

May 1, 1928.

1,668,518

J. C. SHAW ET AL

CONTOURING TRACER

Original Filed Oct. 28, 1924

4 Sheets-Sheet 1

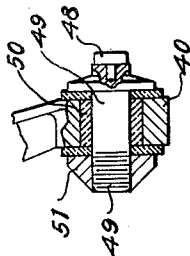


FIG. 2

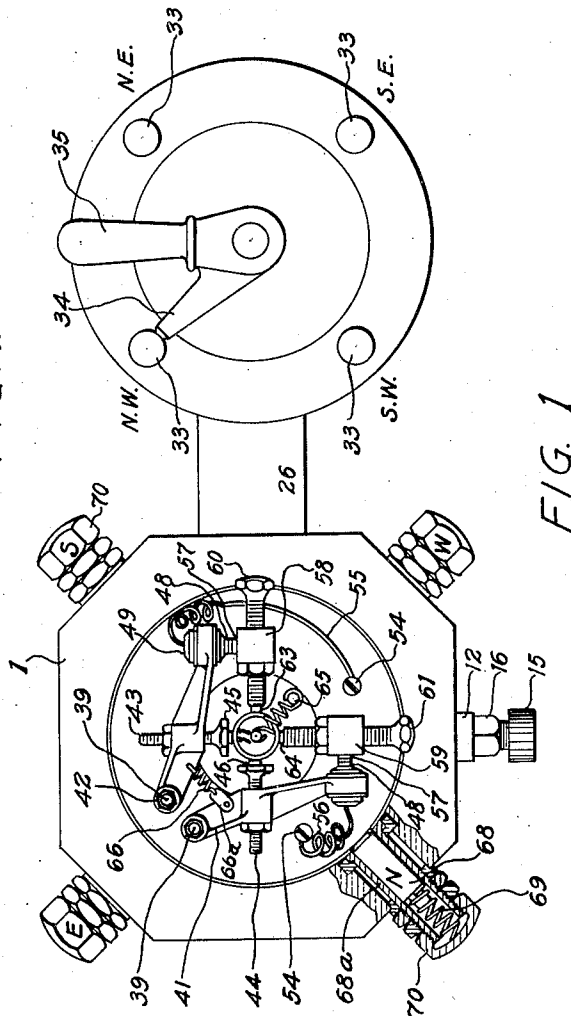


FIG. 1

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May 1, 1928.

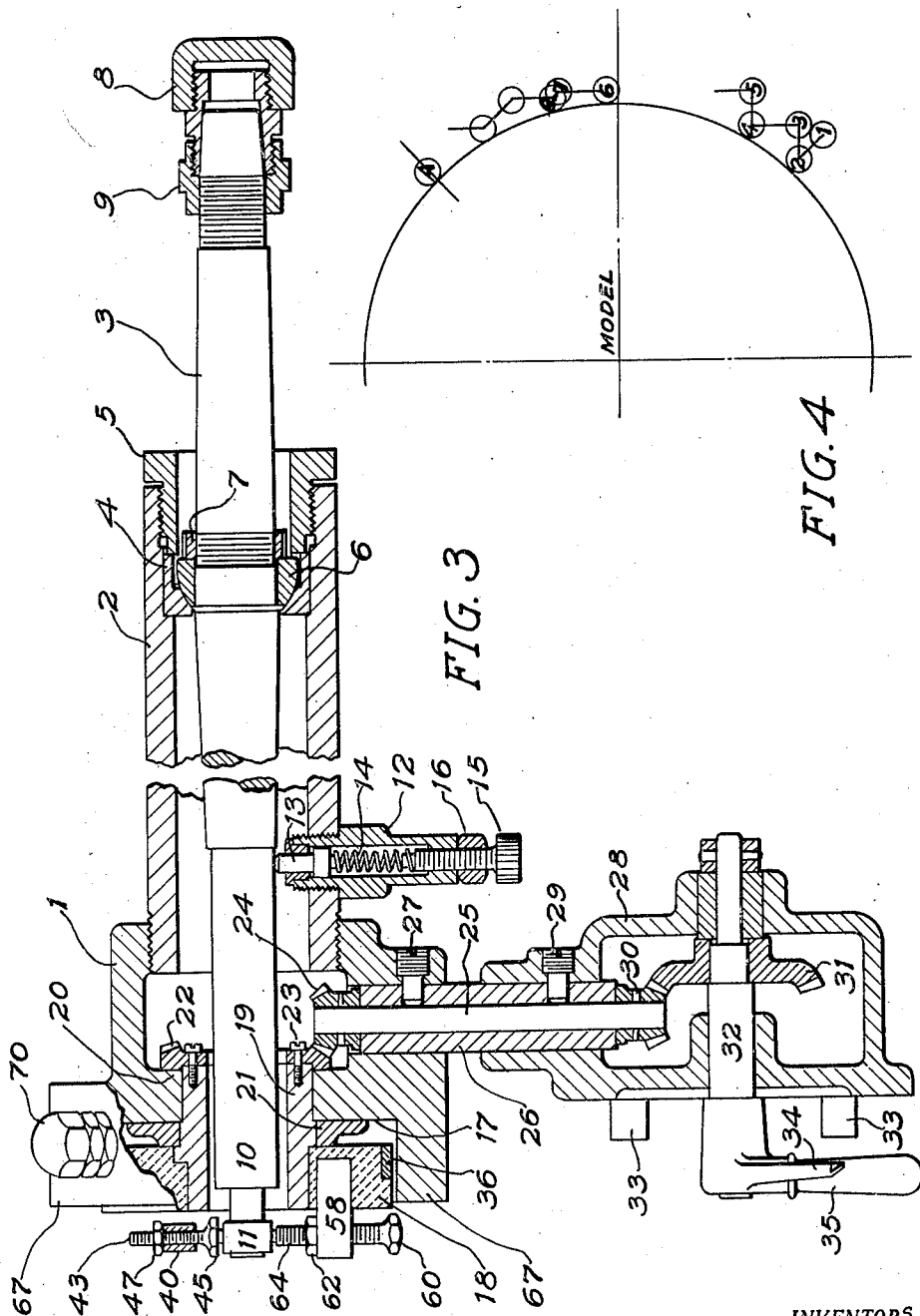
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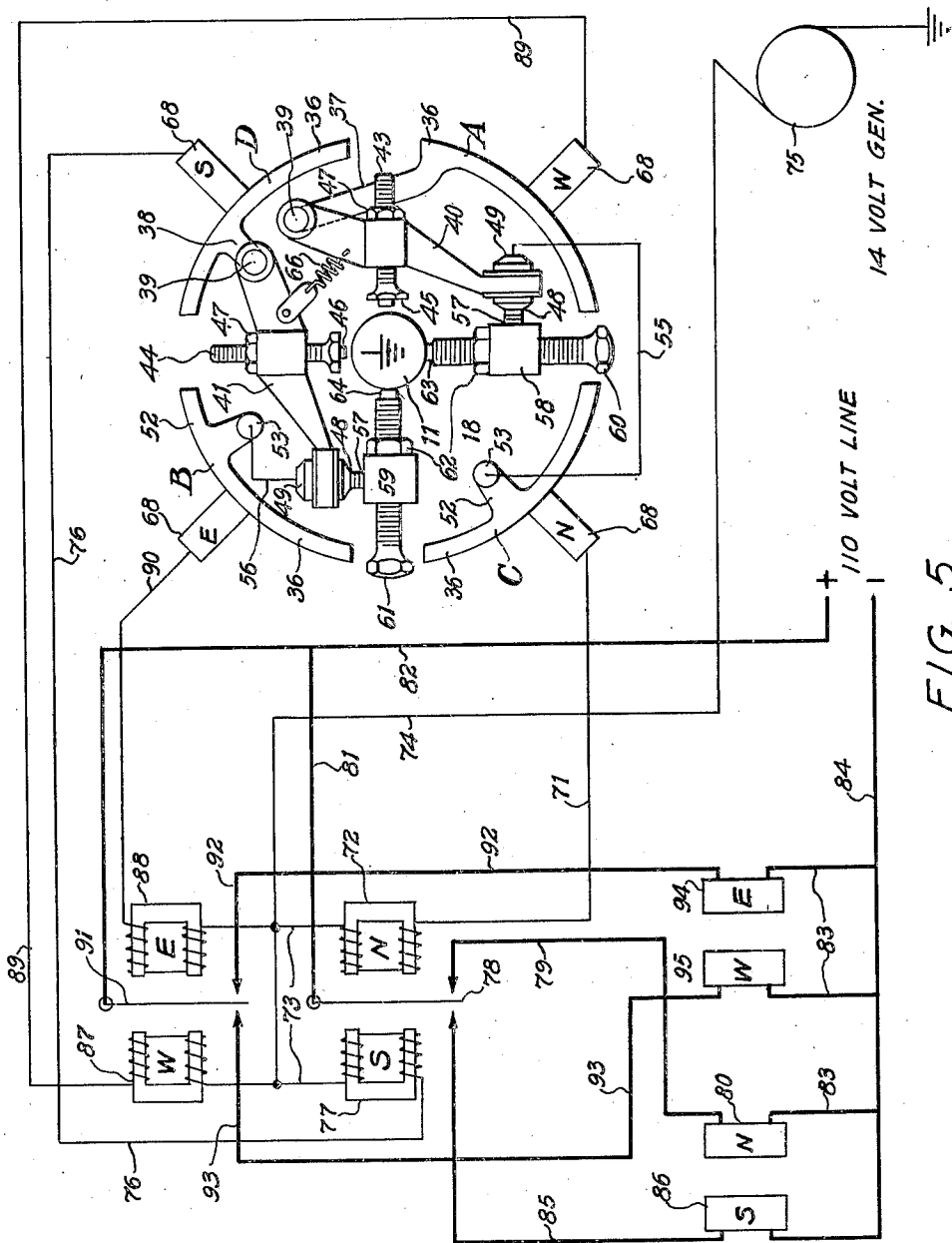
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4 Sheets-Sheet 3



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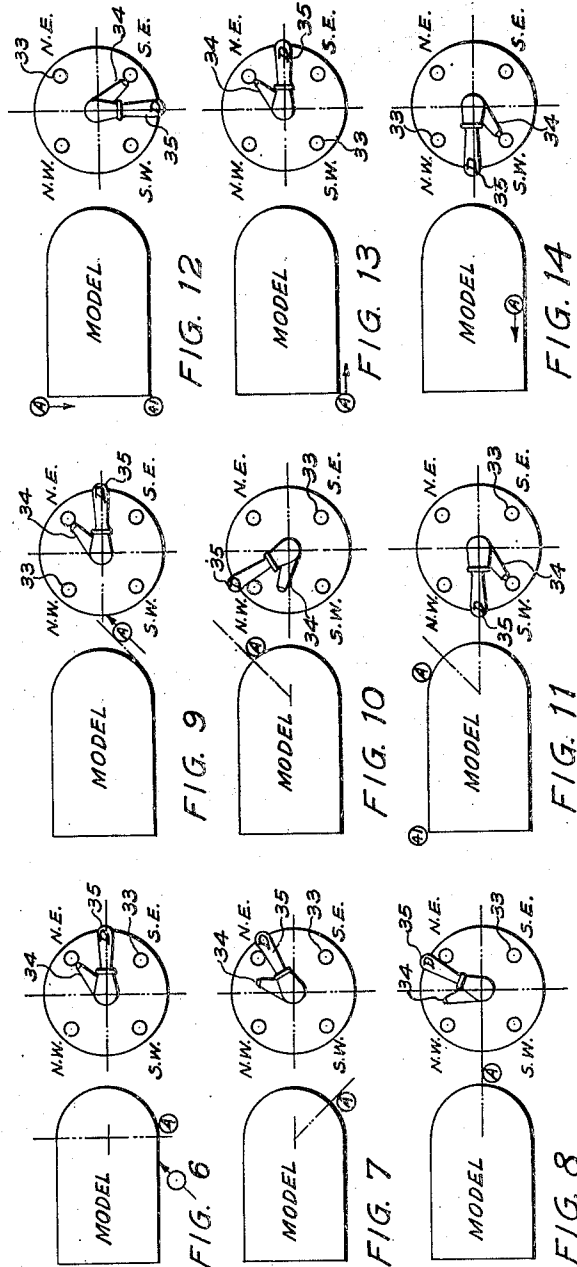
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CONTOURING TRACER

Original Filed Oct. 28, 1924 4 Sheets-Sheet 4



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CONTOURING TRACER.

Application filed October 28, 1924, Serial No. 746,348. Renewed October 17, 1927.

Our invention relates more particularly to the electro-magnetic control of machine tools, in which feeds are provided for feeding the work in two rectilinear directions at right angles to each other in the same plane, and a contouring tracer is adapted to follow a model, pattern or template and so control the two feed motions, as to reproduce the pattern by the action of a suitable cutter upon the work.

In the pending application of John C. Shaw, Serial No. 687,758, filed January 22, 1924, there is shown and described a contouring tracer for controlling the feeds in two rectilinear directions, as above indicated, said contouring tracer being provided with electro-magnet interlocks for breaking the circuits under predetermined conditions. It is found desirable to simplify the construction and make the device as sensitive as possible, therefore, in the present improvement, it is contemplated to substitute for the electrical interlock of the above application, a mechanically operated interlock for controlling the circuits for the feeds in the two rectilinear directions.

In carrying out this object, the arrangement of the circuit closing contacts is much simplified and instead of the relay contacts for direct and reverse feed being carried upon movable levers actuated by the tracer, the direct feed contact points in the present improvement, are fixed and cooperate directly with the button end of the tracer spindle through which the circuits are grounded. In the present improvement, the reverse feed contact points are carried upon pivoted levers and so located as to cooperate with the button on the end of the tracer spindle for closing the circuits therethrough, but it will be understood that, as in the pending application referred to, the reverse feed contacts are normally opened, while the direct feed contacts are normally closed.

It is desirable at times, under certain operating conditions, for the direct feed contact circuits to be broken or opened when the reverse feed contact circuits are closed, and this is accomplished electro-magnetically in the device of the prior application, above referred to, but in the present improvement, the direct feed contact circuits are broken by a slight movement of the respective levers

carrying the reverse feed contacts, such movement being effected by movement of the tracer spindle. Such movement of the tracer spindle moves the contact button on the end of the spindle out of engagement with one of the direct feed contacts and into engagement with a reverse feed contact, the movement of the lever of which is arranged to break the circuit of the other direct feed contact, thus providing a purely mechanically operating interlock.

One form of our improved contouring tracer and mechanical interlock is shown in the accompanying drawings, in which Fig. 1 shows a front elevation of our improved contouring tracer; Fig. 2 is a sectional detail of one of the circuit closing contacts of the interlock; Fig. 3 is a transverse longitudinal section of the contouring tracer, as shown in Fig. 1, except that, for the purpose of illustrating the balancing device for the tracer spindle, the index dial and rotating handle are shown below the tracer head; Fig. 4 is a diagram (much enlarged) representing certain steps in the method of operation; Fig. 5 shows diagrammatically the tracer point contact connections and a wiring diagram of the relays and magnetic clutch feed devices, and Figs. 6 to 14 are diagrams for illustrating the operation of the device.

Referring to the drawings, the tracer body comprises a head 1 in which a tubular body portion 2 is secured, and through the center of both the head and tubular portion a tracer or spindle 3 extends. The outer end of the tubular portion 2 is counterbored and fitted with a ball socket bearing ring 4, which is held in place by a thimble 5, screw threaded into the end of the tube 2, (Fig. 3). The body of the tracer spindle 3 is provided with a spherical segment 6 in the form of a collar secured in place by a suitable nut 7, so as to form a universal bearing with the ball socket 4, for the tracer spindle. The walls of the thimble 5 may be thick enough to overhang the collar 6 to prevent withdrawal of the tracer spindle from the tubular body portion 2. The outer end of the tracer spindle 3 extends beyond the end of the body portion 2 and carries a tracer head 8, which may be preferably secured thereto by a nut 9, so that the head 8 may be removably attached to the tracer spindle, thereby allow-

ing for the interchange of tracer points or heads of different sizes. The inner end 10 of the tracer spindle extends through the head 1 and terminates in a button 11 adapted to engage contact points for closing relay circuits by grounding through the tracer spindle, as hereinafter explained.

Since the size of the tracer head 8 may be varied it will be understood that the balance of the tracer spindle, as a whole, may vary and, for this reason, it is preferable to provide means for accurately balancing the spindle when in use. For this purpose, a tubular plug 12 is preferably inserted on the underside of the forward end of the tubular body portion 2, as shown in Fig. 3 of the drawings, and this plug contains a movable solid plug or feeler 13, engaging the underside of the end 10 of the tracer spindle. A spring 14 is inserted between the lower end of the plug 13 and a screw 15 threaded into the lower end of the tubular plug 12. It will thus be seen that by adjusting the screw 15, the pressure of the spring 14 can be regulated to properly balance the tracer spindle 3—10 and a lock nut 16 will hold the screw in proper adjustment.

As more particularly shown in Figs. 1 and 3 of the drawings, it will be seen that the head 1 of the tracer body is preferably made up of a recessed casting, the forward end of which is bored out at 17 to receive a rotatable contact carrying block 18. The block 18 may be of any suitable insulating material and is preferably annular in form and mounted upon a tubular hub 19, which is rotatably mounted in a bearing formed in an inwardly projecting flange 20 of the head 1. A bearing and spacing collar 21 is preferably mounted on the tubular hub 19 and may be utilized to hold the contact carrying block 18 in place, while its opposite face forms a bearing against the face of the counter bore 17 and flange 20. The other face of the flange 20 serves as a thrust bearing for an annular bevel gear 22, which is secured to the end of the hub 19 by suitable screws 23.

Referring to Fig. 3, it will be seen that the annular bevel gear 22 is engaged by a bevel pinion 24, secured to the end of a shaft 25 extending through a tube 26 projecting from the side of the head 1. The tube 26 is held in place in the head 1 by a suitable screw as at 27 and the outer end of the tube is provided with a housing 28, secured thereto by a screw 29. The shaft 25 extends into the housing 28 and the inner end thereof is provided with a bevel pinion 30, engaging a bevel gear 31, which is secured to a short shaft 32 rotatably mounted transversely in the housing 28, as indicated in Fig. 3. The front wall of the housing 28 is preferably circular in form and pro-

vided with four index studs 33, while a pointer 34, secured to the shaft 32, is adapted to cooperate therewith. A handle 35 is preferably cast integral with the pointer 34, the handle not only serving to adjust the pointer, but serving as an index in itself, for it is spaced 45° from the pointer 34, and its relation to the index studs 33 is of importance as will be more fully explained hereinafter.

It will be seen that by rotating the shaft 32 by means of the handle 35, the contact carrying block 18 may be rotated with respect to the tracer head 1. The contact carrying block 18 is preferably provided with four commutator segments 36, which are located in the respective quadrants thereof, as more particularly indicated in the diagram in Fig. 5 of the drawings. The segments 36 are insulated from each other and spaced apart at their ends and may be referred to as A—B—C and D. The segments A and B are so connected up, through suitable contacts and contact circuits as to control respectively, through suitable relays, the direct and reverse feed in one rectilinear direction and the segments C and D are similarly connected up to control the other feed in the same manner, so that in any position of rotation of the contact carrying block 18, the relation between the various segments will not be changed, but the pairs of segments A, B, C and D may be brought into position to control the direct and reverse feed of the machine in two rectilinear directions, as previously referred to, at each of the four index points or quadrants of rotation of the block 18 or pointer 34.

In our improved construction, two of the quadrant segments 36, designated as A and D, are provided with inwardly extending lugs or arms 37 and 38 embedded in the insulating material of the head 18, and provided with studs 39 projecting through the front surface of the rotatable head 18, the studs preferably standing close together about midway of the commutator segment D, substantially as indicated in Figs. 1 and 5 of the drawings. The studs 39 are adapted to form pivotal bearing for two levers 40 and 41, held in place on the respective studs by nuts 42, (see Fig. 1). The levers 40 and 41 extend, at an angle to each other, on each side of the button 11 of the tracer spindle 3 and are provided respectively with contact carrying screws 43 and 44, carrying contacts 45 and 46 located 90° apart and adapted to lie in position to cooperate with and be engaged by the contact button 11 on the end of the tracer spindle. The contacts 45 and 46 are normally slightly spaced away from the contact button 11, so that the circuits therethrough are open and it will be noted that the respective contact carrying screws 43 and 44 are adjustably mounted in

the respective levers 40 and 41, and lock nuts 47 are provided for holding them in adjusted position. The outer ends of the levers 40 and 41 are provided with circuit closing contacts 48, supported upon bolts 49, passing through insulating thimbles 50 (see Fig. 2) in holes in the respective ends of the levers 40 and 41, the bolts 49 being secured in position by suitable nuts 51.

Each of the quadrant segments 36, designated as B and C, is provided with an inwardly projecting lug 52, which has a boss 53 projecting to the front surface of the insulating material of the head 18 and by suitable screws 54, short lead wires 55 and 56 are connected therewith, the opposite ends of the lead wires 55 and 56 being secured respectively to the ends of the bolts, 49, carrying the contacts 48 of the levers 40 and 41, substantially as shown in Figs. 1 and 5 of the drawings. The circuit closing contacts 48 cooperate with contacts 57 mounted respectively upon fixed supporting posts 58 and 59, embedded in the insulating material of the head 18 and projecting above the front face thereof, the posts being arranged 90° apart. Each post 58—59 is provided with a radially extending contact carrying screw 60 and 61, adjustably mounted in the respective posts, and adapted to be secured in adjusted position by suitable nuts 62. The respective screws 60 and 61, are provided with contact points 63 and 64, located in position to engage the contact button 11, on the end of the tracer spindle; these contact points being arranged 90° apart, and diametrically opposite the movable contact points 45 and 46, as will be seen in Figs. 1 and 5 of the drawings. The relatively fixed contact points 63 and 64 are adapted to control direct feeds of the machine in two rectilinear directions at right angles to each other and normally the contacts are closed so as to ground the circuits through the contact button 11 and tracer 3. To hold the contact button 11 normally in engagement with the fixed contact points 63 and 64 a suitable spring or resilient member 65 (see Fig. 1) is mounted radially, mid-way between the two fixed contact screws, and is effective to close both contacts 63 and 64.

It will thus be seen that the fixed contact points 63 and 64, normally engaging the contact button 11, are electrically connected through the contacts 57 and 48 and lead wires 55 and 56, with two of the segments 36 designated respectively as C and B. On the other hand, the movable contacts 45 and 46, mounted on the respective levers 40 and 41, are electrically connected through the studs 39 to the other two commutator segments, designated as A—D. These latter circuits, as will be more particularly pointed out later, control reverse feed re-

lays which are brought into action only by movement of the tracer button 11, while the tracer is following a pattern. It will be observed that the levers 40 and 41 are under spring tension, by means of a spring 66, which draws the levers toward each other, and thereby holds the circuit contacts 48—57 normally closed, so that control points 63 and 64 close circuits through segments C and B, to operate relays, controlling direct feed in the two rectilinear directions. The spring 66 is connected through a block or link 66^a, of insulating material, thus insulating the levers.

Arranged around the flange 67 of the head 1 of the machine, in the respective quadrants thereof are brushes 68 adapted to cooperate with the commutator segments 36. The brushes 68 are preferably carbon cylinders, and springs 69 (see Fig. 1), adjustably held in place by screw caps 70, are adapted to hold the brushes in contact with the commutator segments 36 on the periphery of the contact-carrying block 18. The tubes 68^a, holding the brushes 68, are insulated from the tracer head flange 67 and, by suitable binding nuts, each is connected to a relay controlling one direction of feed movement of the machine, and, preferably, the various circuits may be connected up as shown in Fig. 5 of the drawings, the letters N—S—W—E, representing the points of the compass, are preferably used and referred to in describing the operation of the machine; north meaning up feed; south, down feed; east, feed to the right, and west, feed to the left.

Referring to the wiring diagram, as shown in Fig. 5 of the drawings, it will be seen that the brush 68, marked N, is connected by a wire 71, with the magnets 72 (marked N) of a relay, the circuit being completed through lead wires 73 and 74 to the low voltage generator 75. The latter is also connected to ground, so that the circuit is completed through the machine, for, as previously pointed out, the several contacts 45, 46, 63, 64 are grounded through the contact button 11 and the tracer spindle 3. Likewise, the brush 68, marked S, is connected by wires 76 with relay magnet 77, (marked S), preferably opposite the relay magnet 72, and an armature 78 is located therebetween for movement in response to the energization of either magnet. It will be seen that when the circuit is completed through the relay magnet (N) 72, the armature 78 will close the 110 volt circuit through the wire 79 to the magnetic clutch 80 (marked N), which operates the North or upward feed of the machine. The 110 volt circuit, passing through the armature 78, passes through wire 81 from the main lead 82 and the circuit from the magnetic clutch (N) 80 is completed through wire 83

to the main return lead 84. Similarly, if the armature 78 is actuated by the magnet (S) 77, connected with the brush 68 marked S, the 110 volt circuit will be connected through wire 85 with the magnetic clutch 86 (marked S) controlling the downward feed movement.

In like manner, the brushes 68, bearing the letters W and E, are connected respectively to relay magnets 87 (marked W) and 88 (marked E) by wires 89 and 90. The relay magnets (E) 88 and (W) 87 cooperate with the single armature 91, which, like the armature 78, is adapted to move in one direction or the other, according to which magnet is energized, to close the 110 volt circuit through wires 92 or 93 to actuate one or the other of the magnetic clutches 94 (marked E) and 95 (marked W), and controlling respectively, the feed of the machine to the right or to the left. The circuits from the respective clutches 80—83—94—95 are completed through the wires 83 to the lead 84, as indicated in Fig. 5 of the drawings.

As represented in Fig. 5, it will be understood that normally, when the tracer is out of contact with the model or pattern, the button 11, under the influence of the spring 65 will close the contacts 63 and 64, thereby completing circuits through brushes 68, marked N and E. In other words, the two feed magnetic clutches marked N and E (80 and 94) will be actuated and the direct feeds will be up and to the right. If the rate of feed is the same in both directions, the resultant direction of motion will be at an angle of 45° or northeast. If the tracer engages the wall of the pattern, when the direct feed movement is in the resultant direction or 45°, one or the other of the contacts 63 or 64 will be broken and the other rectilinear motion will continue. For instance, as shown in Fig. 5 of the drawings, if the up feed or north magnetic clutch is deenergized, so that this motion will stop, the magnetic clutch marked E will continue to feed toward the right or east so long as the contact 64 remains in engagement with the contact button 11.

The space between the contact points 63 and 46, and 64 and 45, on opposite sides of the contact button 11, is such that in normal operation, one of the feed contacts 63 or 64 may be broken to stop the direct feed without the button engaging the diametrically opposite movable contact 45—46, but if, through some irregularity in the contouring surface being traced, the tracer is moved excessively, the opposite or reverse feed contact 45 or 46 will be closed by grounding through the button and the pressure exerted against the movable contact throws the corresponding lever outward and breaks the circuit through the corresponding contacts 48—57, connected with the other direct feed fixed contact point,

thus stopping the direct feed controlled thereby. The reverse feed will continue until the tracer is drawn or moved out of the field of obstruction, after which normal action may be restored.

The operation of our improved contouring tracer embodying the mechanical interlocking mechanism will now be described in connection with the diagrammatic views shown in Figs. 4 and 6 to 14 inclusive. It will be understood that our improved contouring tracer is designed to be operated in connection with electro-magnetic clutches controlling the feeds in two rectilinear directions, substantially as shown and described in Patent No. 1,506,454, of August 26, 1924, to John C. Shaw.

It will be understood that the great value and importance of our improved interlock contouring tracer lies in the utility of the device for operating upon models or templates of extremely complicated contour, as well as upon those of simple contour. In order to illustrate the operation in connection with a more or less complex job, attention is called to the diagram of Fig. 4 of the drawings where the steps of movement of the contouring tracer are shown enlarged or magnified many times. This illustration of the operation is more particularly adapted to show the action of the interlocking mechanism and how the tracer will follow a humpy or irregular job, without rotating the contact carrying block 18 and the associated contact points to the extent that ordinarily should be done, as explained later. In other words, this will explain how the tracer will work itself over a small hump in the contour. For instance, in Fig. 4, assume that the pointer 34 is moved about 40° clockwise from the position illustrated in Fig. 1 and the contact carrying block and contact points are correspondingly moved clockwise. In this position, as previously stated, the direction of motion will be up and toward the left or northwest. The tracer (represented by the small circles) will then move from position (1) to position (2) at an angle of 45°, on the assumption that the feeds are equal in both directions. As soon as the tracer strikes the contour of the pattern at (2) the west feed will stop and the west contact will be open, but the north feed will continue and contact button 11, after breaking the west feed, will be thrown over far enough to close the back feed contact 46 for the reverse or east feed and the tracer will be moved to (3). When the relay circuit through the back contact 46 and the relay 88—E is operating, it will be understood that the mechanical interlock will be brought into action by the thrust of the button 11, which moving the lever 41, will positively break the contacts 48—57 in the north feed circuit.

As soon as the tracer moves east to the point (3) the east or reverse contact 46 will be broken and the north feed circuit will be closed by closing the contacts 48—57. The tracer will then move to position (4). Here the operation will be again repeated, that is, closing the east contact and breaking the north feed circuit, and the tracer will move out to position (5). This operation will be repeated exceedingly rapidly and an indefinite number of times, while following up the curve to the point (6). Here it will be seen that the north movement against the curve of the model ceases to give pressure enough to open the east contact but; the contact controlling the west feed through the relay 87—W will remain broken and the feed will be north or up to the point (7). As soon, however, as the tracer moves away from the contour far enough to permit contact 63 to close through the button 11, the west relay 87—W will again throw the magnetic clutch for the west feed and the movement will be north-west to the point (8). Here again the west feed will be broken and the feed will be north and this will be repeated indefinitely until tracer arrives at the point (A), at which point, it will be seen that the north-west direction is tangent to the curve and the tracer will pass off the contour. It is then necessary to rotate the pointer 34 counterclockwise to a corresponding position relative to the next index post 33, SW.

The preferred operation, particularly for a simple model or template, having an external contour to be reproduced, may be illustrated in connection with the diagrams shown in Figs. 6 to 13. Assuming the model to have straight horizontal sides and a rounded end, it will be seen that if the machine is started, as shown in Fig. 6, with the pointer 34 on the index 33, designated as NE, the direction of feed will be northeast, as indicated by the arrow crossing the circle just below the model. As soon as the tracer strikes the periphery of the model, the north or up feed will be stopped by breaking the direct feed contact 63, while the feed toward the east (right), controlled through the contact 64 and relay 88 (E) will continue until the tracer reaches the point (A) where the curve begins. Then, as shown in Fig. 7, both the north and east contacts will operate intermittently to carry the tracer around the curve and, preferably, the pointer 34 is moved to the position indicated in Fig. 7 and maintained practically parallel to a tangent to the curve at the point of contact of the tracer. Obviously, this does not change the two directions of feed, but facilitates the action of the tracer spindle or button 11 on the feed contacts 63 and 64 by maintaining the resultant di-

rection of feed, at all times substantially at 45° to the contact screws 60 and 61, thus equalizing the effect of any movement of the tracer.

The north and east feed motions should be continued until the tracer (A) reaches the point indicated in Fig. 8 of the drawings. Then the handle 35 should be moved past the NE index to the position indicated in Fig. 8. This brings into action the north and west feed control relays. This movement of the handle 35 past the index NE, it will be understood, is necessary, for as shown in Fig. 5, the commutator segments 36 are spaced apart and the relation between the handle 35 and the segments is such that, when the handle 35 is immediately over one of the index points 33, the brushes 68 are on the insulating material of the contact carrying block 18, between the segments 36, therefore, these points, being dead points, both feeds will be cut out. If the handle 35 is not moved from the position of Fig. 7 to a position beyond the index point, as shown in Fig. 8, the tracer would continue in the northeast direction, as indicated by the tangent line and arrow in Fig. 9 of the drawings.

After the handle 35 has been moved to the position shown in Fig. 8, the north and west feeds will be in operation simultaneously or alternately, while following the curve up to the point (A) in Fig. 10 of the drawings, and here again, if the handle 35 and pointer are not moved, beyond the dead point, the tracer would continue in a line tangent to the curve in the northwest direction. The handle 35 should, therefore, be moved to the position shown in Fig. 11, after which the two feeds in operative control will be south and west. These will continue to finish the curve to the point (A) in Fig. 11 and, after the curve merges into the straight line at the upper side of the model, the south feed will be stopped by breaking of the south contact and west feed will be continued until the tracer arrives at the point (A) in Fig. 12 of the drawings. The handle 35 is then shifted to the index SE as shown in Fig. 12, and the tracer will then follow the vertical line south, while the east feed is suppressed by opening the east contact. When the tracer reaches the lower left hand corner of the model, as indicated in Fig. 13 of the drawings, the handle 35 again should be moved, so as to bring the pointer 34 to the NE index, after which the feed will be east with the north feed suppressed by the north contact being held open. This will bring the tracer back to the starting point, as indicated in Fig. 6 of the drawings.

When the model or pattern to be reproduced has an internal contour, the operations are substantially the same as those de-

scribed for Figs. 6 to 13, except that, as shown in Fig. 14, the tracer (A) is on the inside of the pattern and, of course, can never run off or out of contact with the contour of the pattern. Furthermore, when working on an internal contour, as illustrated in Fig. 14, it is preferable to work around the contour in clockwise direction, while, as previously described, when operating on an external contour, as shown in Figs. 6 to 13, it is preferred to work around the model and index dial counter-clockwise. Therefore, the direction of feed on the lower internal edge of the model, as shown by the arrow in Fig. 14, will be toward the left, provided the handle 35 is turned as it should be, so that the pointer is at the SW index 33. In this position the south feed will be suppressed, while the west feed will continue until the tracer reaches the corner, when it will be stopped by the breaking of the contact. The pointer 34 should then be turned to the index NW, after which the north feed will carry the tracer to the upper left corner. The pointer should then be turned to the index NE and the operation continued until the curve is reached, after which the tracer is worked around the curve, substantially as previously described.

It will be understood that the rate of feed in the two rectilinear directions should be the same for the best results, and it is found in practice that a feed of two (2) inches per minute gives satisfactory results and, preferably the feed should not exceed $2\frac{3}{4}$ inches per minute. It will also be understood that, when following a curve, the circuits are interrupted by breaking the contacts momentarily, so that, while the feed, as represented in magnified form in Fig. 4 of the drawings, produces a saw-tooth edge, the interruptions are so rapid and the amount of feed prior to the interruptions is so small, that the teeth formed are really microscopic, therefore, the result is a substantially accurate reproduction of the curve of the contour.

While we have shown our improved contouring tracer in the preferred form, it will be understood that we do not wish to be limited in the interpretation of the claims, to the specific details shown, for various modifications may be made therein without departing from the spirit and scope of the invention.

We claim:—

1. A contouring tracer comprising a tracer spindle provided with a contact button at one end, a pair of contact points, maintained in fixed position relative to said button; said contact points being 90° apart, and adapted to be connected with suitable relays for controlling direct feed in two directions at right angles to each other, the circuit being completed by grounding through said button

and the tracer spindle, and a resilient member for normally holding said button in contact with said contact points.

2. A contouring tracer comprising a tracer spindle provided with a contact button at one end, a rotatable head mounted concentrically of said spindle and provided with a central opening through which the end of said spindle passes, a pair of contacts mounted on said head 90° apart, and adapted to be engaged by said button for grounding the respective circuits of said contacts through said tracer spindle, resilient means for normally holding the button in engagement with said contacts, and manual means for rotating said head.

3. A contouring tracer comprising a movable tracer spindle provided with a contact button at one end, a head concentrically arranged for rotation about the button end of said spindle, a pair of contact points 90° apart, mounted upon said head, commutator segments mounted upon said head and electrically connected with said contact points and means actuated by movement of said tracer spindle for breaking the circuits between said contact points and the respective segments.

4. The contouring tracer as claimed in claim 3, in which four brushes are provided at diametrically opposite points for engagement with said commutator segments and means is provided for rotating said head so as to vary the engagement of the segments and brushes.

5. A contouring tracer comprising a movable tracer spindle provided with a contact button at one end, a rotatable head mounted concentrically of the button end of said spindle, a pair of contacts 90° apart, mounted on said head for engagement with said button, four commutator segments mounted on said head in the respective quadrants thereof, electrical connections between said contacts and two of said quadrants lying adjacent, resilient means for holding the button normally in engagement with said contacts, a second pair of contacts electrically connected respectively with the other two of said segments, said second contacts being adapted to be engaged by said contact button when said spindle is moved a predetermined amount, and means controlled by said button when engaging said last mentioned contacts for breaking the circuits between said first mentioned contacts and their respective segments.

6. A contouring tracer, comprising a tracer spindle mounted for universal movement of its ends and provided at one end with a contact button, a head provided with an opening through which the button end of said spindle extends, a pair of fixed contact points mounted on said head 90° apart in position to cooperate with said contact

button, a pair of levers pivotally mounted on said head and carrying contact points 90° apart diametrically opposite said fixed contact points, said lever contacts being normally open while the fixed contacts are normally closed through said contact button, and resilient means for holding said button in engagement with said fixed contact points.

7. The contouring tracer as claimed in claim 6, in which said head is mounted for rotation about said spindle and manual means is provided for rotating it.

8. The contouring tracer as claimed in claim 6, in which said head is mounted for rotation about said spindle, and is provided with four commutator segments electrically connected respectively to the fixed and lever contact points to complete circuits by grounding through said button and four brushes are mounted 90° apart around said head for cooperation with said commutator segments.

9. A contouring tracer comprising a movable tracer spindle provided with a contact button at one end, a head provided with an opening through which the button end of said spindle passes, two fixed and two movable contact points mounted on said head 90° apart in position to be engaged by said contact button for grounding circuits through said spindle, and a spring for normally holding said contact button in engagement with said fixed contact points.

10. The contouring tracer as claimed in claim 9, in which said two movable contact points are carried by levers mounted on said head and extending transversely of the axis of said spindle, said movable contact points being located in position to be engaged by said button diametrically opposite the fixed contact points, said lever contact points being so adjusted as to be normally out of engagement with said button.

11. The contouring tracer as claimed in claim 9, in which said movable contact points are located diametrically opposite said fixed contact points, with respect to said contact button, and means is provided for breaking the respective circuits through said fixed contact points by movement of said movable contact points.

12. A contouring tracer comprising a

movable tracer spindle provided with a contact button at one end, a head rotatable concentrically of the button end of said spindle, manual means for rotating said head, a pair of fixed contact points mounted on said head 90° apart in position to be engaged by said button, a spring normally holding said button in engagement with said fixed contact points, a pair of movable contact points supported on said head 90° apart and diametrically opposite the respective fixed contacts, four commutator segments mounted in the four quadrants of said rotatable head and each electrically connected respectively to one of said contact points, four brushes mounted 90° apart around said head for cooperation with said commutator segments for completing relay circuits through said contacts when the latter are grounded through said contact button, and means controlled by the movement of said movable contact points for breaking the circuits of said fixed contact points.

13. The contouring tracer as claimed in claim 12, in which said movable contact points are mounted on levers pivoted on said head and said levers carry circuit closing contacts normally closing the circuits between the two fixed contact points, and their respective segments, springs being provided for holding said levers with said circuit closing contacts closed.

14. A contouring tracer comprising a movable tracer spindle provided with a contact button at one end, adapted for cooperation with two fixed and two movable contacts, a head concentrically arranged for rotation about the button end of said spindle, a pair of fixed contact points 90° apart, mounted upon said head, four commutator segments mounted upon said head two of which are electrically connected with said fixed contact points through normally closed circuit closing contacts, a pair of movable contacts on said head and permanently in electrical connection with the other two segments respectively, and mechanical means for breaking said circuit closing contacts when said movable contacts are closed through said contact button.

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