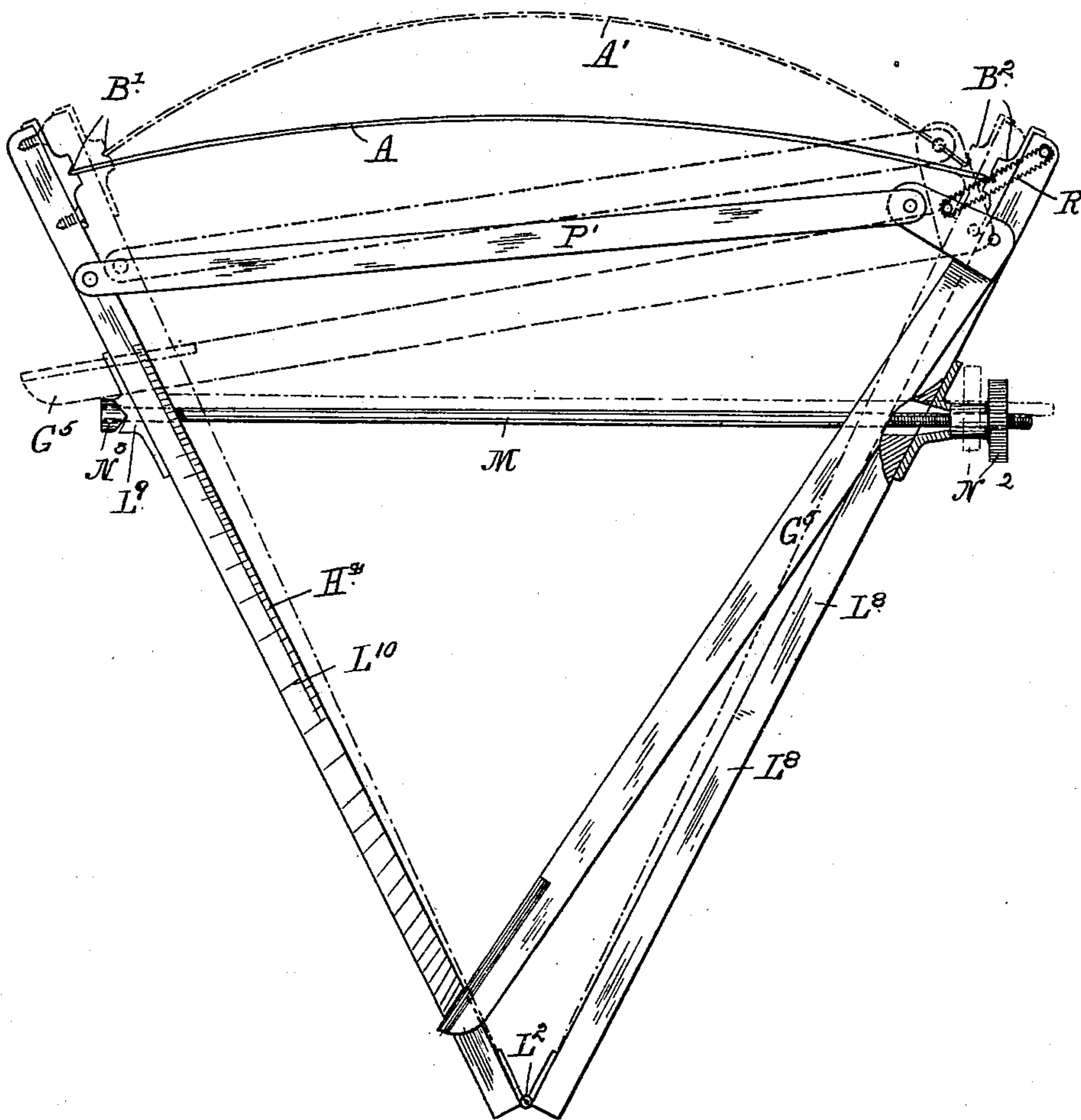
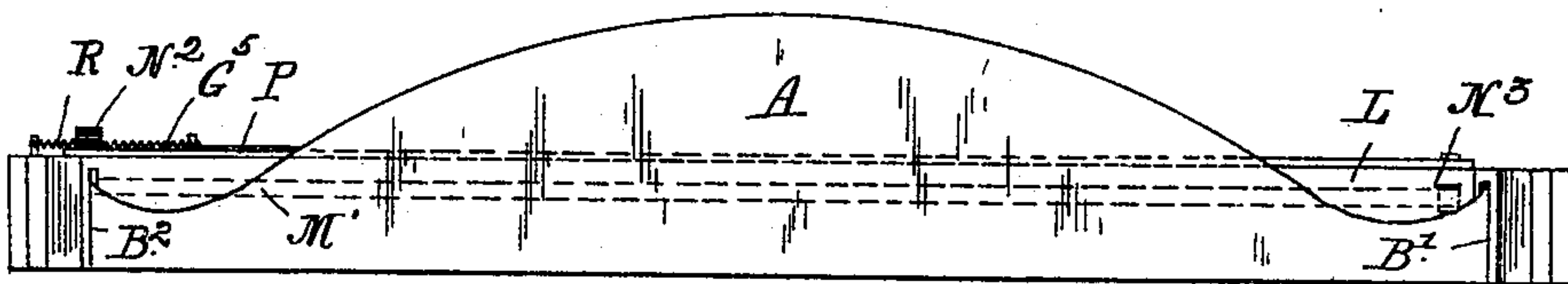


Fig. 4.



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**No. 633,307.**

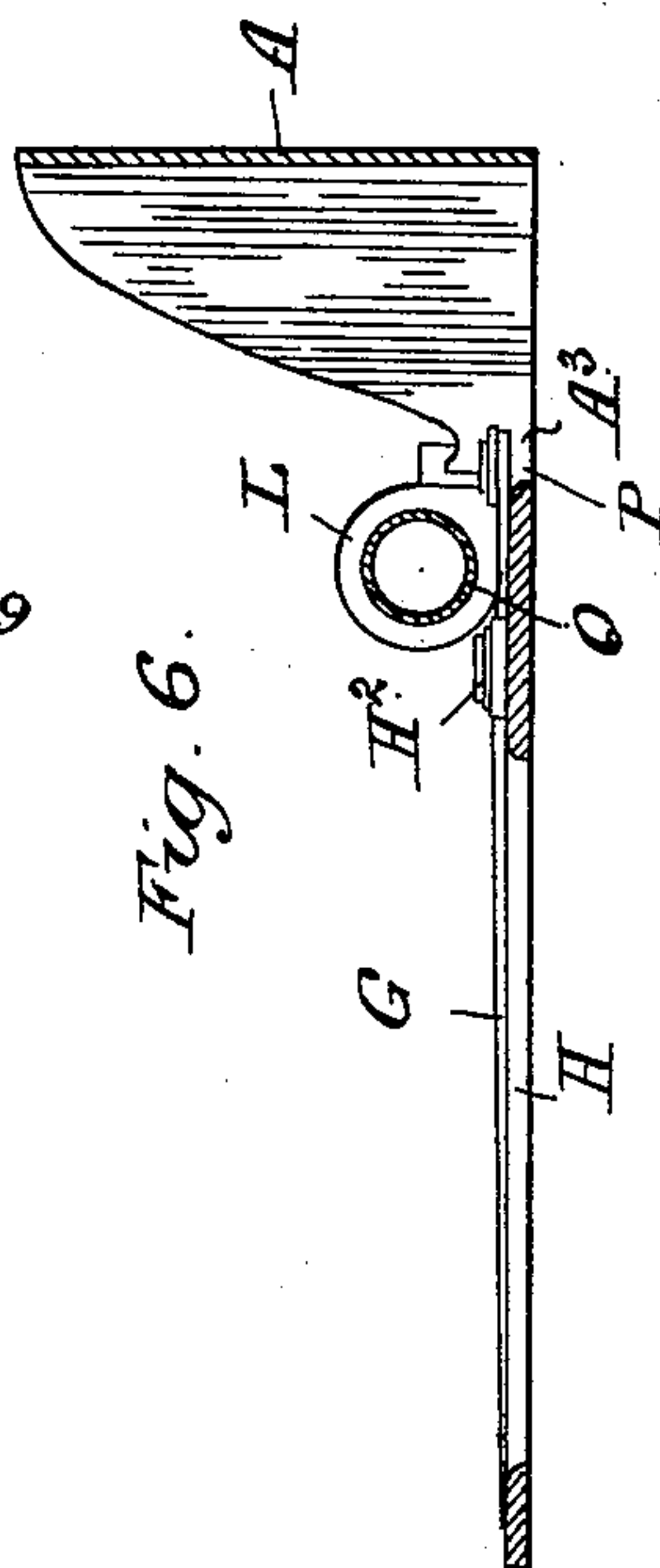
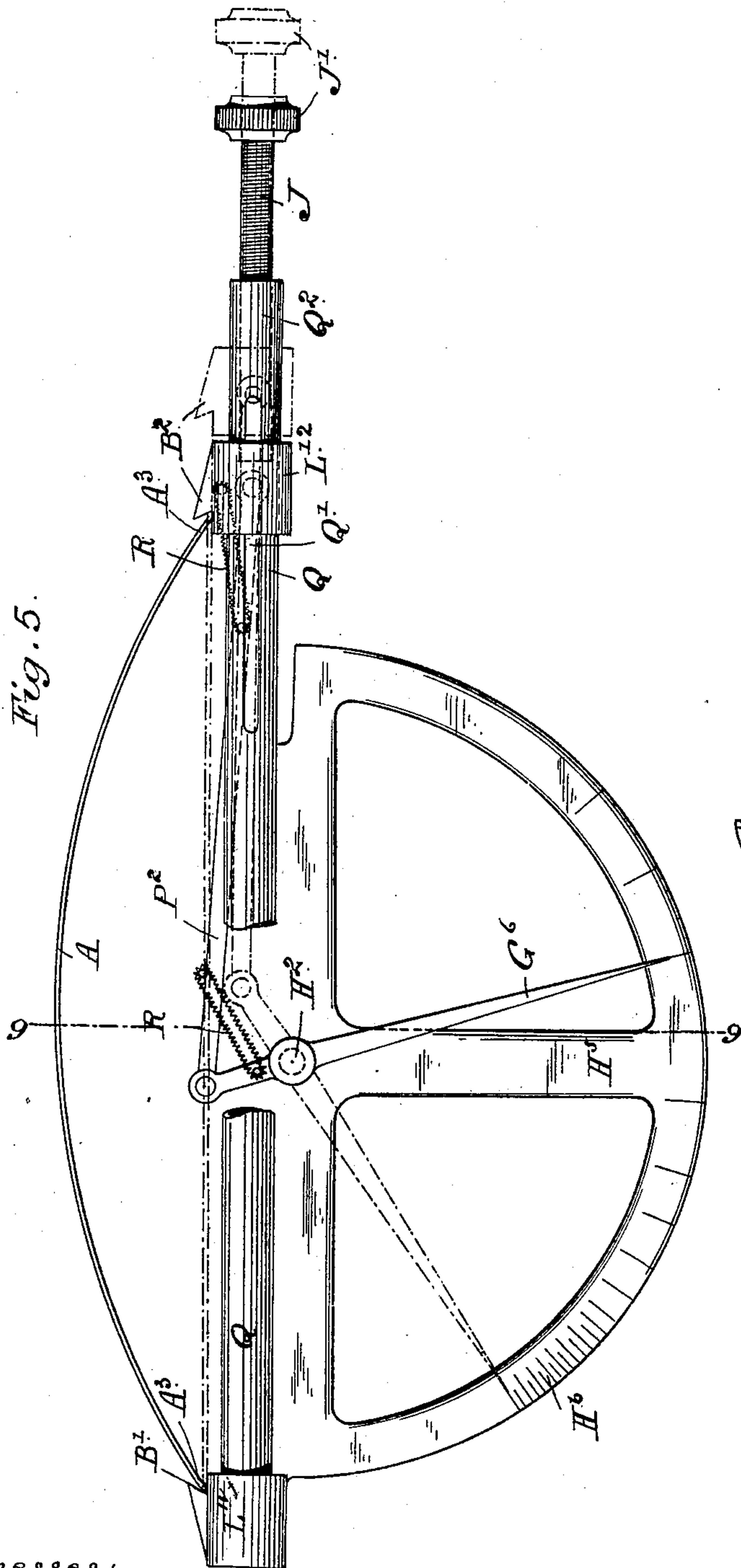
**Patented Sept. 19, 1899.**

**T. CLARKSON.**  
**MATHEMATICAL INSTRUMENT.**

(Application filed Mar. 5, 1897.)

(No Model.)

**4 Sheets—Sheet 3.**



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**No. 633,307.**

**Patented Sept. 19, 1899.**

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**MATHEMATICAL INSTRUMENT.**

(Application filed Mar. 5, 1897.)

(No Model.)

**4 Sheets—Sheet 4.**

Fig. 7.

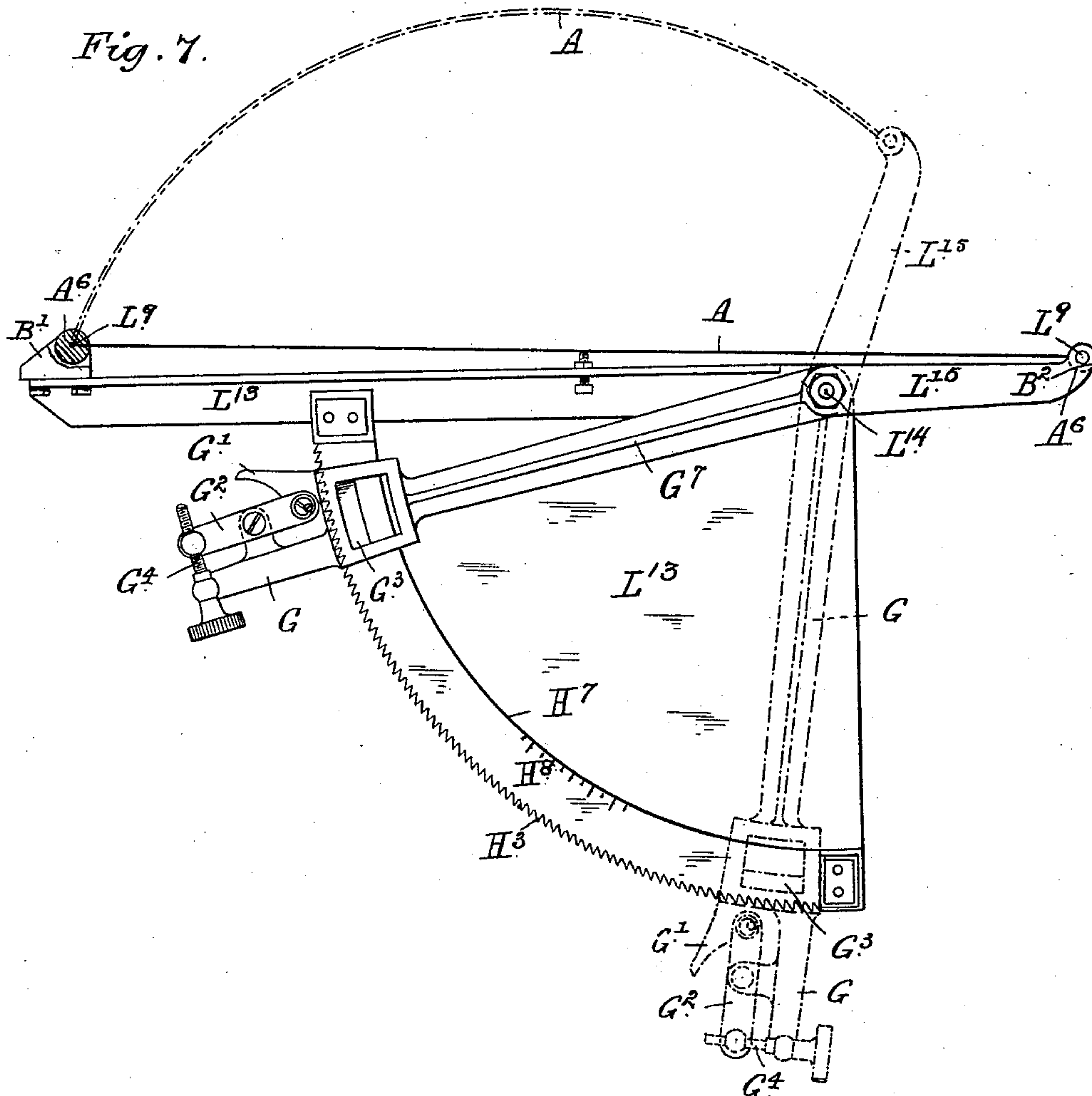
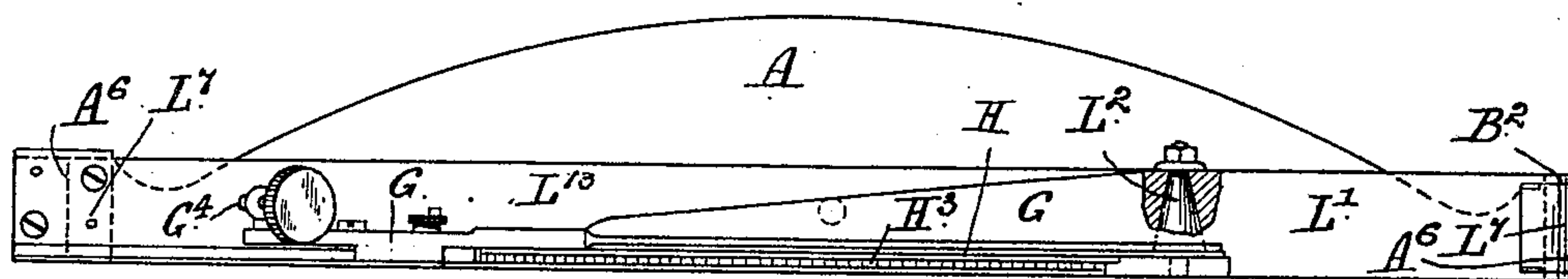


Fig. 8.



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# UNITED STATES PATENT OFFICE.

THOMAS CLARKSON, OF SUTTON, ENGLAND.

## MATHEMATICAL INSTRUMENT.

SPECIFICATION forming part of Letters Patent No. 633,307, dated September 19, 1899.

Application filed March 5, 1897. Serial No. 626,107. (No model.)

*To all whom it may concern:*

Be it known that I, THOMAS CLARKSON, a subject of the Queen of England, residing at Sutton, Surrey county, England, have invented certain new and useful Improvements in or Relating to Mathematical Instruments for Use in Drawing Arcs of Circles, of which the following is a specification.

This invention relates to mathematical instruments for use in drawing arcs of circles whose diameters are too great to permit the arcs to be drawn by ordinary compasses. Hitherto a long wire or rod or a trammel has been used as a radius-arm in drawing such arcs; but these devices are unwieldy and cumbrous and frequently need two operators. Moreover, the curved lines produced by such means are more or less wavy or otherwise inaccurate, owing to the absence of rigidity from the apparatus. Another common device consists in bending a thin piece of spring-steel or wood so that it will approximately correspond with three points previously determined upon the required curve, the said spring then constituting a ruler for completing the curve. It is well known, however, that this device does not give a true circular arc, for the established reason that a straight spring when bent either by end pressure or by pressure applied to the middle while the ends are supported yields more in the center than toward each end, so that its curve approximates more to a parabola than a circle. It has also been proposed to use for like purposes an elastic metallic strap of uniform thickness cut upon a circle at one edge and straight upon the other edge; but such a strap will not form a true circle vertically when the ends are made to approach each other.

It is the object of the present invention to construct a compact and simple instrument wherein a novel form of flexible ruler specially designed to give true circular arcs is combined with means for enabling it to be easily given the desired curvature.

The improved flexible ruler is a thin flat strip so tapered or reduced from the middle of its length toward its ends that successive parallel measurements of its width taken parallel with the intended axis of curvature

would if plotted side by side perpendicular to a straight line be ordinates of a symmetric hyperbolic segment. This is the theoretical form of the strip. As, however, minute differences in temper at different parts of the plate or in thickness or in quality of the metal or material may affect the result, I find it desirable to slightly alter the edge of the plate, so that it differs a little from the true theoretical form above described. This, however, would depend very much upon circumstances, and the above illustration will serve to indicate the broad principle of the construction. I curve the ruler by applying pressure to its ends, which are specially shaped for a purpose hereinafter stated. When the ends approach, the middle bends outward into a true circular arc. As regards the principle involved in the shaping of the plates it will be sufficient for present purposes to say that they are substantially those well understood in connection with the bending strains of girders, it being remembered that in this instance the object is not to prevent the plate from bending, but to cause it to bend always in a true circular arc.

It will be readily appreciated that the form or construction of the retaining and bending devices carrying the plate can be greatly varied and that any suitable materials may be employed for them or for the plate, though hitherto I have found that for the plate a high quality of steel gives excellent results.

As a matter of convenience in constructing these instruments I prefer to make the plates of fixed lengths commonly useful, so that they may serve for purposes of measurement, and to make the flat edge true, so that it may be used as a straight-edge, and, if desired, to let the plate bear a scale, so that it may be used as a rule, trammel, or for other similar purposes.

In the accompanying drawings, Figures 1 and 2 are rear elevation and plan, respectively, of one construction of improved instrument according to this invention. Figs. 3 and 4 are plan and front elevation of another construction thereof. Figs. 5 and 6 are respectively plan and transverse section (the latter on the line 6 6 of Fig. 5) of a further alter-



native construction, and Figs. 7 and 8 are respectively plan and rear elevation of yet another alternative form of the instrument.

Like letters indicate like parts throughout the drawings.

In the instrument illustrated in Figs. 1 and 2 I employ to hold the ruler A and bend it compressors L L', pivoted to each other at L<sup>2</sup> and provided with jaws B' B<sup>2</sup> to engage with the ends A<sup>3</sup> of the ruler A. These jaws are of V form, so as to put no undue restraint upon the bending of the ruler A into arcs. A screwed rod M, which has a milled head M' thereon, is connected with both the compressors L L' in such manner that when the screwed rod M is rotated by means of its milled head M' the compressors L L' will move about their pivot L<sup>2</sup> relatively to each other, so as to bend the plate in the manner indicated in Fig. 2 by chain-lines or, conversely, to permit it to partly or wholly unbend. The connection of the screwed rod M with the compressors L L' is effected by sleeves N N', both of which are pivoted to the compressors. Collars O, fixed on the rod M, bear against the sleeve N, so that the rod can rotate in the latter, but cannot move endwise in it. The sleeve N' is screw-threaded internally to engage with a threaded portion of the rod M.

H is a segmental scale graduated along its arc H'. It is pivoted at L<sup>3</sup> to the compressor L' and coupled at L<sup>4</sup> to a link P, which at L<sup>5</sup> is pivoted to the compressor L.

L<sup>6</sup> is an index on the compressor L'. This index is employed with reference to the graduations of the arc H' to indicate the radius or other dimension of the circular arc into which the ruler A is bent.

The length of the link P and the distances between the points L<sup>3</sup> and L<sup>4</sup> and L<sup>2</sup> and L<sup>5</sup> are so chosen and the parts H and P so disposed relatively to each other that when the compressors L L' are opened out to allow the ruler A to be flat, as in Fig. 1, the link P and the points L<sup>3</sup>, L<sup>4</sup>, and L<sup>5</sup> are nearly in line with each other. The result of this arrangement is that the ratio of the angular movement of the segmental scale H to equal increments of the angle between the compressors L L' decreases rapidly as the compressors approach each other, and, conversely, increases rapidly as the compressors open out from one another into the extreme position indicated in full lines in Fig. 2. Consequently it is possible for a small angular movement of the compressors near this extreme position (effecting great variations of the radius of the arc of the ruler A) to be measured by graduations on the scale H which are not necessarily cramped, as they would have to be if variations in the curvature of the ruler had to be indicated directly by the angular movement of one compressor relatively to the other.

The instrument shown in Figs. 3 and 4 is similar to that which is shown in Figs. 1 and 2, except that the adjusting-screw M<sup>2</sup>, by which the compressors can be drawn together,

has on one end a milled nut N<sup>2</sup>, with a hemispherical end, adapted to seat itself in a hemispherical seat on one compressor L<sup>3</sup>, and has also a knife-edged nut N<sup>3</sup> on the other end engaging with a correspondingly-shaped recess L<sup>9</sup> in the other compressor. The screw-thread upon the rod M is of a limited length, so that only a limited endwise movement of the nut N<sup>2</sup> is possible. This arrangement is designed in order to prevent overcompression of the ruler A. The indicating mechanism is slightly different from that shown in Fig. 2, the scale H<sup>4</sup> being marked along the compressor L<sup>10</sup> and the index-lever G<sup>5</sup> being pivoted to the compressor L<sup>8</sup> and coupled to a link P, which is pivoted to and operated by the compressor L<sup>10</sup> in the movement of the two compressors relatively to each other. Chain-lines in Fig. 3 show the compressors brought toward each other, the ruler A bent, and the indicating mechanism in a corresponding position.

In the modification illustrated by Figs. 5 and 6 the compressors L<sup>11</sup> L<sup>12</sup> instead of being hinged arms are blocks, one, L<sup>11</sup>, of which is fixed at one end of a hollow beam or tube Q. The other compressor-block L<sup>12</sup> slides upon the opposite end of the tube, and part of it enters the interior thereof through a slot Q', provided in the wall of the tube. J is a screw with a milled head J'. It is screwed through the end Q<sup>2</sup> of the tube, which is plugged and internally threaded to receive it, and it engages with the compressor-block L<sup>12</sup>, which it moves along the tube to compress, as required, the ruler A. H<sup>5</sup> is a semicircular scale graduated on one edge, as shown at H<sup>6</sup>. G<sup>6</sup> is an index-lever pivoted at H<sup>2</sup> to the scale H<sup>5</sup> and connected by a link P<sup>2</sup> to the movable compressor L<sup>12</sup>. The connections of the index-lever G<sup>6</sup> and the link P<sup>2</sup> with the movable compressor L<sup>12</sup> of Figs. 5 and 6 are so arranged that when the compressors L<sup>11</sup> and L<sup>12</sup> therein shown are moved apart from each other to allow the ruler A to become flat the link P<sup>2</sup> and the shorter arm of the index-lever G<sup>6</sup> are more nearly in line than when the compressors are moved to buckle the ruler A. This arrangement is to enable clear readings of the values of the arcs of larger radii to be obtained on the scale and is similar to the devices for a like purpose hereinbefore described with reference to Figs. 1 and 2. In Fig. 5 the ruler A is shown fully extended in chain-lines, with the compressors and indicating mechanism in corresponding positions.

In the instrument shown in Figs. 7 and 8 the ends of the ruler A are provided with small cylindrical sleeves A<sup>6</sup>, which have saw cuts along one side into which the ends of the ruler are passed. This instrument has a flat base L<sup>13</sup>, which may be regarded as a stationary compressor. One edge of this base is segmental. Upon the base is pivoted at L<sup>14</sup> a lever constituted by the two arms L<sup>15</sup> and G<sup>7</sup>. The arm L<sup>15</sup> forms a movable compressor, and the outer end of the arm G<sup>7</sup> travels along the edge



of the segmental portion  $H^7$  of the base and may be moved to bend the ruler  $A$  as shown by chain-lines. It is made to engage with the ratchet-teeth  $H^8$  of the base by means of a  
 5 spring-detent or thumb-lever  $G^1$ , pivoted to an intermediary lever  $G^2$ , which in turn is pivoted on the arm  $G^7$ . The exact adjustment of the arm  $G$  is provided for by means of a vernier  $G^3$  and micrometer-screw  $G^4$ , which latter is  
 10 carried in the end of the arm  $G^7$  and adapted to act through the intermediary lever  $G^2$  upon the detent  $G^1$  in a manner which may be well understood by reference to the drawings. The other arm  $L^{15}$  and the part  $L^{18}$  of the base  
 15 carry pins  $L^7$ , which enter and engage with the sleeves  $A^6$ , so that by adjusting the lever  $L^{15}$   $G$ , the ruler  $A$  is bent into a circular arc the curvature of which is indicated by a scale  $H^8$ , marked in contiguity to the teeth  $H^8$ .

20 To prevent backlash, which might produce error in the indications of certain of the indicating apparatus hereinbefore described, I provide springs  $R$  to connect the ends of the links  $P$  with the compressors and the scale or  
 25 index in such a manner as to take up the slack in the connections.

The indicating apparatus in these improved instruments is calibrated by comparison with standard curves and graduated accordingly,  
 30 preferably to indicate the radii of the arcs assumed by the templet. The indicating mechanism may be dispensed with if the instrument is to be used for the production of circular arcs and it is not desired to know their  
 35 radius.

The instruments are made so as to lie flat and steady on a level surface, such as that of a drawing.

To insure the obtainment of an accurate  
 40 templet or ruler, I put it in compression with its straight edge downward, so that its curvature corresponds approximately with a circular arc of convenient radius which has been carefully drawn upon a sheet of paper. If  
 45 the plate does not exactly correspond with the drawn arc, those parts of the plate where the curvature is too flat are narrowed by removing part of the metal from the angular or curved edge, for example, until the plate ex-  
 50 actly corresponds with the drawn arc at all points, excepting only for the short distance at each end where the small portions of the plate are allowed to remain outside the angu-

lar or curved edge to be engaged by the compressors, as before stated; but this may be 55 compensated for by removing a small portion of the metal at the adjacent part of the plate. I have found by trial that a plate made and operated in the manner described will always spring into a circular arc whether the 60 bending be much or little—that is to say, if a plate is made so as to bend exactly to a twelve-inch circle it can be also made to exactly correspond with any circular arc of any larger radius by simply allowing its extremi- 65 ties to move apart or its center to approach the chord of the arc.

I claim—

1. In a mathematical instrument for use in drawing arcs of circles the combination with 70 a resilient ruler of hyperbolic outline, (*i. e.* so tapered from the middle of its length toward its ends that successive parallel measurements of its width taken parallel with the intended axis of curvature of the ruler would 75 be ordinates of a symmetric hyperbolic segment if plotted side by side as perpendiculars to a straight line) of retaining and bending devices arranged to engage the ends of the ruler and force them toward each other 80 so as to move its middle outwardly and separate mechanism arranged to indicate directly the curvature of the ruler said mechanism having actuating connections with the bending devices substantially as described. 85

2. In a mathematical instrument for use in drawing arcs of circles the combination with a resilient plate  $A$  having one edge straight and the opposite edge hyperbolic of hinged compressors  $L$   $L'$  and an adjusting-rod  $M$  op- 90 eratively connected with both compressors and indicating mechanism constituted by the link  $P$  and segmental scale  $H$  substantially as described.

3. In a mathematical instrument for use in 95 drawing arcs of circles and comprising compressors, an index and scale operatively connected to both the compressors, substantially as set forth and for the purpose described.

In witness whereof I have hereto set my 100 hand in the presence of the two subscribing witnesses.

THOMAS CLARKSON.

Witnesses:

ALFRED J. BOULT,  
 HARRY B. WADE, Jr.