June 15, 1926. 1,588,856

J. C. SHAW

CONTOURING TRACER

Filed Jan. 22, 1924 4 Sheets-Sheet 1

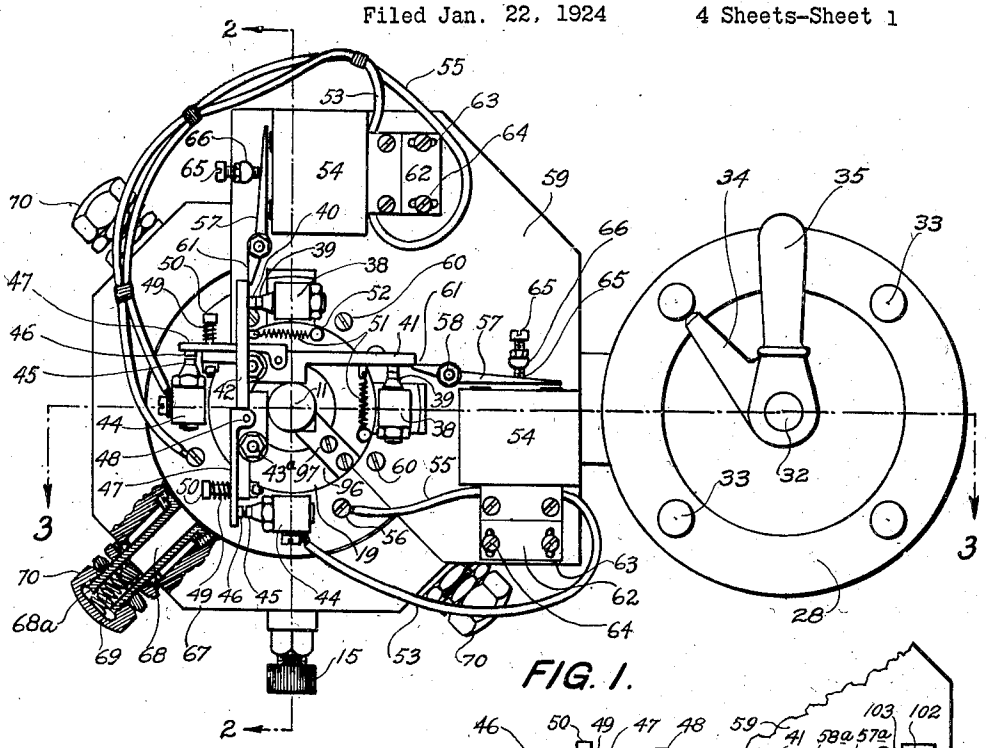


FIG. 1.

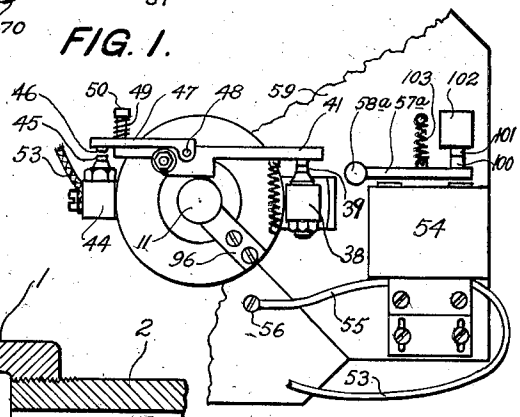


FIG. 15.

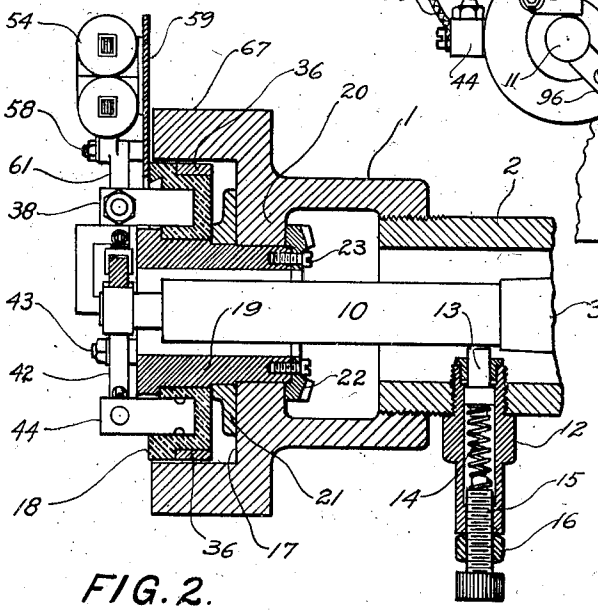


FIG. 2.

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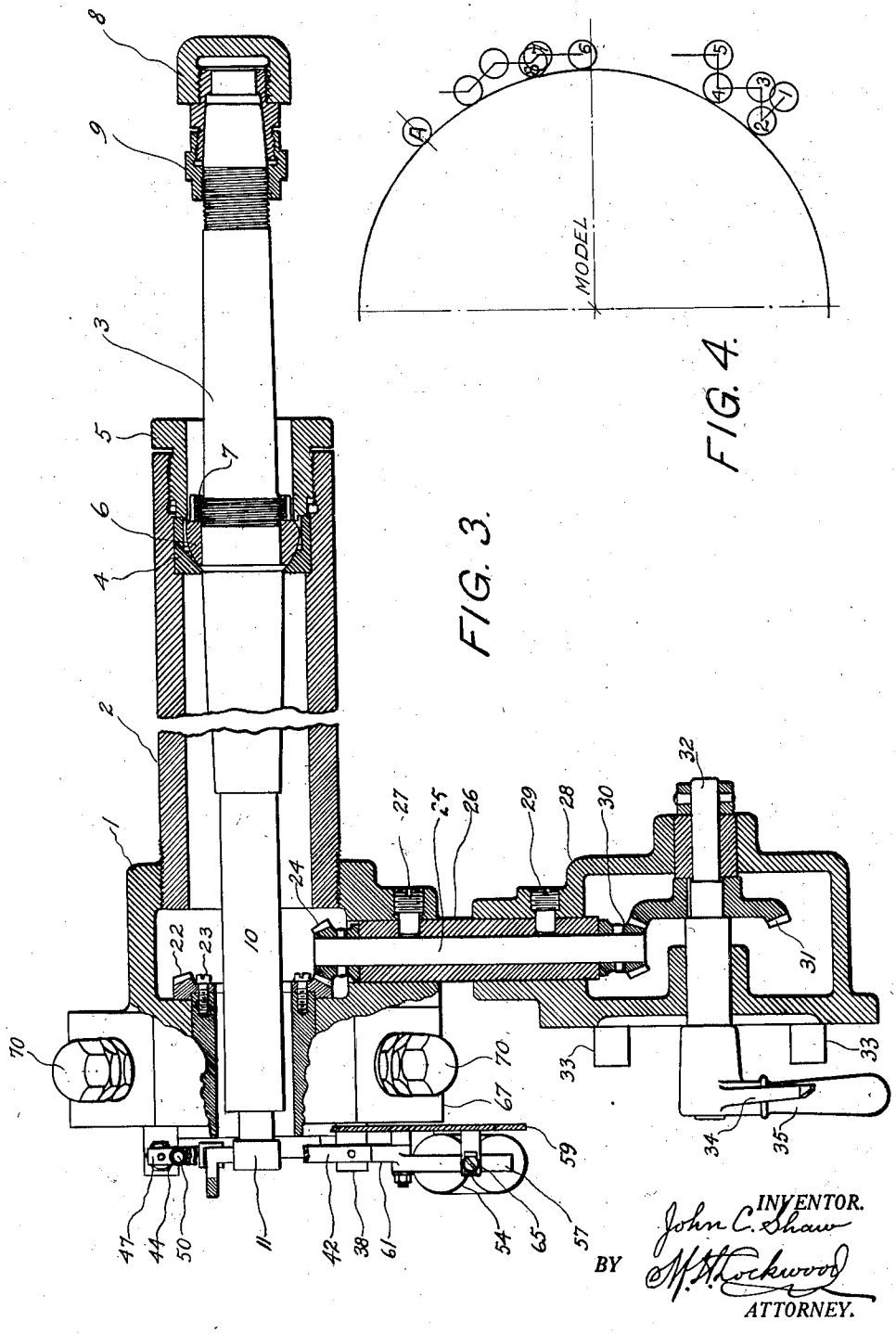



FIG. 3.




FIG. 4.

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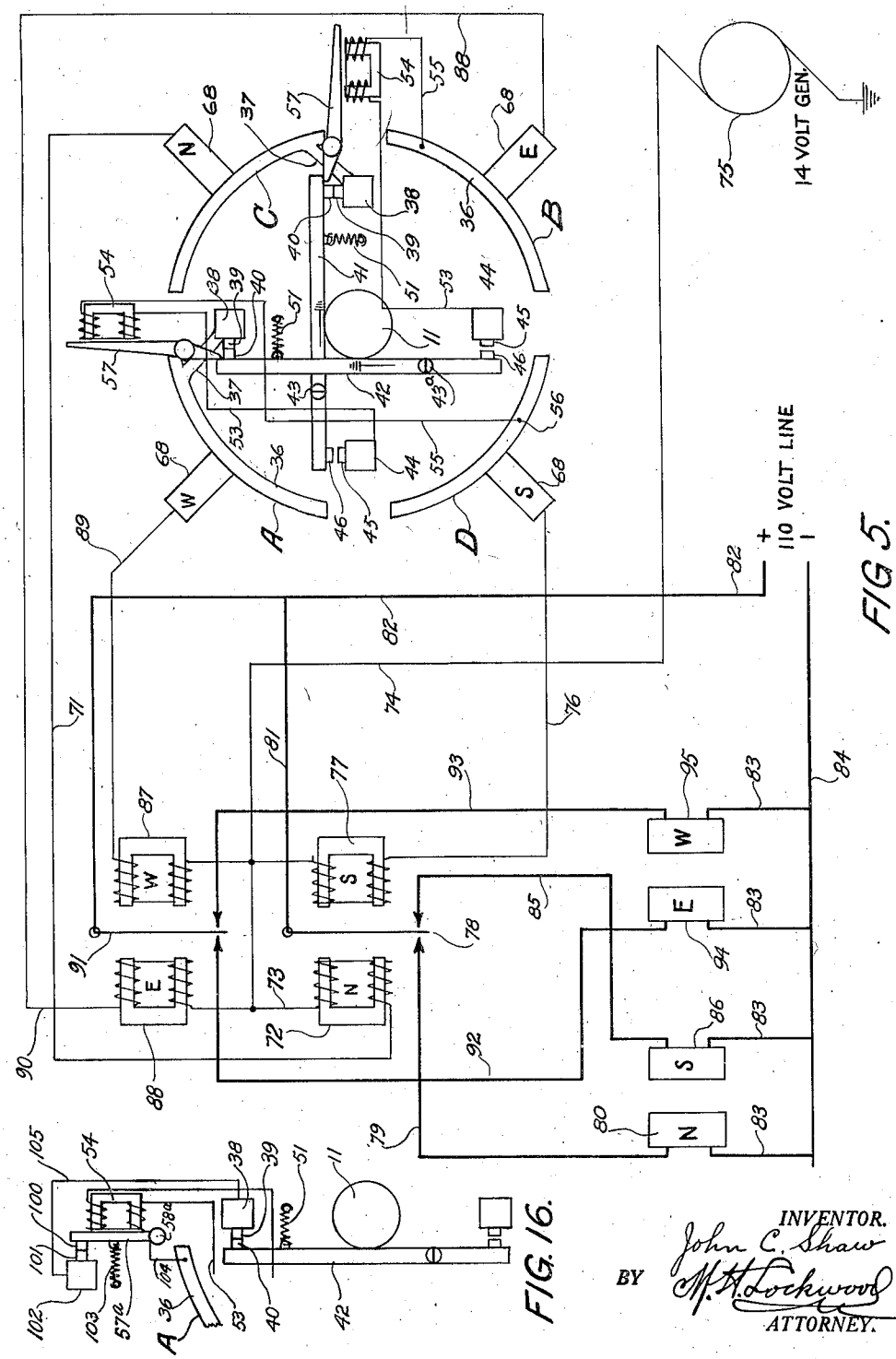



FIG 5.

FIG. 16.

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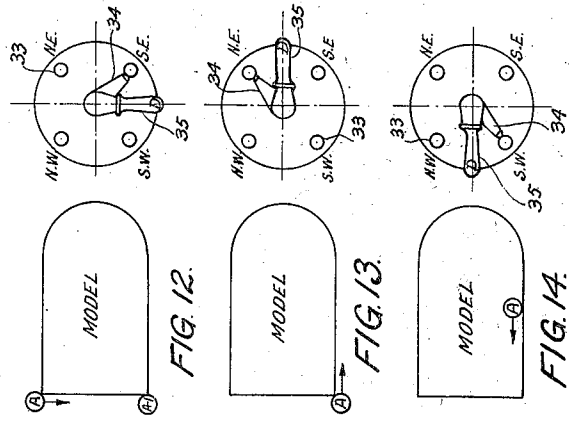



FIG. 12. FIG. 13. FIG. 14.

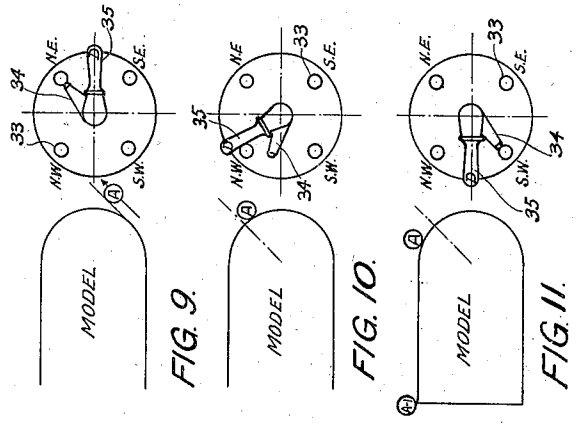



FIG. 9. FIG. 10. FIG. 11.

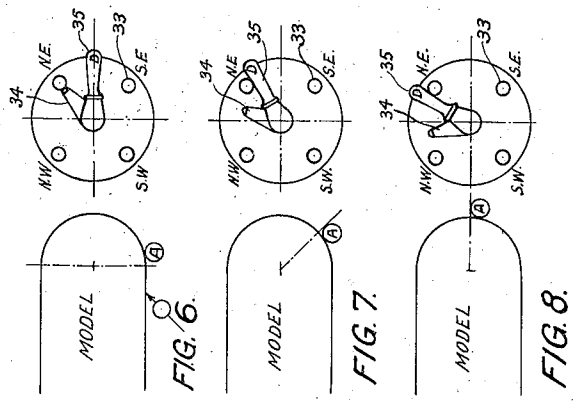



FIG. 6. FIG. 7. FIG. 8.

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# UNITED STATES PATENT OFFICE.

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## CONTOURING TRACER.

Application filed January 22, 1924. Serial No. 687,758.

My 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 my previous application, Ser. No. 604,923, filed December 4, 1922, there is described one form of contouring tracer, which, while giving satisfactory results for some classes of work, does not meet all of the requirements and, therefore, one object of my improved contouring tracer is to increase the sensitiveness of the control and to provide a satisfactory interlocking mechanism, whereby excessive feed motion in one direction or the other is adapted through the interlocking mechanism to break the direct feed circuit of the other arm, and simultaneously reverse the feed controlled by the first arm.

Another object is to reduce the number of contact carrying arms to a minimum and adjust the leverage to reduce the movement of the contacts and thereby increase the sensitiveness of the control, so that the contacts controlling the feeds may be operated by excessively small movements of the tracer head and the interlocking device is so coordinated that when the reverse feed of one arm is brought into play, by closing the back contact of that arm, the forward or direct feed circuit of the other arm will be broken. In this manner, the cutter and tracer are fully protected against injury and the pattern will be accurately and efficiently reproduced in the work.

In the accompanying drawings, I have illustrated the one form of my improved contouring tracer, together with a slight modification, Fig. 1 shows a front elevation of the tracer; Fig. 2 shows a vertical longitudinal section on the line 2—2 of Fig. 1; Fig. 3 shows a horizontal longitudinal section, in part broken away, on the line 3—3 of Fig. 1; Fig. 4 is a diagram representing (much enlarged) certain steps in the method of operation; Fig. 5 represents a diagrammatic lay-out of the wiring connections; Figs. 6 to 14 are diagrams for illustrating the operation of the device; and Figs. 15 and 16 show a modification of the interlock mechanism.

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 allowing 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 and operate contact carrying arms 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. 2 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. 2 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 shaft 25 extending laterally 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 provided 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 carrying arms 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.

Of the commutator segments 36, the segments A and C (Fig. 5) are provided with inwardly projecting arms 37, preferably integral with contact carrying posts 38, projecting through the contact carrying block 18, as more particularly shown in Figs. 1 and 2 of the drawings. Each contact post 38 carries a contact 39, cooperating with contacts 40, on the respective contact carrying arms 41 and 42. The contact carrying arms 41 and 42 are pivotally mounted at 43 and 43ª on studs or screws entering the hub 19, to which the contact carrying block 18 is secured, as previously pointed out. In this manner, it will be seen that the contact carrying arms 41 and 42 are grounded through the machine by the metallic connection through the hub 19.

The contact carrying block 18 supports two additional contact carrying posts 44, which, as shown in Fig. 2 of the drawings, are merely embedded in the insulating material of the contact carrying block 18, but each is provided with contacts 45 for cooperation with contacts 46 on the rear ends of the contact carrying arms 41 and 42, as more particularly shown in Figs. 1 and 5 of the drawings. The back contacts 46 of the arms 41 and 42 are preferably mounted upon short levers 47, pivoted at 48 to the respective arms, and are held in operating position by means of light springs 49, extending between the heads 50 and the rear faces of the respective short levers 47. Springs 51 are connected from the respective arms 41 and 42 to studs 52 in the hub 19, thereby providing resilient means for holding the direct or forward contacts 39 and 40 closed under normal conditions.

The insulated contact posts 44 are connected by lead wires 53, through small electro-magnets 54 and lead 55 with posts at 56 extending upward from the respective commutator segments B and D, so that when the back contacts 45—46 of the contact carrying arms are closed, the respective magnets 54 will be energized. Cooperating with each of the magnets 54 is an armature 57, pivoted at 58 to a plate 59, secured by screws 60 to the rotatable contact carrying block 18, as more particularly shown in Fig. 1 of the drawings. The armatures 57 are formed as levers, the short arms 61 of which extend under the outer ends of the respective contact carrying arms 41 and 42. The magnets 54 are preferably secured to the supporting plate 59 by rearwardly extending brackets 62 provided with slots at 63, through which screws

64 are passed, thus providing means for adjusting the position of the magnets relative to the respective armatures 57. Also, cooperating with the armatures 57, stop screws 65 are preferably mounted in posts 66 and adjustable to limit the outward throw of the armatures 57. The adjustment of the magnets 54 and armatures 57 is such that when the magnets are energized, the respective contact carrying arms 41 and 42 will be lifted or moved sufficiently to break the contacts 39—40 for the direct feed, but the arms will not be moved far enough to close the back contacts 45—46. It will be seen, however, that the respective magnets 54 are energized only by closing one or the other of the back contacts of the arms 41 and 42, and when the back contact of one arm is closed, the forward contact of the other arm will be broken by the attraction of the armature 57 of the corresponding electro-magnet 54. In this manner, it will be seen that the contact carrying arms are interlocked through the magnets so that excessive movement of one of the contact carrying arms will result in breaking the direct contact of the other arm.

Thus, incidentally, when one of the back contacts 45—46 is closed, the corresponding circuit is completed, not only through the corresponding electro-magnet 54 for breaking the direct contact of the other arm, but also through the associated commutator segment B or D to the magnetic clutch to operate the reverse feed of the machine in one or the other of the feed directions, according to which contact arm is making the back contact and the relative angular position of the contact carrying block 18.

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, adjustably held in place by screw caps 70, are adapted to hold the brushes in contact with the commutator segments 36 and the periphery of the contact carrying block 18, (see Fig. 1). 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 contact carrying arms 41 and 42 are grounded through the hub 19. Likewise, the brush 68, marked S, is connected by wire 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—86—94—95 are completed through the wires 83 to the lead 84, as indicated in Fig. 5 of the drawings.

As represented in Figs. 1 and 5, it will be understood that normally, when the tracer is out of contact with the model or pattern, the parts will occupy the positions shown in these views and the contacts 39 and 40 of both contact carrying arms 41 and 42 will be closed, thereby completing the circuits through brushes 68 marked N and W. In other words, the two feed clutches marked N and W will be closed and the direct feeds will be up and to the left. If the rate of feed is the same in both directions, the resultant direction of motion will be at an angle of 45° of northwest. Obviously, if one of the forward contacts 39—40 of one of the arms 41 or 42 is broken,

the direction of feed will be either up or to the left according to which contact is broken. For instance, if the direct contact of the arm 41 through the brush N, as shown in Fig. 5 of the drawings, is broken, the relay magnet N will be de-energized, while the relay magnet 87, marked W, will remain energized and the direction of feed will be solely toward the left.

It will be understood that provision for rotating the contact carrying block 18, together with the contact carrying arms 41 and 42 and the interlocking mechanism, is an important feature, in that it enables the operator to follow the work, that is, keep the button end 11 of the tracer spindle thrusting always toward the crotch between the contact carrying arms 41 and 42. Nevertheless, it frequently occurs, or may be desirable for the thrust to be exerted at a sharper angle relative to one or the other of the contact carrying arms 41—42, and when this occurs, it is exceedingly important to prevent the button 11 from sliding longitudinally of the contact carrying arm without lifting it sufficiently. This is effectively accomplished in the present device by means of a fixed member 96 secured by screws 97 to the face of the hub 19 of the rotatable unit, including the contact carrying block 18 and the contact carrying arms 41 and 42. As will be seen in Fig. 1 of the drawings, the block 96 is preferably provided with a V-shaped end, so as to provide two points of engagement with the periphery of the button 11, when the latter is central of the rotating member. Obviously, there is just space enough between the button, when barely touching the fixed points of the block 96, for the forward contacts on the arms 41 and 42 to be closed by their respective springs 51. It will be seen, however, that by this arrangement, it is impossible for the button 11 of the tracer spindle to slide longitudinally of either of the contact carrying arms, for any pressure in that direction will merely cause the button 11 to be cammed off the point of stop 96 and thrust toward the corresponding contact carrying arm to lift it further, thereby actuating the arm as it should be actuated without permitting longitudinal sliding movement with respect thereto.

The operation of my improved contouring tracer embodying the electro-magnet 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 my improved contouring tracer is designed to be operated in connection with electro-magnetic clutches controlling the feeds in the two directions substantially as shown and described in my Patent No. 1,506,454 of August 26, 1924, and electro-magnetic clutches of this character are now well known on the market.

It will be understood that the great value and importance of my 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 in 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 carrying arms 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 in the position illustrated in Fig. 1 and the contact carrying block and contact carrying arms are in the position shown in Figs. 1 and 5 of the drawings. In this position, as previously stated, the direction of motion will be up and toward the left or northwest. The tracer 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 north or up feed will stop. Then the west feed will be interrupted and the arm 42, controlling the west feed will be thrown over far enough to close the back contacts 45—46 for the reverse or east feed and the tracer will be moved to (3). When the relay circuit through the back contact 45—46 and the relay $88^{E}$ is operating, it will be understood that the interlock magnet 54 is energized and, through the armature 57 and arm 61, will positively break the contact of the north feed.

As soon as the tracer moves east to the point (3) the east or reverse contact 45—46 will be broken and the north contact 39—40 of the arm 41 will be closed. 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 contact 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 contact controlling the west feed through the relay $87^{W}$ will be 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 contacts 39—40 of the arm 42 to operate, the west relay 87 will again throw the magnetic clutch for the west feed and the movement will be northwest 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 northwest direction is tangent to the curve and the tracer will pass off the contour. It is then necessary to rotate the pointer 34 to the next index post 33.

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 of the direct or forward contact of the contact carrying arm 42, while the feed toward the east (right) 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 contact carrying arms 41 and 42, by maintaining the resultant direction of feed, at all times, substantially at 45° to each of the arms 41 and 42, 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 previously pointed out, the commutator segments 36 are spaced apart and the relation between the handle 35 and the segments, as shown in Fig. 5 of the drawings, 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 beyond the dead 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 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 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 described 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. 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 2¾ 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 resultant is a substantially accurate reproduction of the curve of the contour.

It is sometimes desirable to operate the tracer with rather heavy springs 51 holding down the respective contact carrying arms 41 and 42, and under these conditions, it is preferable to break the circuit through the contacts 39—40, without lifting the respective contact carrying arms. With this in view, I have shown in Figs. 15 and 16 a modification of the interlock mechanism, in which the magnet 54 operates a relay circuit, thus removing the interlock mechanism from the influence of spring 51. Referring to Figs. 15 and 16, it will be seen that the electrical connections to the magnets 54 remain the same as previously described, but instead of the lever armature 57—61, a simple relay armature 57ª is pivoted at 58ª, in position to cooperate with the magnet 54. The free end of the armature 57ª is provided with a contact point 100, which is adapted to cooperate with a contact 101 mounted upon an insulated post 102, the latter being secured to the plate 59, as shown in Fig. 15. A spring 103 is provided to normally hold the contacts 100—101 closed. In providing for this change in the interlock, the bridge 37, as shown in Fig. 5, between the commutator bar 36 and the post 38 is removed and the associated commutator segment 36 is electrically connected to the armature 57ª by the lead wire 104. The circuit previously established through the bridge 37 is completed by connecting the contact 101 on the post 102 with the post 38, by means of the lead wire 105. By this construction, it will be seen that the interlock is effected through the relay armature 57ª by breaking the contacts 100—101 instead of breaking the contacts 39—40, thus avoiding lifting the contact carrying lever 42, as is required in the interlock mechanism previously described. Obviously, this construction permits the use of heavier springs 51, while, at the same time, providing rapid and easy operation of the relay contacts for effecting the interlock. This has the advantage of providing a quick operating device, requiring less power.

While I have shown my improved contouring tracer in the preferred form, it will be understood that for special machines, and in adapting the contouring tracer to various types of work, numerous modifications in the specific details of construction may be required, and, therefore, I 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.

I claim:—

1. In a contouring tracer, the combination with a tracer spindle, of a contact carrying head, a pair of contact carrying arms pivotally mounted upon said head, and carrying contact on each side of the respective pivots, said arms extending at right angles to each other and adapted to engage and be actuated by the end of said tracer.

2. In a contouring tracer, the combination with a tracer spindle, of a contact carrying head, a pair of contact carrying arms pivotally mounted upon said head and extending at right angles to each other, said arms being adapted to engage the end of said tracer spindle at points 90° apart, and direct and reversing contacts carried by each of said arms.

3. In a contouring tracer, the combination with a tracer spindle, of a contact carrying head, a pair of contact carrying arms pivotally mounted on said head and extending at right angles to each other, said arms being adapted to engage the end of said tracer bar, a fixed member mounted on said block at an angle of 45° to each of said arms, said member being provided with points engaging said tracer spindle.

4. In a contouring tracer, the combination with a tracer spindle, of a contact carrying block, rotatable about the axis of said spindle, a pair of contact carrying arms pivotally mounted upon said block and carrying contacts on each side of the respective pivots, said arms extending at right angles to each other and adapted to engage and be actuated by the end of said tracer spindle, and means for rotating said block.

5. In a contouring tracer, the combination with a tracer spindle, of a contact carrying block, rotatable about the axis of said spindle, a pair of contact carrying arms pivotally mounted upon said block and ex-

tending at right angles to each other, said arms being adapted to engage the end of said tracer spindle at points 90° apart, direct and reversing contacts carried by each of said arms, and means for rotating said block.

6. In a contouring tracer, the combination with a tracer spindle, of a contact carrying block, rotatable about the axis of said spindle, a pair of contact carrying arms pivotally mounted on said block and extending at right angles to each other, said arms being adapted to engage the end of said tracer spindle at points 90° apart, a fixed member mounted on said block at an angle of 45° to each other of said arms, said member being provided with points engaging said tracer spindle, and means for rotating said block.

7. In a contouring tracer, the combination with a tracer spindle, of a contact carrying block, rotatable about the axis of said spindle, a pair of contact carrying arms mounted on said block at right angles to each other and adapted to be engaged and actuated by the end of said tracer spindle, electro-magnets supported on said block for actuating each of said arms independently of said tracer spindle and means for rotating said block.

8. The contouring tracer, as claimed in claim 7, in which each of said contact carrying arms carries a back contact for closing the circuit through the magnet actuating the other of said contact carrying arms.

9. The contouring tracer, as claimed in claim 8, in which each of said contact carrying arms carries a forward and a back contact for controlling respectively direct and reverse feed circuits, and the electro-magnet for actuating each arm is in series with the reverse feed circuit of the other arm.

10. The system of electro-magnetic control of the feed of machine tools, in which magnetic clutches are provided for establishing direct and reverse feed in two rectilinear directions at right angles to each other in the same plane, comprising a tracer spindle, the tracer end of which is adapted to engage the contour of the model to be reproduced, a contact carrying block mounted for rotation about the axis of said spindle, a pair of contact carrying arms mounted upon and rotatable with said block, said arms being adapted to engage the other end of the tracer spindle, circuit connections from said contact carrying block to said magnetic clutches for controlling the respective direct and reverse feeds upon actuation of said contact carrying arms by movement of the tracer spindle, and means for rotating said block.

11. The system of feed control as claimed in claim 10, in which each of said contact carrying arms carries a forward and a back contact for the respective direct and reverse feed circuits, the circuits of the latter being each interlocked through electro-magnets to break the direct feed circuit of the other arm.

12. In a contouring tracer, the combination with a body portion, of a tracer spindle, supported therein for universal lateral movement, one end of said tracer spindle being provided with a tracer head, for engagement with the model or pattern to be reproduced, a pair of contact carrying arms pivotally mounted at right angles to each other, in position to engage the other end of said tracer spindle, each of said arms being provided with two contacts, one on each side of the respective pivots thereof, and a contact carrying block supporting said arms and provided with contacts for cooperation with the contacts of the arms.

13. The contouring tracer, as claimed in claim 12, in which said contact carrying block is mounted on said body portion, for rotation about the axis of said tracer spindle and manual means is provided for rotating said block.

14. In a contouring tracer, the combination with a tubular body portion, provided with a head at one end, a tracer spindle mounted in said tubular body for universal lateral movement of the ends thereof, one end of said spindle, projecting beyond the body portion, being provided with a tracer for cooperation with the contour of the model to be reproduced, a contact carrying block rotatably mounted in said head, a pair of contact carrying arms mounted on said block at right angles to each other, each of said arms carrying two contacts adapted to cooperate with contacts on said block, said arms engaging the other end of said tracer spindle, whereby movement of the latter is adapted to control the making and breaking of said contacts, a plurality of commutator segments mounted on the periphery of said block and connected with the respective contacts carried by the block and a corresponding plurality of contact brushes supported in the head of said body member.

15. The contouring tracer as claimed in claim 14, in which two of said contacts carried by the block are connected to their respective commutator segments through electro-magnets, the armatures of which are adapted, when the magnets are energized, to break the respective circuits through the other two contacts.

16. In a contouring tracer, the combination with a body portion, of a tracer spindle mounted therein for universal movement of the ends thereof, a contact carrying block rotatably mounted in said body portion, manual means for rotating said block, four commutator segments in the periphery of said block, four brushes for engagement with said commutator segments, said brushes be-

ing mounted on said body portion and equally spaced around said block, a corresponding number of contacts mounted on said block and connected with the respective segments, two of said contacts being connected to their segments through electro-magnets supported upon and rotatable with said block, a pair of contact carrying arms pivotally mounted upon said block, at right angles to each other, in position to be actuated by movement of said tracer spindle, each of said arms being provided with front and back contacts for cooperation respectively with the contacts on said block, the back contacts of said arms closing the respective circuits through said magnets, and armatures actuated by said magnets for breaking the circuits through the front contacts of the respective arms.

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