No. 731,533. PATENTED JUNE 23, 1903.

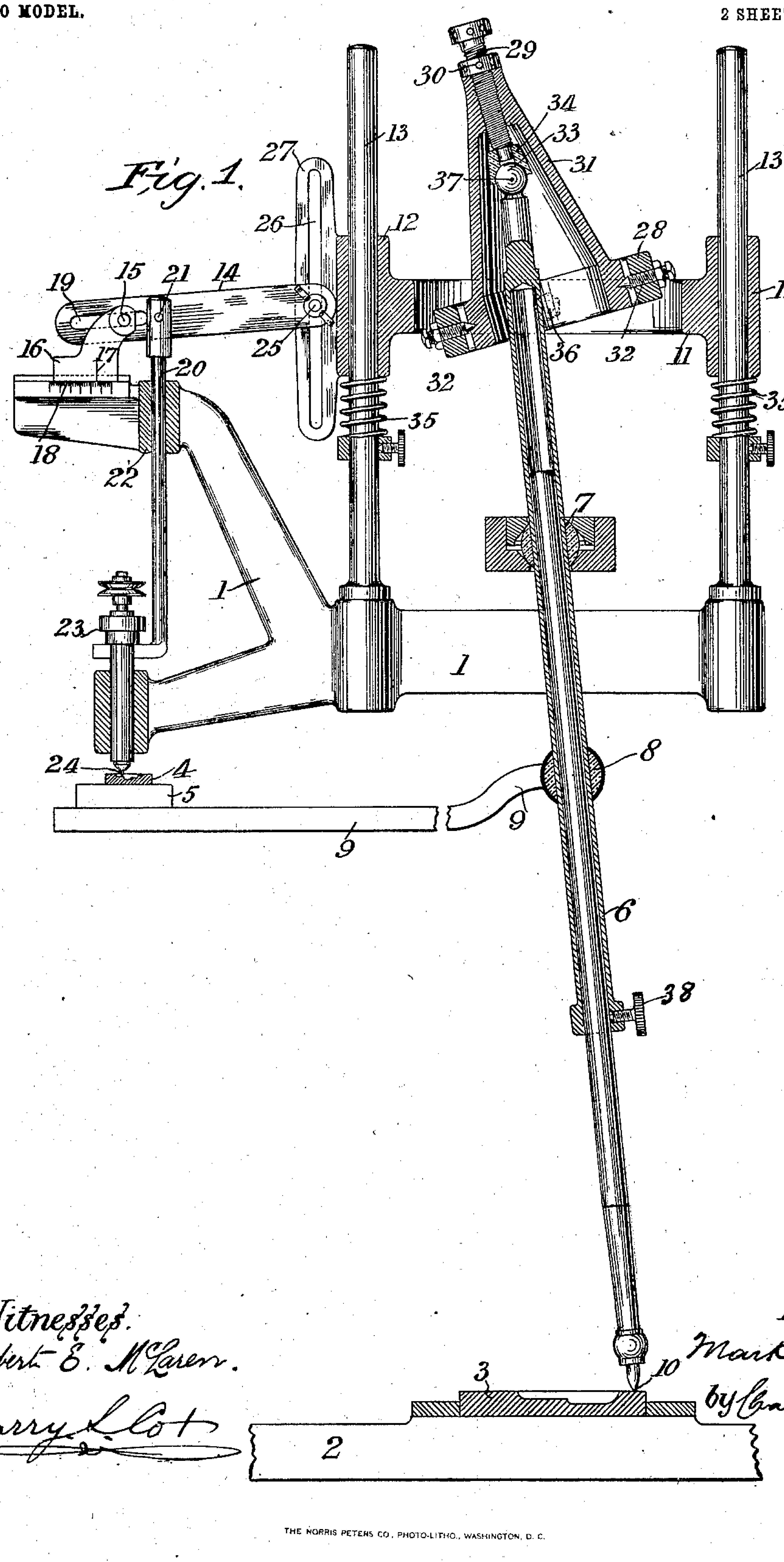
M. BARR.

PANTOGRAPH ENGRAVING MACHINE.

APPLICATION FILED JULY 26, 1900.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.



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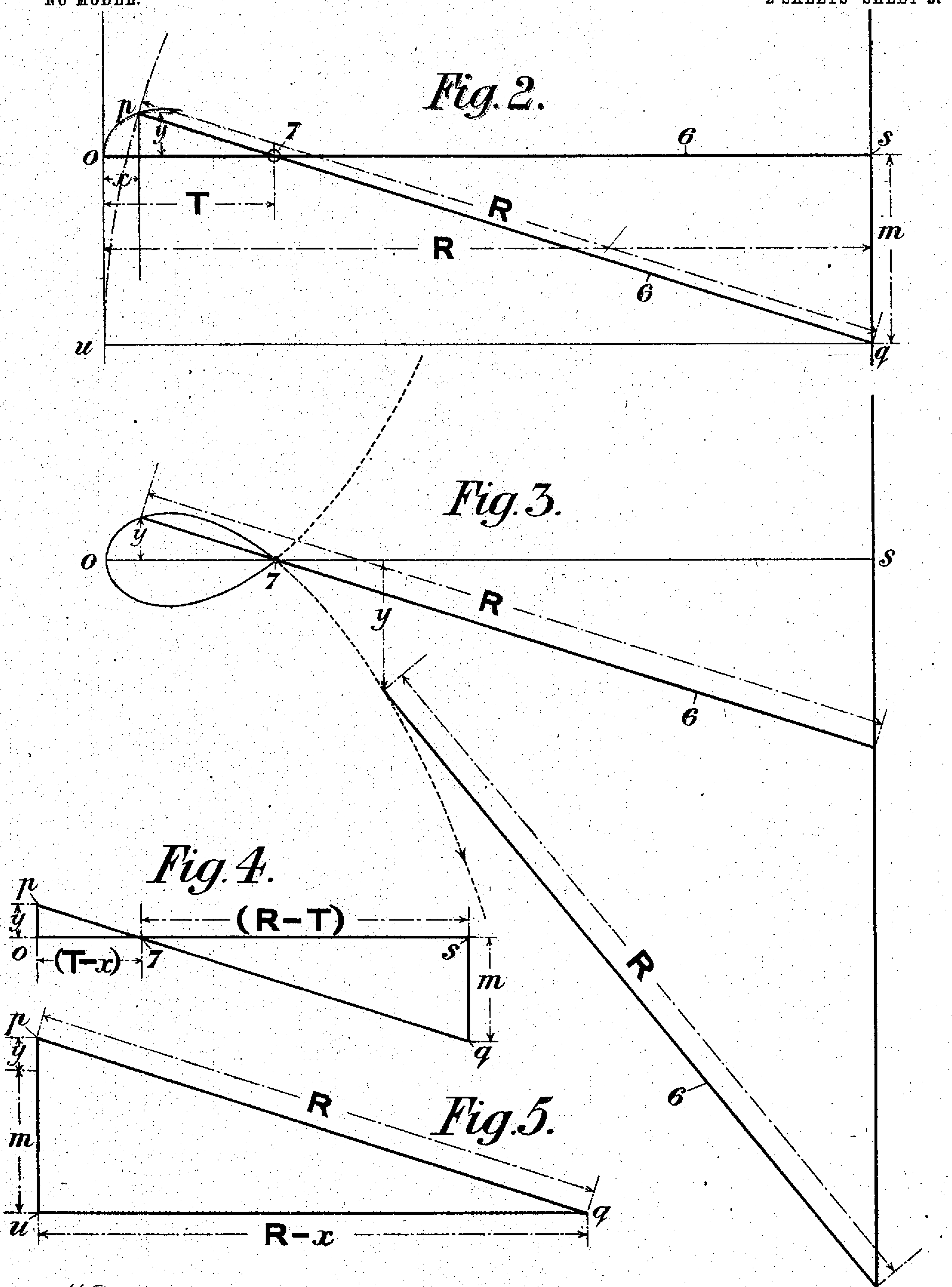

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No. 731,533. Patented June 23, 1903.

UNITED STATES PATENT OFFICE.

MARK BARR, OF BROADHEATH, ENGLAND, ASSIGNOR TO THE LINOTYPE COMPANY, LIMITED, OF LONDON, ENGLAND.

PANTOGRAPH ENGRAVING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 731,533, dated June 23, 1903.

Application filed July 26, 1900. Serial No. 24,919. (No model.)

To all whom it may concern:

Be it known that I, MARK BARR, of Broadheath, in the county of Chester, England, have invented certain new and useful Improvements in Three-Dimension Pantograph Engraving-Machines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

The present invention relates to improvements in three-dimension pantograph engraving-machines having swinging tracer-rods.

An engraving-machine that can deal only with a plane surface in both pattern and work has a two-dimension capacity—that is, it can deal with length and breadth; but an engraving-machine whose tracer-rod and tool have each a capacity for vertical motion or for motion that has a vertical component, such as would be required in engraving the intaglio or the cameo contours of a medal, has a third-dimension capacity, hence the term "three-dimension" engraving-machines. When a swinging tracer-rod is being moved laterally over the plane portions of the pattern, there is a vertical component in its motion which must not be communicated to the tool. On the other hand, when the same tracer-rod is following either the cameo or the intaglio portions of the pattern there is a vertical component in its motion which must be communicated to the tool.

The specification of Letters Patent No. 655,750, dated August 4, 1900, granted on another invention of mine, describes an engraving-machine in which the first-mentioned vertical component is compensated, it being thereby prevented from reaching the tool, while the second of the two vertical components is communicated to the tool. The compensation so effected is exact at the expense of complication in the mechanism employed.

The object of the present invention is to effect such compensation with a degree of exactitude sufficient for all practical purposes by means of a simpler mechanism than the one just referred to.

Figure 1 is a sectional and partially diagrammatic elevation of the improved machine, and Figs. 2, 3, 4, and 5 are diagrams hereinafter more particularly referred to.

The drawings and diagrams are to be taken as part of this specification and read therewith.

1 1 represent the frame of the machine; 2, the pattern-table; 3, the pattern fixed thereon, and 4 the work fixed on the work-table 5.

6 is the tracer-rod sliding freely through the ball-joint 7, which serves as the fulcrum of the rod 6 and upon which the latter rocks. This joint 7 is adjustable vertically on the frame 1 by any suitable means for ratio between the pattern 3 and the work 4.

8 is a boss fitting the tracer-rod 6, and through which the said rod can slide freely. The pantograph linkage indicated by the lines 9 extend from this boss 8 to the work-table 5 to transfer the lateral or two-dimension motions of the tracer-point 10 to the work 4.

11 is a ring concentric with the vertical position of the tracer-rod 6 and adjustable vertically on suitable guides in the frame 1. The figure shows the use of sockets 12 12, sliding on upright posts 13 13; but any convenient means may be used to secure the required vertical adjustability.

14 is a lever having its fulcrum 15 in the machine-frame 1. It is preferred that this fulcrum should be adjustable horizontally, and for that purpose it is in a pillow-block 16, capable of horizontal adjustment upon the frame 1, according to an index 17 on, say, the pillow-block and a scale 18 on, say, the adjacent part of the frame 1.

19 is a slot lengthwise of the lever 14, along which the fulcrum-pin 15 moves as the fulcrum is being adjusted.

20 is a link pivoted at 21 on the lever 14 and passing down through a guide 22 in the frame 1 to the tool-carriage 23, carrying the tool 24, to communicate the vertical rock of the lever 14 on its fulcrum 15 to the said tool. The opposite end of the lever 14 is connected to the ring 11 by a screw-threaded bolt and wing-nut 25 and a vertical slot 26 in a plate 27, fast to the adjacent edge of the ring 11, the shank of the bolt passing through the end of the lever 14 and the slot 26, as shown. The ring

11, above described, is the outer one of a pair of gimbal-rings, 28 being the inner one.

29 is a screw working vertically through a nut 30, supported by a hollow inverted cone or frame 31, pivoted by the pivot-screws 32 32 of the ring 28 to the latter. The nut 30 is carried in such a position that when the gimbal-rings are horizontal the axis of the screw 29 alines with that of the vertical position of the tracer-rod 6. The object of this nut, screw, and cup is described farther on. The top of the tracer-rod 6 is a ball 33.

34 is a cup on the nose of the screw 29 and fitting down upon the said ball.

35 35 are cushioning-springs vertically adjustable upon the frame 1 at the proper height to take the weight of the tracer-rod 6, the gimbal-rings, and the parts attached thereto, so far as to prevent the tracer-point 10 pressing too heavily upon the pattern 3. Thus when the tracer-point 10 is moved laterally over the plane portion of the pattern 3 the top end of the tracer-rod 6 describes a curved path, which for the comparatively small angular swing required of the said rod is so nearly a circular arc that when the circular arc of the gimbals is adjusted in the way described farther on to coincide approximately with the said curved path no motion is given to the center 36 of the gimbal-rings, and as motion can only be given to the ring 11 by a vertical movement of the center 36 a lateral motion of the tracer-point 10 gives no motion to the lever 14; but the actual vertical motion of the tracer-point 10 over an intaglio or cameo portion of the pattern 3 moves the ring 11 vertically and the tool 24 vertically too and proportionally as well. As a matter of fact the tracer-rod 6 swings through an angle of twelve degrees at most; but as the tracer-point 10 moves over a plane the top—*i. e.*, the center 37 of the ball 33—of the rod 6 does not describe a circular arc. The line which it follows is a curved path, the ends of it dropping toward what would be the center of a circular arc, which for twelve degrees closely approximates the curved path, and it is this drop which has to be compensated for. Now there is a point in the length of the tracer-rod 6 when it is vertical, which is the center of a sphere having an arc closely approximating the line that the point 37 follows. The center 36 (being the intersection of the two axes of gimbal-rings 11 and 28) should be made to coincide with the point in question. Hence the importance for the purpose of the present invention of finding its position. Thus let v equal vertical drop of the point 37 (or center of the top of the tracer-rod 6) from its highest position, R equal length of tracer-rod 6 from said point 37 to the tracer-point 10, and a equal angle of tracer-rod 6 with the vertical, then $v = \mathrm{R}\,(1 - \cos. a)$. Such being the functions of the apparatus, there is obtained the Cartesian equation of the curved path of the above-mentioned point 37 on either side of the vertical in terms of two rectangular axes, one, X, of which is vertical through the point 37 when the rod 6 is vertical and the other, Y, horizontal through the said point and at right angles with the vertical one, the point 37 being in that case the point of origin of the said curved path.

Referring to Fig. 2, the line $o\ s$ represents the axis of the rod 6 when that rod is standing vertically upon the pattern 3 in Fig. 1. The plane of the pattern is represented in Fig. 2 by the line $s\ q$. The rod 6 is shown in Fig. 2 in two positions—namely, $o\ s$ and $p\ q$—and its length is symbolized by R. As its lower end moves along the line $s\ q$ its upper end moves from o along a path which is represented by the curved line $o\ p$. In following this path its upper end comes to be at various distances y from the line $o\ s$ and at various distances x from the line $o\ u$, which line is drawn parallel with the line $s\ q$. Thus for every position of the rod end on the curved path $o\ p$, such as p, there will be two correlated values y and x, and it is the purpose to determine the variation of y in terms of the variation of x.

The point 7 represents the fulcrum-center 7, (shown in Fig. 1,) and the straight line 6, representing the rigid rod 6 in Fig. 1, is assumed to have free motion through the point 7 in the direction of its length and angular motion about the point 7.

The distance of the point 7 from o is symbolized by T.

The distance which the lower end s of the line o–s is supposed to have moved along s–q in the present example is symbolized by m. Fig. 4 shows the values in symbols of various parts of the diagram involved by the positions of the parts shown in Fig. 2.

Referring to Fig. 4,

$$\frac{m}{y} = \frac{\mathrm{R} - \mathrm{T}}{\mathrm{T} - x}$$

Therefore

$$m = y \cdot \frac{\mathrm{R} - \mathrm{T}}{\mathrm{T} - x} \qquad (1)$$

The arc p–u (shown in Fig. 2) represents the path which the upper rod end would trace if the lower end were stationary at q and the line p–q were swung from q as a center until this line became perpendicular to q–s and also parallel with o–s. Fig. 5 shows the diagram involved by the supposition just referred to.

Referring to Fig. 5,

$$(m + y)^2 = \mathrm{R}^2 - (\mathrm{R} - x)^2$$

$$m + y = \sqrt{\left\{\mathrm{R}^2 - (\mathrm{R} - x)^2\right\}}$$

$$\therefore m = \sqrt{\left\{\mathrm{R}^2 - (\mathrm{R} - x)^2\right\}} - y \qquad (2)$$

Now the value of m in (1) equals the value of m in (2.) Thus

$$y \cdot \frac{R-T}{T-x} = \sqrt{\left\{R^2-(R-x)^2\right\}} - y$$

Therefore

$$y \cdot \left(\frac{R-T}{T-x}\right) + y = \sqrt{\left\{R^2-(R-x)^2\right\}}$$

Therefore

$$y \cdot \left\{\frac{R-T}{T-x}+1\right\} = \sqrt{\left\{R^2-(R-x)^2\right\}}.$$

Now

$$\left\{\frac{(R-T)}{(T-x)}+1\right\} = \frac{(R-T)+(T-x)}{(T-x)}$$

$$\left\{\frac{(R-T)}{(T-x)}+1\right\} = \frac{R-T+T-x}{T-x}.$$

$$\left\{\frac{(R-T)}{(T-x)}+1\right\} = \left(\frac{R-x}{T-x}\right)$$

Whence

$$y = \frac{(T-x)\sqrt{R^2-(R-x)^2}}{(R-x)} \qquad \ldots\ldots\ldots\ldots(3)$$

The last-mentioned equation having been obtained, it is possible to obtain for any point on the curved path the mathematical expression which states the radius of curvature of the path at that point. There are obtained in this manner the radii of curvature for, say, twenty points in the curved path, all the said points lying between the limits of that portion of the said path that is used in practice and being taken in pairs symmetrically disposed on both sides of the axis of the rod 6 when the latter is in its vertical position. Assuming, to make the matter as clear as possible, that these points have mass and that all such masses are equal, there is obtained the mass center (=the point 36) of them and which, seeing that the curved path is symmetrical with regard to the vertical axis, will lie on it, and the distance from the point 37 to the said mass center is the radius of that circular arc which most nearly approximates to the curved path. Having thus obtained the average or mean radius of curvature, the distance from the mass center 36 to the point 37 is adjusted so that it equals this mean radius. Then upon moving the tracer-point 10 along the plane the point 37 swings in a path which satisfies the purely angular motion of the gimbal arrangement 11 and 28 with only an inappreciable error; and at any plane comparatively near to the average plane this condition holds approximately good. Hence no lateral motion of the tracer-point 10 communicates any motion to the gimbal-rings 11 28 other than an angular one, excepting practically inappreciable movements due to the approximating nature of the arrangement; but all longitudinal movements of the tracer-point 10 raise both the gimbal-rings 11 28, and so move the outer ring 11 vertically in accordance with the vertical components of such axial movements, as already explained.

If it were not for the influence of the motion of the tracer-point 10, any path of the point 37 would be a circular one; but that influence deprives such path of absolute circularity and makes it a nearly circular one instead.

The mathematical expression for the radius of curvature is obtained by differential calculus in the usual way, dx and dy, d^2y and d^2x being the usual differentials and ρ the radius of curvature,

$$\rho = \frac{(dx^2+dy^2)^{\frac{3}{2}}}{dx\,d^2y - dy\,d^2x}$$

From the formula for the radius of curvature there are calculated a number of values of ρ, which correspond with a number of chosen values of x.

The values of x chosen are those determined by choosing several values of y, positive and negative in pairs, which are symmetrical about the axis X, while R and T are constants, and also by choosing the same values of y while R and T are constant, but with a value of T which corresponds to a different pattern-plane lying below the first plane chosen at the extreme distance met with in the practice of copying patterns having various depths in design. These values of ρ so found give a number of points near to one another and upon and about the axis X, and by interpolation the position of the mass center of these points is found, and this point is taken as the center of the nearly-spherical surface traced over by the point 37.

As a matter of fact the maximum error produced by the approximate nature of the sphere center is inappreciable.

Calculations as above are made in sets, each set corresponding to a different value for R, and thus data are obtained from which tables are printed, these tables forever afterward giving the user of the machine the immediate means of adjusting the radius of the approximate sphere by setting the screw 29.

The adjustment of the position of the point 37 is provided for by the above-described combination of screw 29, nut 30, and cup 34. The latter is held down in working position on the tracer-rod ball-top 33 by the adjustment of the screw 29 through the nut 30 up or down, as may be required. As it is desirable that the necessary variations of the radius of the gimbal arrangement be as small as possible for the various changes in position of the fulcrum 7 of the tracer-rod 6, the range of the screw 29 is kept small by varying the relationship of the distance from the fulcrum 7 to the point 37 and that from the tracer-point 10 to the said point by making the lower portion of the tracer-rod telescopic in the upper portion, a set-screw 38 being provided to hold the two together in the adjusted position. It is unnecessary to telescopically adjust the tracer-rod 6, except when a considerable change in the mean vertical position of the fulcrum 7 would necessitate a great alteration in the longitudinal position of the screw 29. Therefore when a considerable change is to be made in the said vertical position the necessity for a large alteration of the longitudinal position of the screw 29 is obviated by increasing or diminishing the length of the tracer-rod 6 between 7 and 37 by means of the telescopic device described, for it is obvious that the curvature of the motion path of 37 can be altered by the change of length between 7 and 37.

I claim—

The hereinbefore-described combination of swinging tracer-rod; tool; gimbal arrangement about the top of the tracer-rod; connection from the gimbal arrangement to the tool; and vertical adjusting device carried by the gimbal arrangement for adjusting the distance from the center of the top of the tracer-rod to the fulcrum upon which the said arrangement rocks.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

MARK BARR.

Witnesses:

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