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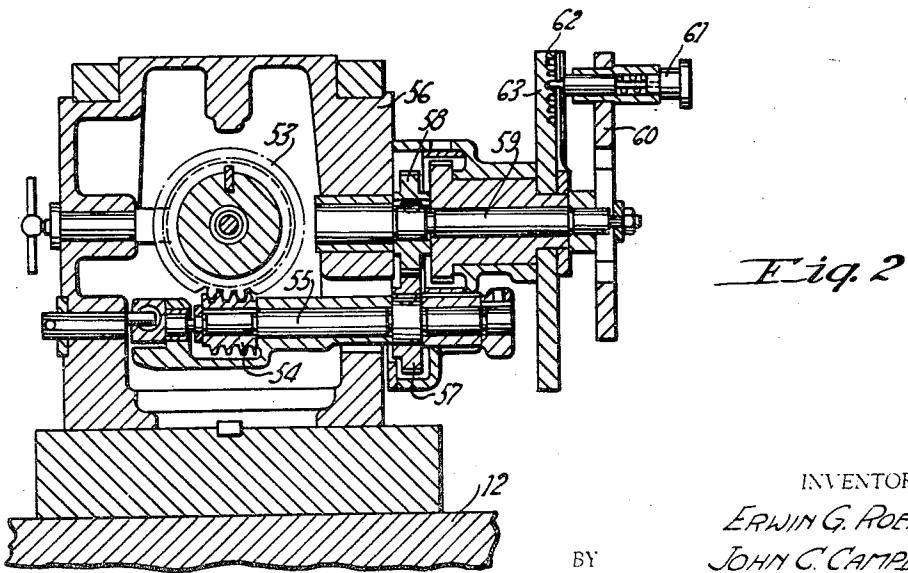
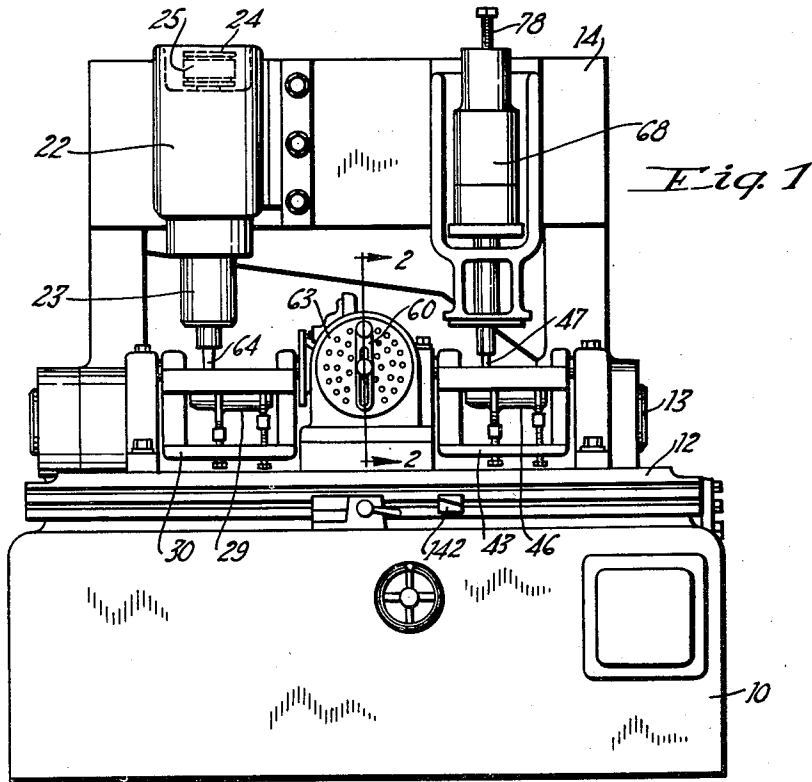
E. G. ROEHM ET AL

2,089,099

DIE SINKING AND ENGRAVING MACHINE

Filed Jan. 8, 1936

4 Sheets-Sheet 1



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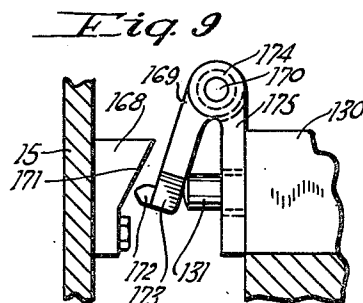
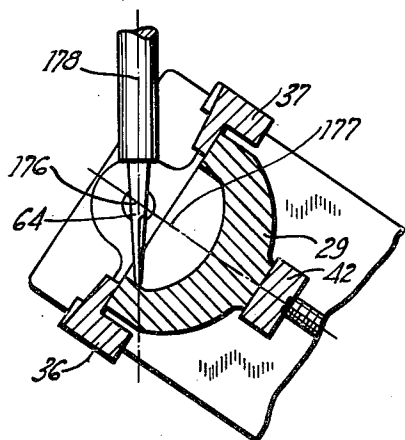
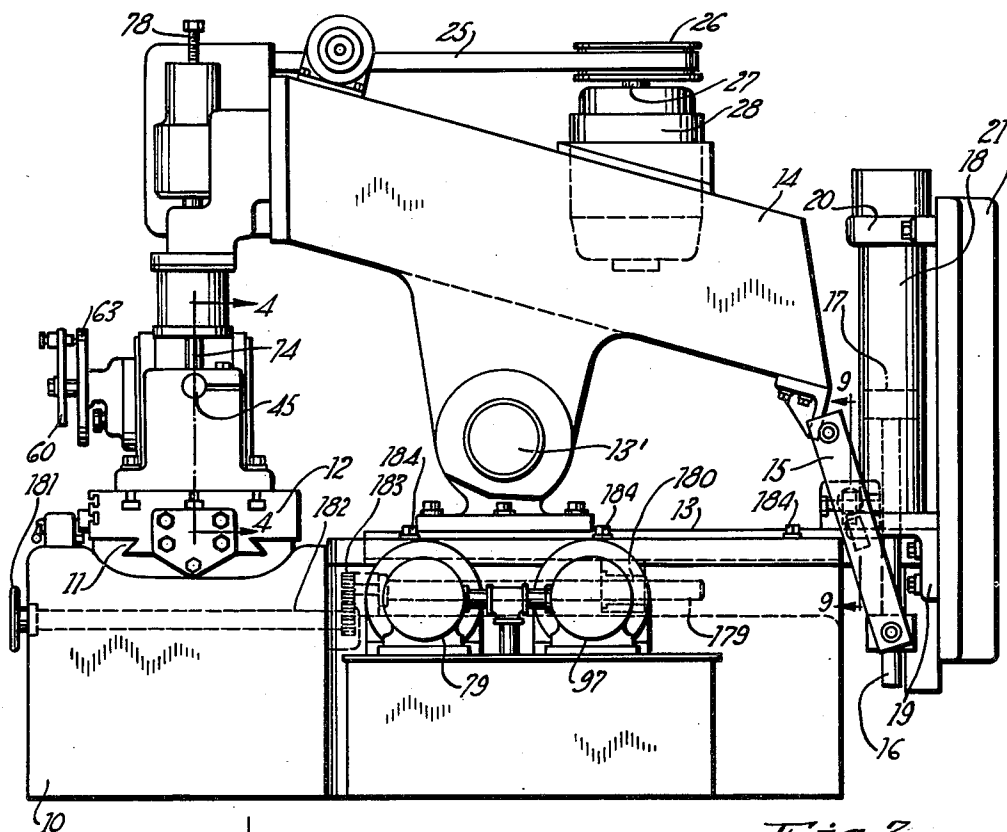
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DIE SINKING AND ENGRAVING MACHINE

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4 Sheets-Sheet 2



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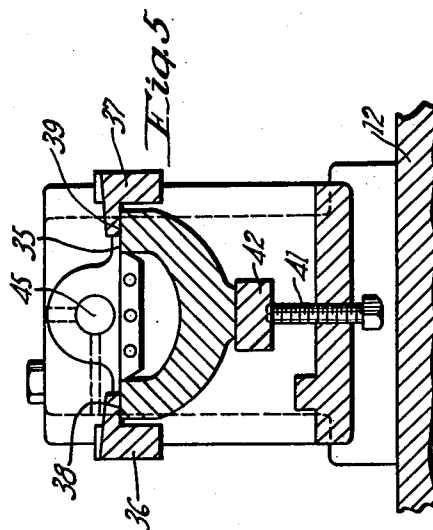
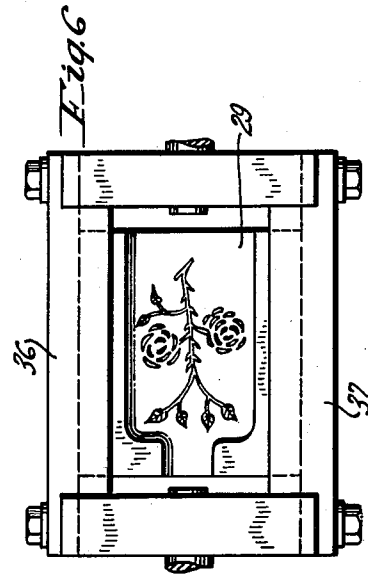
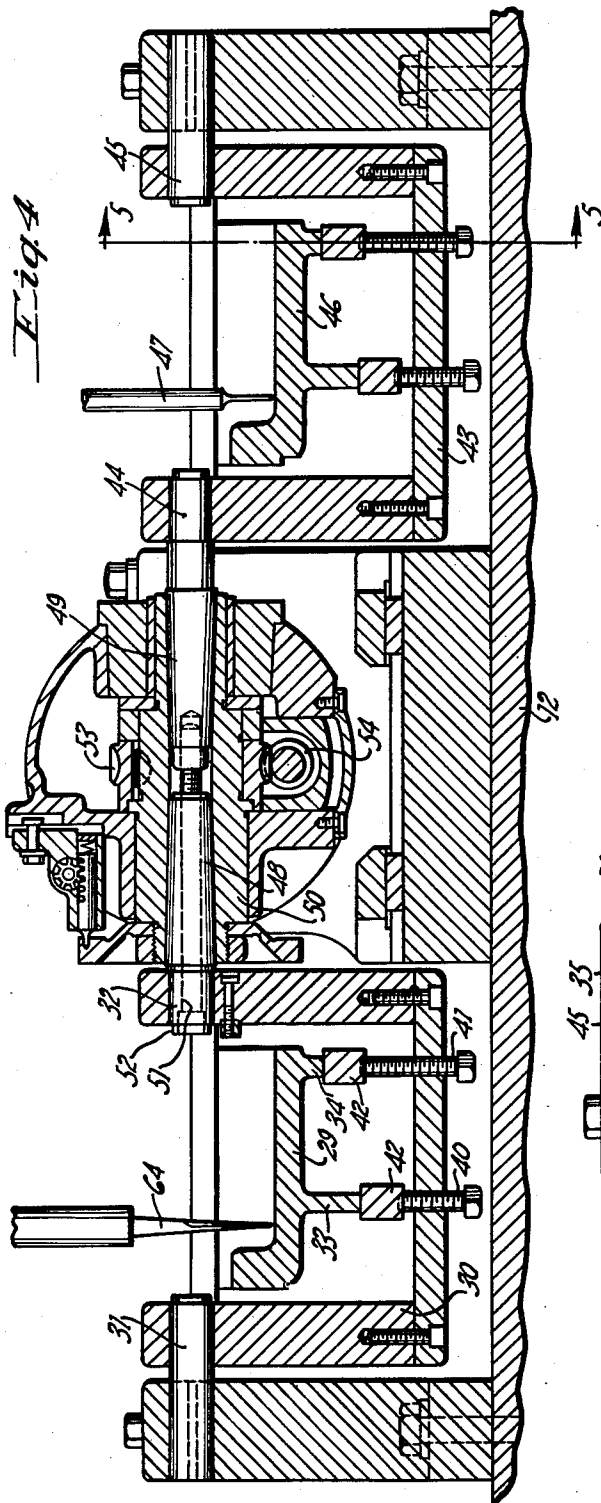
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DIE SINKING AND ENGRAVING MACHINE

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4 Sheets-Sheet 3



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DIE SINKING AND ENGRAVING MACHINE

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4 Sheets-Sheet 4

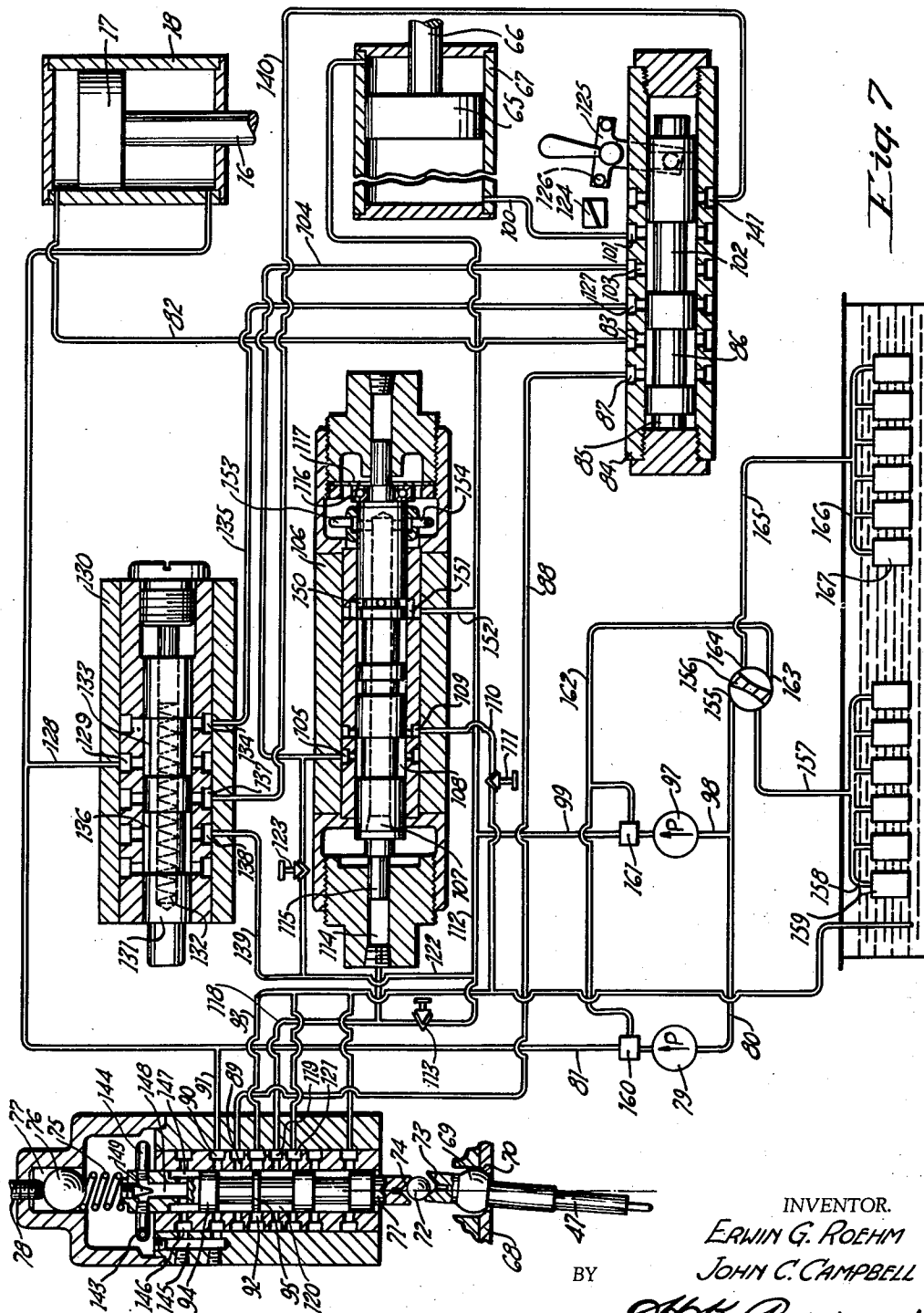


Fig. 7

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UNITED STATES PATENT OFFICE

2,089,099

DIE-SINKING AND ENGRAVING MACHINE

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Application January 8, 1936, Serial No. 58,150

21 Claims. (Cl. 90—13.5)

This invention relates to pattern controlled milling machines, and more particularly to an improved machine of the automatic tracer controlled type.

One of the objects of this invention is to provide a machine which is adaptable for reproducing non-rectilinear surfaces which the tracer cannot advantageously scan in a single setting thereof; and especially for engraving designs on such surfaces.

Another object of this invention is to provide a machine for automatically reproducing concave or convex surfaces which extend through 180 degrees of arc.

Still another object of this invention is to provide a machine for reproducing non-rectilinear surfaces automatically in which the cutter and work are relatively positioned in such a manner that the cutter is substantially perpendicular to the pattern of the surface being worked upon.

A further object of this invention is to provide an improved control circuit for an automatic pattern controlled machine.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a front elevation of a machine embodying the principles of this invention.

Figure 2 is a section on the line 2—2 of Figure 1, showing the details of the work and pattern indexing mechanism.

Figure 3 is a side elevation of the machine shown in Figure 1.

Figure 4 is a longitudinal section through the work and pattern holder as viewed on the line 4—4 of Figure 3.

Figure 5 is a detailed section on the line 5—5 of Figure 4.

Figure 6 is a plan view of one of the oscillatable cradles showing the means for clamping a part therein.

Figure 7 is a diagrammatic view of the tracer controlled hydraulic circuit.

Figure 8 is a view similar to Figure 5, but showing one of the cradles in an almost maximum tilted position.

Figure 9 is a detail section on the line 9—9 of Figure 3.

In Figures 1 and 3 of the drawings there is shown a front and side view respectively of a machine embodying the principles of this invention. In these figures, the reference numeral 10 indicates the bed of the machine. As viewed in Figure 3, the bed has a dovetailed guideway 11 formed thereon for receiving and supporting a work table 12.

Movable at right angles to the work table is a slide 13 having a fulcrum 13' upon which is pivotally mounted a beam 14 which is similar to a walking beam and one end of this beam is connected by a link 15 to a piston rod 16 which has a piston 17 on one end and is reciprocally mounted in the vertical cylinder 18. The cylinder is supported by brackets 19 and 20 attached to an upright 21 which rises from the rear end of the slide 13. By admitting fluid pressure to the cylinder 18 the walking beam may be oscillated about the fulcrum 13'. The other end of the walking beam has a spindle head 22 secured thereto and in this head is a rotatable spindle 23 having a driving pulley 24 attached to the upper end thereof. This driving pulley is connected by a belt 25 to a drive pulley 26 secured to the end of the armature shaft 27 of a prime mover, such as the electric motor 28. The electric motor 28 is also mounted on the rocking beam, and in such a position relative to the fulcrum 13' that it aids in counterbalancing the weight of the spindle head and other parts carried at that end of the beam.

Referring to Figure 4, the work piece 29, which may be one-half of a bottle mold, is supported in a cradle 30 which is oscillatable about pivots 31 and 32. Since these molds have bosses 33 and 34 projecting therefrom they are utilized to clamp the mold in the carrier. Referring to Figure 5, the mold 29 has a parting line or surface 35 which is utilized as the locating surface, and the cradle 30 has a pair of longitudinally extending angle bars 36 and 37 which have surfaces 38 and 39 finished to lie in one plane and against which the locating surface of the work piece is clamped. The clamping means comprises a pair of clamping bolts 40 and 41 which are threaded into the bottom of the carrier and in suitable alignment with the bosses 33 and 34 whereby the work piece may be clamped solidly against the angle bars. Blocks 42 may be inserted between the ends of the screws and the work piece to prevent marring the same by the pressure of the screws.

The table is also provided with a second cradle 43 which is oscillatable about pivots 44 and 45 and contains means similar to that described in connection with cradle 30 for securing and clamping a pattern or master mold 46 therein. Since the two cradles are exactly the same and are mounted for oscillation about co-axial axes, and since the pivots 32 and 44 are connected together for simultaneous movement and keyed to the respective cradles, the work and pattern are always in alignment during operation of the machine and if the tracer 47 is supported by the walking beam in the same plane as the axis of the cutter spindle, precision duplication may be obtained.

The pivots 32 and 44 have tapered shanks 48 and 49 respectively which fit in tapered sockets formed in opposite ends of the rotatable member 50. The members are frictionally held in the sockets by a draw bar 51 which passes centrally through the member 32 and is threaded in the end of the member 44. The draw bolt has a head 52, of course, which acts to draw the two members together. The member 50 has a worm gear 53 keyed thereto which intermeshes with a worm gear 54, as more particularly shown in Figure 2, and this worm gear is secured to a shaft 55 which is horizontally journaled in the index head 56.

A gear 57 keyed to the shaft 55 intermeshes with a gear 58 keyed to the index shaft 59. The shaft 59 carries the index lever 60 having the spring pressed plunger 61 located in one end of it and adapted to cooperate with holes 62 formed in the fixed index plate 63. By withdrawing the plunger 61 the handle 60 may be rotated and thereby, through the interconnected gearing, may effect rotation of the cradles to oscillatably index the work and pattern.

In the cycle of operation of this machine the cutter 64 and the tracer 47 are moved down into engagement with the work and pattern respectively and then the table is traversed at a feed rate by means of a piston 65 connected by piston rod 66 to the table, the piston being slidably mounted in a cylinder 67. During this traversing movement the tracer 47 controls the up and down movement of the cutter and also varies the rate of table movement whereby a substantially uniform rate of feed between the cutter and work is effected. At the conclusion of the feeding stroke of the table a trip is operated which elevates the tracer and cutter from the pattern and work, followed by a quick return movement of the table to a starting position. During this quick return movement the operator has time to index the work any desired amount, which is usually very small. At the end of the quick traversing movement a trip is again operated which causes the cutter and tracer to reengage the work and pattern and the parts are conditioned for the next feeding stroke of the table. Thus, the machine automatically goes through this cycle and the operator's only duty is to index the work during the rapid return movement of each cycle. The control circuit by which this cycle is repeatedly effected will now be explained.

The tracer 47 which controls the relative feeding movement between the cutter and work is supported for universal movement in the tracer head 68 by means of a spherical portion 69 which is adapted to rest on a spherical seat 70 formed integrally with the tracer head 68. The tracer may now pivot or swing in any vertical plane, and since it is not positively held against the

seat it is also capable of axial movement. The deflection of the tracer is utilized to operate the tracer control valve 71 through the medium of a ball 72, which is interposed between conical depressions 73 and 74 formed respectively in the end of the tracer 47 and the valve plunger 71. In other words, when the tracer is deflected, the ball 72 tends to ride on the sides of the conical depression and thereby move the plunger relative to the tracer. A spring 75 is interposed between the upper end of the valve plunger and a ball 76 mounted in a socket 77 formed in the upper end of a tracer head, the spring constantly urging the valve plunger downward against the tracer to urge the same to a vertical position. A set screw 78 threaded in the upper end of the tracer head and engaging the ball is utilized to vary the pressure of the spring.

A pump 79, having an intake 80, is connected by channel 81 to the lower end of the vertical cylinder 18. From this it will be seen that the full pressure of the pump 79 is continuously applied against the underside of the piston 17, but the area of the underside of the piston is only one-half of the area of the upper side of the piston, which means that if the full pump pressure is applied to the underside of the piston that in order to hold the piston stationary only one-half of the pump pressure should be applied to the upper side of the piston.

Therefore, the upper end of the cylinder is connected in such a manner as to accomplish this result. A channel 82 connects the upper end of the cylinder to port 83 of a reversing valve 84. This valve has a reciprocable plunger 85 in which is formed a cannellure 86 for connecting the port 83 to port 87 when the reversing valve is in a feed position, which is the position in which it is shown in Figure 7. The port 87 is connected by channel 88 to port 89 of the tracer controlled valve. This valve has a port 90 which is connected by branch line 91 to the main delivery line 81 of pump 79. The tracer valve also has another port 92 which is connected to reservoir by the return line 93.

When the tracer engages the pattern, and throughout the feeding movement, the tracer is automatically kept in a deflected position which thereby moves the tracer valve axially upward. The valve plunger has what may be termed a neutral position and when it is moved axially upward by deflection of the tracer to this position it will hold the piston 17 against movement, which means that the tracer and cutter are held in a definite position while the table is being moved relative thereto. To facilitate the description, the tracer valve plunger is shown in this neutral position in Figure 7 of the drawings. From the drawings it will be seen that the spool 94 and the spool 95 on the tracer valve plunger are in such a position that ports 90 and 92 are each slightly uncovered and the amount that each is uncovered is substantially the same, which means that the resistance to the flow of pressure fluid from channel 91 to cannellure 96 is equal to the resistance to flow of the fluid from cannellure 96 to the return line 93. If this is maintained, then the pressure in the chamber formed by cannellure 96 is equal to one-half of the pump pressure due to a law of hydraulics which is that if the resistance to flow of a source of pressure into a chamber is equal to the resistance to flow out of the chamber then the pressure in the chamber is equal to one-half of the incoming pressure. There, therefore, has been established

a chamber in which the pressure is equal to one-half of the pump pressure. Advantage is taken of this and it will be noted that the port 89, which is connected to the upper end of cylinder 18 as previously described, is intermediate ports 90 and 92 whereby the pressure communicated to line 88, and thereby to the upper end of cylinder 18, is equal to one-half of the pump pressure and therefore the piston 17 will remain stationary because the resultant opposing pressures acting thereon are exactly equal.

If, however, the tracer controlled valve is moved upward the pressure in chamber 95 will increase due to the simultaneous restriction of the exhaust port 92 and opening of the pressure port and the piston 17 will move downward, but on the other hand, if the tracer control valve is moved downward from this neutral position the pressure port will be restricted and the exhaust port opened, causing a drop in pressure in the upper end of cylinder 18 and thereby permitting the piston 17 to move upward. Thus, variations in the amount of tracer deflection produce oscillation of the walking beam 14 to either move the cutter further into the work or withdraw the same.

Another pump 97 is provided for supplying fluid pressure to the table cylinder 67 and this pump has an intake 98 and a delivery line 99 which, it will be noted, is connected directly to the right hand end of cylinder 67. The piston 65 contained in cylinder 67 has the piston rod 66 connected to the right hand end, and this piston rod is of such size that the area of the right hand side of the piston is one-half of the area of the other side of the piston. Therefore in order for the piston to move toward the left to feed the table the pressure in the left hand end of the cylinder must be less than one-half of the pressure developed by pump 97. This is accomplished by connecting the left end of the cylinder to reservoir through a variable throttle valve which will maintain a substantial back pressure, which is low enough to permit movement, but still high enough to prevent the table from running away.

To this end, the left end of cylinder 67 is connected by channel 100 to port 101 of reverse valve 84. The valve plunger 85 has a cannellure 102 which, when the valve is in the feed position shown in Figure 7, connects port 101 to port 103. This port is connected by channel 104 to port 105 of a throttle valve 106. The throttle valve has a reciprocable plunger 107 in which is formed a cannellure 108 for connecting port 105 to port 109 of the valve. Port 109 is connected by channel 110 to reservoir but this channel has an adjustable feed rate control valve 111 connected in series in the line.

During the feeding movement of the table the valve plunger 107 is held in such a position that the port 109 is open to permit flow therethrough to reservoir, but the position of the plunger will vary in accordance with the movement of the tracer controlled valve. In other words, this plunger is so controlled by the tracer that when it becomes necessary for the cutter to move upward or downward the feed rate will be reduced so that the actual cutting rate will not vary and place undue stress on the cutter.

The manner in which this is accomplished will now be explained. The pressure from pump 97 is connected through channel 112 and the adjustable throttle valve 113 to the small cylinder 114 formed in the left end of the housing of valve 106. Reciprocable within this cylinder is

a piston 115 integrally connected to the left end of plunger 107.

The other end of the plunger 107 has an anti-friction thrust bearing 116 interposed between the end of the plunger and a flexible diaphragm 117. When there is no pressure in cylinder 114 the diaphragm will straighten out and move the valve plunger 107 a sufficient amount to almost close port 109. The valve 113 is so adjusted that the pressure in cylinder 114 is normally sufficient to deflect the diaphragm 117 and thereby increase the opening at port 109. A branch line 118, however, connects cylinder 114 to port 119 of the tracer controlled valve and when this valve is in its neutral position, a cannellure 120, formed in the valve opposite port 119, is of sufficient length to uncover the exhaust port 92 located at one end of the cannellure and an exhaust port 121 located at the other end of the cannellure.

These two exhaust ports are uncovered an equal amount when the tracer valve is in a central position, but the resistance to flow to the exhaust line 93 through these ports is sufficient to maintain the desired pressure in cylinder 114. In this case, however, regardless of whether the tracer valve plunger is moved upward or downward by the tracer, the effect is the same in that the opening to reservoir is increased, permitting a drop in pressure in cylinder 114. This means that regardless of whether the cutter has got to be moved up or down that the variable throttle valve 107 will restrict the opening of port 109 and slow down the feeding rate of the table. It will now be evident that the tracer controlled valve serves to control the upward and downward movement of the cutter and tracer by movement of the walking beam 14 and also varies the feeding rate of the table whenever these vertical movements become necessary.

In order to eliminate the necessity of the valve plunger 107 moving such an amount to seal port 109, this port is never actually closed but there is always some leakage therethrough, and means are provided to compensate for this leakage so that the leakage into the line 104 will be equal to the leakage past port 109, with the result that if the leakage in is equal to the leakage out the effect will be the same as if the port was entirely sealed. This effect is produced by taking a branch line 122 off of the main pressure line 99, and connecting it through a throttle valve 123 to channel 104 and adjusting the throttle valve 123 to such a position that when the diaphragm is undeflected that the leakage into the line will be sufficient to prevent movement of the table piston 65.

The description of the circuit, so far, has concerned the feeding movement of the cycle only and the various valves are shown in their respective proper positions to effect this feeding movement.

When the table has traveled the length of the mold, a trip dog 124 operates on a trip lever 125 by engaging a pin 126 projecting therefrom and shifts the valve plunger 85 to an extreme right position, as viewed in Figure 7. The first result of this is that port 83 is connected to port 127 and thereby interconnects both ends of cylinder 18 to the pressure line 81. In other words, the fluid from channel 81 not only flows, as before, to the lower end of cylinder 18, but also flows through the branch line 128 to port 129 of an interlock valve 130. This valve has a plunger 131 which is normally held in the position shown

in Figure 7 by an axially located spring 132. When in the position shown, a cannellure 133 formed in the valve plunger interconnects port 129 with port 134, which has a channel 135 leading therefrom to port 127. Due to the differential areas of the piston 17, the pressure on the upper end of the piston is now greater than the total resultant pressure on the lower side of the piston and this moves the right hand end of the walking beam 14, as viewed in Figure 3, downward, thus raising the cutter and tracer from the work and pattern respectively.

When the cutter and tracer have been raised a desired amount the plunger 131 is shifted to the right against the compression of the spring, which thereby closes port 129, terminating further downward movement of piston 17 and furthermore preventing escape of fluid from the upper end of cylinder 18 whereby even although the pump pressure is still acting on the underside of piston 17 there is not sufficient escape of fluid from the upper end of the cylinder to permit upward movement. Therefore, the parts are held in a stationary position.

Movement of the plunger 131 of the interlock valve to the right also results in the cannellure 136 interconnecting ports 137, and 138, which results in the left end of the table cylinder 67 being connected to the pump delivery line 99. In other words, the pump 97 is now connected to both ends of the cylinder 67 with the result that the resultant pressure on the left end of piston 65 is greater than the resultant pressure on the right end thereof, which will cause the table to return at a rapid traverse rate.

The fluid from pump 97 now flows through line 99, branch 112, channel 122, and branch 139 to port 138 which is connected to port 137 so that the fluid continues through channel 140 to port 141 of the reversing valve 84. This port is now connected by the cannellure 102 to port 101 so that the fluid continues through channel 100 to the right hand end of cylinder 67. Since the total effective pressure in this end of the cylinder is greater than that in the other end, the piston 65 will move toward the right and the fluid in the right hand end of the cylinder will be forced back through channel 99 into channel 112, thereby adding to the delivery of the pump 97 and creating a rapid traverse movement of the table toward the right.

At the termination of the rapid traverse movement a dog 142 will again trip the reverse valve back into the position in which it is shown in Figure 7. The first effect of this is that the pump 97 is still connected to the right hand end of cylinder 67, but even although the pump is disconnected from the left hand end of cylinder 67 through the closing of port 141, the feeding movement will not start because the tracer, having been raised out of engagement with the pattern, has now moved downward to such a position that the exhaust port 121 is open, thereby relieving the pressure in cylinder 114 and allowing the plunger 107 to be shifted by the diaphragm to the left and thereby close port 109. Therefore, the piston 65 is held for the time being against movement and the table is stopped. The other effect is that the reconnection of ports 83 and 87 cause the upper end of cylinder 18 to be connected to reservoir because the channel 88, which leads from port 87, is connected to the reservoir port 92 of the tracer valve due to the fact that the tracer valve is in its lowermost position.

Since the pump 79 is still connected to the lower end of cylinder 18, the piston 17 can now move upward, which will cause downward movement of the tracer and cutter toward the pattern and work respectively. As soon as this downward movement starts, the innerlock valve plunger 137 returns to the position shown in Figure 7 and subsequently, as the tracer engages the pattern, and the tracer control valve is moved upward, the necessary pressure is recreated in cylinder 114 to shift the plunger 107 to the right and permit the feeding movement of the table to begin. Upward movement of the tracer valve to its neutral position also re-establishes the necessary pressure in the upper end of cylinder 18 to terminate the downward movement of the tracer head when the tracer has reached its neutral position.

This cycle of operation will be repeated indefinitely until the operator decides to stop the machine, which may be accomplished by closing the rate control valve 111.

In order to facilitate movement of the tracer controlled valve and the throttle valve by reducing the friction against movement, each valve is provided with a small reaction turbine. For instance, the valve plunger 71 has a pair of reaction nozzles 143 and 144 attached to the upper end thereof, and these nozzles point in opposite directions whereby pressure fluid from channel 91 flowing through the internal bore 145, which communicates with port 90, port 146, annular groove 147 and axial bore 148, will be delivered through the nozzles to cause rotation of the valve. The amount of fluid utilized for this purpose is small and may be varied by the adjustable tapered throttle valve 149.

Similarly, the valve plunger 107 has an annular groove 150 which is in constant communication with port 151 which is connected by a branch line 152 to the pressure channel 99.

This annular groove communicates through interdrilling in the plunger to a pair of reaction nozzles 153 and 154, secured to the periphery of the plunger.

Due to the sensitive valve mechanism utilized in this machine it is necessary and vitally important that the oil which is utilized in the circuit should be free from foreign particles, and an improved means has been provided for straining the oil which goes to the pumps 79 and 97. To this end the intakes 80 and 98 of these pumps are connected to a port 155 of a reverse valve 156. This valve in one position connects port 155 to channel 157 which has a plurality of branches 158, to the end of each of which is connected a strainer 159.

At the delivery end of each pump there are relief valves 160 and 161 which are jointly connected to channel 162 leading to port 163 of the reverse valve 156. The relief valves are so set that there is always some flow through channel 162. In the position in which the reverse valve is shown, port 163 is connected to port 164 which also has a channel 165 connected thereto and terminating in a series of branches 166, each of which terminates in a strainer 167. It will thus be seen that oil is being drawn through the series of strainers 159 by the pumps 79 and 97 and that a predetermined flow is being forced through strainers 167 in an opposite direction and in a direction which would tend to remove foreign articles clinging to the outside of the strainers. This tends to clean one set of strainers while the other set is being utilized. By throwing the

reverse valve 156 through an angle of 90 degrees it will be seen that channel 157 will be connected to port 163 and port 165 will be connected to port 164, which will thereby reverse the action and cause the oil to be drawn into the pumps through the set of strainers 167 and cause a reverse flow through the series of strainers 159, thereby automatically cleaning them.

In Figure 9 there is shown a detailed view of the mechanism for automatically operating the interlock valve 130 and this mechanism comprises a dog 168 which is secured to the link 15 and a lever 169 which is pivoted at 170 and interposed between the end of plunger 131 and dog 168. The dog 168 has a beveled surface 131 which, upon downward movement of the link 15, acts on a boss 172 projecting from the lever 169 to force the plunger 131 to the right against the compression of spring 132.

When the link 15 moves upward the parts will be released and the valve plunger will return to its normal position shown in Figure 7.

If, for any reason, the dog 168 should pass completely beyond the lever 169 means have been provided for shifting the lever out of the path of dog 168, and this means consists in beveling one side of the lever at 173 so that as the dog moves upward it will shift the lever longitudinally of its support 170 so that the dog may pass by it without causing damage to the parts. A spring 174 may be interposed between the side of the lever 169 and the supporting lug 175 to return it to a normal operating position.

Attention is invited to the fact that, as shown in Figure 8, the axis of oscillation 176 which is formed at the intersection of the axis 177 which passes centrally through the work piece and the axis 178 of the tracer or cutter is in front of the work or pattern locating surface and therefore does not pass through the pattern and work. This makes possible a condition, such as shown in Figure 8, in which the cutter can reach the entire surface of the mold without interference.

It will also be noted that the side bars 36 and 37 of the carriers may be reversed end to end by rotation through 180 degrees so that the surfaces 38 and 39 are adapted to support a pattern or mold in such a manner as to expose a convex surface to the tracer and cutter.

Attention is invited to the fact that the slide 13 may be adjusted by rotation of the screw 179 relative to the nut 180 integrally attached to the slide 13 by the hand wheel 181 secured to shaft 182, which shaft is operatively connected to the screw by gearing 183. Ordinarily, the slide 13 is so adjusted that the axis of the cutter and tracer lie in a plane, passing through the axis of rotation of the work and pattern carriers but it may be found desirable to reposition the cutter and tracer laterally of this plane in order that they may engage surfaces at more suitable working angles. Clamping bolts 184 are provided for clamping the slide 13 to the bed after any adjustment to insure that the tracer and cutter support are securely held against inadvertent relative movement with respect to the work and pattern support.

There has thus been provided an improved machine for the purposes described, which is relatively inexpensive to construct, being comprised of a relatively few number of parts and which is entirely automatic in operation, thereby requiring little attention on the part of the operator.

We claim:

1. In an automatic pattern controlled milling

machine, the combination with a bed, of a slide reciprocably mounted thereon, means to oscillatably support a work piece and a pattern on said slide for movement about an axis parallel to the direction of slide movement, a walking beam pivotally supported by the bed for movement about an axis parallel to the direction of slide movement, a rotatable cutter and a tracer supported by the walking beam for operative engagement with the work and pattern, fluid operable means for traversing said slide, additional fluid operable means for oscillating said beam and means controlled by the tracer while in engagement with the pattern for automatically controlling the movement of said slide and the oscillation of said walking beam.

2. In an automatic pattern controlled milling machine, the combination with a bed, of a slide reciprocably mounted thereon, means to oscillatably support a work piece and a pattern on said slide for movement about an axis parallel to the direction of slide movement, a walking beam pivotally supported by the bed for movement about an axis parallel to the direction of slide movement, a rotatable cutter and a tracer supported by the walking beam for operative engagement with the work and pattern, fluid operable means for traversing said slide, additional fluid operable means for oscillating said beam, means controlled by the tracer while in engagement with the pattern for automatically controlling the movement of said slide and the oscillation of said walking beam, and means to index the work and pattern about their axes of oscillation after each reciprocation of said slide.

3. In a pattern controlled milling machine, the combination with a pair of supports mounted for relative movement in two directions, means to support a pattern and work piece on one of said supports, and means to support a tracer and cutter on the other of said supports, of means for effecting each direction of relative movement including individual cylinders and pistons, said pistons having differential areas, individual pumps directly connected to one end of the individual cylinders for applying pressure to the smaller side of said pistons, additional means for supplying an opposing pressure to said pistons, and means controlled by the tracer for determining the amount of said opposing pressures and thereby movement in the respective relative directions.

4. In a pattern controlled milling machine, the combination with a pair of relatively movable supports, one of which is adapted to carry a work piece and a pattern, and the other having a cutting tool and a tracer supported thereon, of separate means for moving the supports and each including a piston and cylinder, a pump having its outlet connected to each end of the cylinder, and means controlled by the tracer for varying the pressure in one end of each cylinder to control movement of the supports.

5. In a pattern controlled milling machine, the combination with a first support for carrying a pattern and a work piece, and a second support having a cutter and tracer mounted thereon, of fluid operable means for moving each of said supports, each of said means including a piston, a cylinder, and a pump having its outlet directly connected to one end of the cylinder, a pressure reducer connecting said outlet to the other end of said cylinder, and means governed by the tracer for controlling each of said pressure reducers to determine movement of said supports.

6. In a pattern controlled milling machine, the

combination of a pair of supports relatively movable in two directions substantially normal to one another, means to support a pattern and a work piece on one of said supports, means to support a cutter and a tracer on the other of said supports, separate means for moving each support and each means including a cylinder and contained differential piston operatively connected to the support, a first constant displacement pump having its delivery pipe connected to both ends of one of said cylinders, a second constant displacement pump having its delivery pipe connected to both ends of the other of said cylinders, and means governed by the tracer for controlling the pressure produced by said pumps on the larger end of the respective pistons to control the movement of the respectively connected supports.

7. In a pattern controlled milling machine, the combination of a pair of supports relatively movable in two directions substantially normal to one another, means to support a work piece and a pattern on one of said supports, means to support a cutter and a tracer on the other of said supports, separate fluid operable devices for moving the respective supports and each including a constant displacement pump having its delivery pipe directly connected for moving the support in one direction, and means governed by the tracer for controlling the escape of fluid from the return line of each of said devices to reservoir and thus determine the rate of movement of each of said supports.

8. In an automatic die-sinking machine, the combination of a pair of supports relatively movable in two directions, means to support a pattern and a work piece on one of said supports, means to support a tracer and a cutter on the other of said supports, separate means for moving each support including a cylinder, a contained differential piston, and a constant displacement pump having its delivery connected to both ends of the cylinder, a pressure reducer between the pump delivery and the larger end of said piston, a reservoir connection between each pressure reducer and the respective cylinder, and means governed by the tracer for controlling the rate of escape of fluid to said reservoir to thereby determine the rate of movement of each support.

9. In a die-sinking machine, the combination of a pair of relatively movable supports, one of which is adapted to carry a pattern and a work piece, a tracer and a cutter mounted on the other of said supports, said tracer being deflectible by the pattern to a neutral position, a cylinder having a contained differential piston for moving the tracer support, a pump for supplying pressure to opposite ends of said cylinder, means governed by the tracer when in said neutral position to reduce the unit pressure on the larger end of said piston sufficiently to hold the same at rest; a cylinder and contained differential piston for moving the work support and including a pump having a direct connection to the end of the cylinder adjacent the smaller end of said piston, means to control the pressure drop between the other end of the cylinder and reservoir, a reservoir connection for the tracer support cylinder, and means operable by the tracer upon movement from its neutral position to increase the pressure drop between the work support cylinder and reservoir and decrease the pressure drop between the tracer support cylinder and reservoir.

10. In a pattern controlled milling machine having a tracer and cutter support, and a work and pattern support, of means for controlling rel-

ative movement of one of said supports toward and from the other support including a cylinder, a contained piston having the area of one end equal to twice the area of the other end, a constant displacement pump, means connecting the delivery of said pump to both ends of said cylinder, means controlled by the tracer for reducing the unit pressure on the large end of said cylinder to one-half of the unit pressure on the small end of said piston to hold the movable support stationary, and means operable by the tracer to increase or decrease the unit pressure on the large end of said cylinder to cause relative movement between the supports.

11. In a pattern controlled milling machine having a tracer and cutter support, and a pattern and work support, the combination of means for controlling the rate of feeding movement between the supports including a cylinder, a piston contained therein, a constant displacement pump, means connecting the delivery of said pump to one end of said cylinder, a throttle valve for controlling the escape of fluid from the other end of said cylinder to reservoir, and fluid operable pilot means governed by the tracer for controlling the position of said throttle valve and thereby the rate of said feeding movement.

12. In a pattern controlled milling machine, the combination of a work support, means to support a cutter and tracer for relative movement with respect to the work support, a differential piston operatively connected for feeding the work support in one direction, a differential piston operatively connected for moving the tracer into and out of contact with a pattern, separate constant displacement pumps for supplying fluid pressure to the smaller end of said piston, means positionable by the tracer when out of contact with the pattern for coupling the larger end of one of said pistons to reservoir to cause movement of the tracer into contact with the pattern, means positionable by the tracer when in contact with the pattern for coupling the larger end of the other piston to a throttled reservoir connection for feeding said table, and means trip operable by the feeding table to cause return movement of the parts.

13. In a pattern controlled milling machine, the combination of a work support, means to support a cutter and tracer for relative movement with respect to the work support, a first differential piston operatively connected for feeding the work support in one direction, a second differential piston operatively connected for moving the tracer into and out of contact with a pattern, separate constant displacement pumps for continuously applying fluid pressure to the smaller end of the respective pistons, means positionable by the tracer when out of contact with the pattern for coupling the larger end of said second piston to reservoir to cause movement of the tracer into contact with the pattern, means responsive to deflection of the tracer by the pattern to couple the larger end of the other piston to a throttled reservoir connection for feeding said work support, and means trip operable by the work support to cause return movement of the parts including a reversing valve having shiftable means therein for connecting the pumps to both ends of the respective pistons, and means to prevent one of said connections until the tracer support has returned.

14. In a pattern controlled milling machine, the combination of a work support, means to support a cutter and tracer for relative move-

ment with respect to the work support, a first differential piston operatively connected for feeding the work support in one direction and for rapidly returning it, a differential piston operatively connected for moving the tracer into and out of contact with a pattern, separate constant displacement pumps having fluid connections to the smaller end of the respective pistons, means positionable by the tracer when out of contact with the pattern for coupling the larger end of the tracer moving piston to reservoir to cause movement of the tracer into contact with the pattern, means subsequently operable for coupling the larger end of the work supply piston to a throttled reservoir connection for feeding the work support, means trip operable by the work support to cause return movement of the work support and tracer support including a reversing valve having means therein for connecting the larger end of both pistons to their respective supply pumps, and means to prevent one of said connections including an interlock valve operable by the tracer support.

15. In a pattern controlled milling machine, the combination of a work support, means to support a cutter and tracer for relative movement with respect to the work support, a first differential piston operatively connected for feeding the work support in one direction and for rapidly returning it, a differential piston operatively connected for moving the tracer into and out of contact with a pattern, separate constant displacement pumps having fluid connections to the smaller end of the respective pistons, means positionable by the tracer when out of contact with the pattern for coupling the larger end of the tracer moving piston to reservoir to cause movement of the tracer into contact with the pattern, means subsequently operable for coupling the larger end of the work supply piston to a throttled reservoir connection for feeding the work support, means trip operable by the work support to cause return movement of the work support and tracer support including a reversing valve having means therein for connecting the larger end of both pistons to their respective supply pumps, means to prevent one of said connections including an interlock valve operable by the tracer support, additional means for tripping the reverse valve at the end of the return stroke of the table to reposition the reverse valve in a feeding position, and means in the interlock valve to prevent the table from starting its next feeding stroke until the tracer has engaged the pattern.

16. In a machine tool having a fluid operable controlled circuit for effecting relative movement between a tool and a work piece to effect the machining operation, the combination with a plurality of pumps for supplying fluid pressure to said circuit, of a reservoir, two sets of strainers in said reservoir, valve means for selectively connecting one of said reservoirs to the intakes of said pumps and connecting the delivery end of said pumps to the other set of strainers whereby one set may be utilized to clean the fluid supplied to the circuit while the other set is being cleaned by forcing oil through it in a reverse direction.

17. In a hydraulic tracer controlled automatic copying machine, the combination with a pair of fluid operable devices for effecting a rela-

tive feeding movement between a cutter and a work piece and a second relative movement between the cutter and work piece in a direction substantially normal to the first direction of movement, of a plurality of valve plungers for controlling the operation of said circuit, and fluid operable means for continuously rotating said valve plungers to reduce the static friction thereof and increase the accuracy of reproduction of the machine.

18. In a bottle mold engraving machine, the combination of a slide, a pair of cradles mounted thereon for oscillation about co-axial axes and adapted to receive a rough bottle mold and a master mold, a surface in each cradle located eccentric to said axes against which said molds may be clamped, a tracer and a cutter supported for movement substantially perpendicular to said axes, means to traverse said slide, an index head located between said cradles and operatively connected for movement thereof, a pair of operable means governed by the tracer for controlling traversing of the slide and movement of the tracer and cutter toward and from the cradles.

19. In a bottle mold engraving machine, the combination of a support, devices carried thereby for oscillatably supporting a rough bottle mold and a master mold, a tracer and a cutter, power operable means controlled by the tracer for determining relative movement between said master mold and the cutter in two directions, one of which has a relative traversing movement whereby a cross sectional profile of the master mold will be reproduced, and means to effect an indexible movement of the molds at the end of each of said traversing movements to present a new cross sectional profile of the pattern to the tracer for reproduction by the cutter.

20. In an automatic pattern controlled machine, the combination of a bed, a slide reciprocally mounted upon the bed, means to support a pattern and a work piece upon the slide, a walking beam pivotally supported by the bed for movement about an axis extending parallel to the direction of movement of said slide, a cutting tool and a tracer mounted on the end of said walking beam for operative engagement with the work and pattern respectively, fluid operable means controlled by the tracer for automatically oscillating said walking beam as dictated by the pattern during traversing movement of said slide, and means to adjust the pivotal axis of the walking beam to change the plane of operation of the tool and tracer relative to the pattern and work piece.

21. In a pattern controlled milling machine, the combination with a pair of relatively movable supports, one of which is adapted to carry a work piece and a pattern and the other having a cutting tool and a tracer supported thereon, of separate means for moving the supports and each including a piston and cylinder, a first pump having its outlet connected to both ends of one cylinder, a second pump having its outlet connected to both ends of the other cylinder, and means located between the pump outlets and one end of the respective cylinders controlled by the tracer for varying the pressure in one end of each cylinder relative to the pressure in the other end to control movement of the supports,

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