July 9, 1935. E. L. WALL 2,007,231

DUPLICATING MACHINE

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Fig. 2.

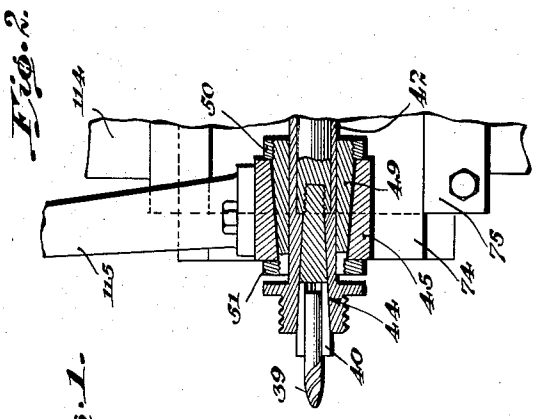


Fig. 1.

WITNESSES

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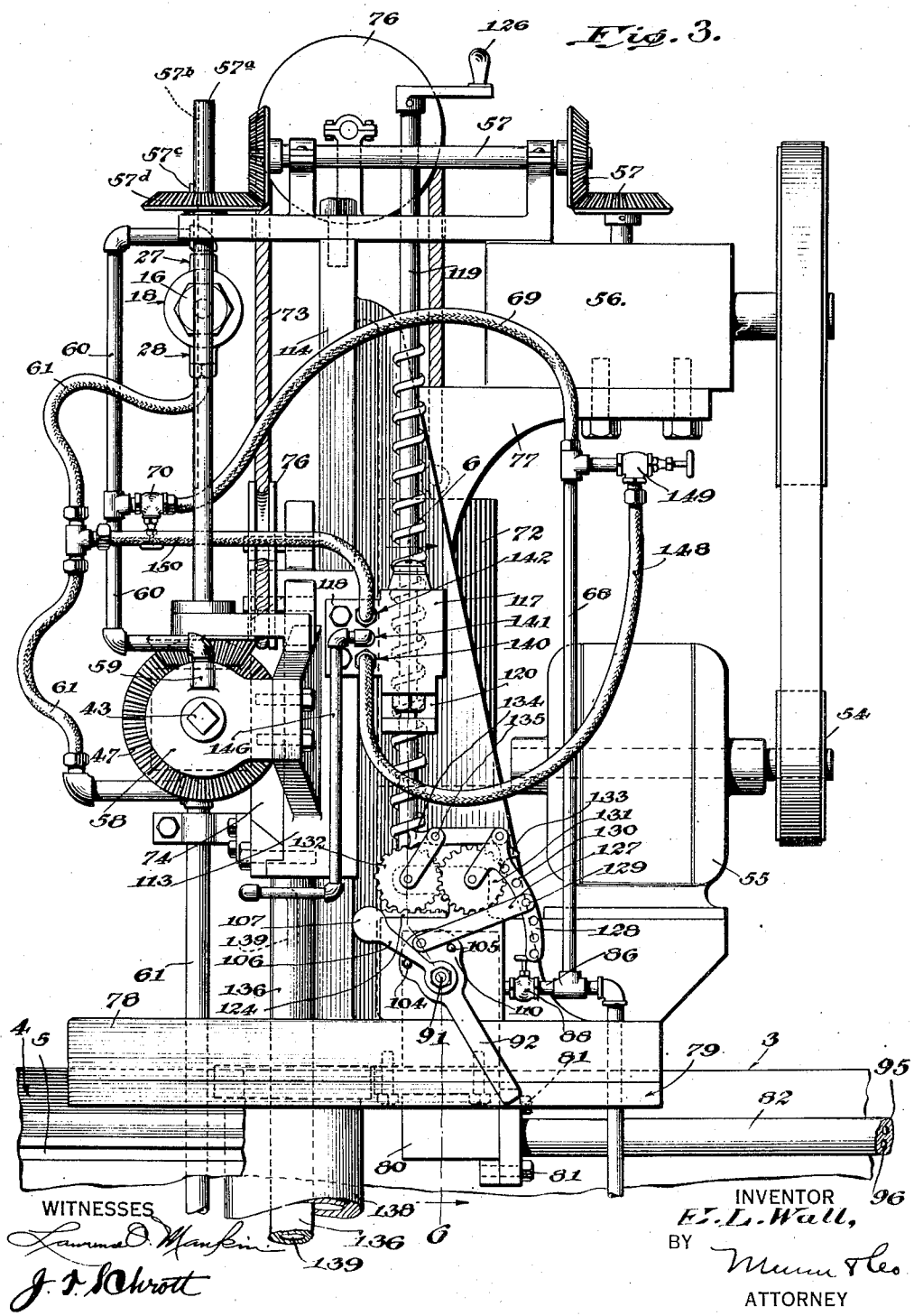
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Fig. 3.



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DUPLICATING MACHINE

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Fig. 1.

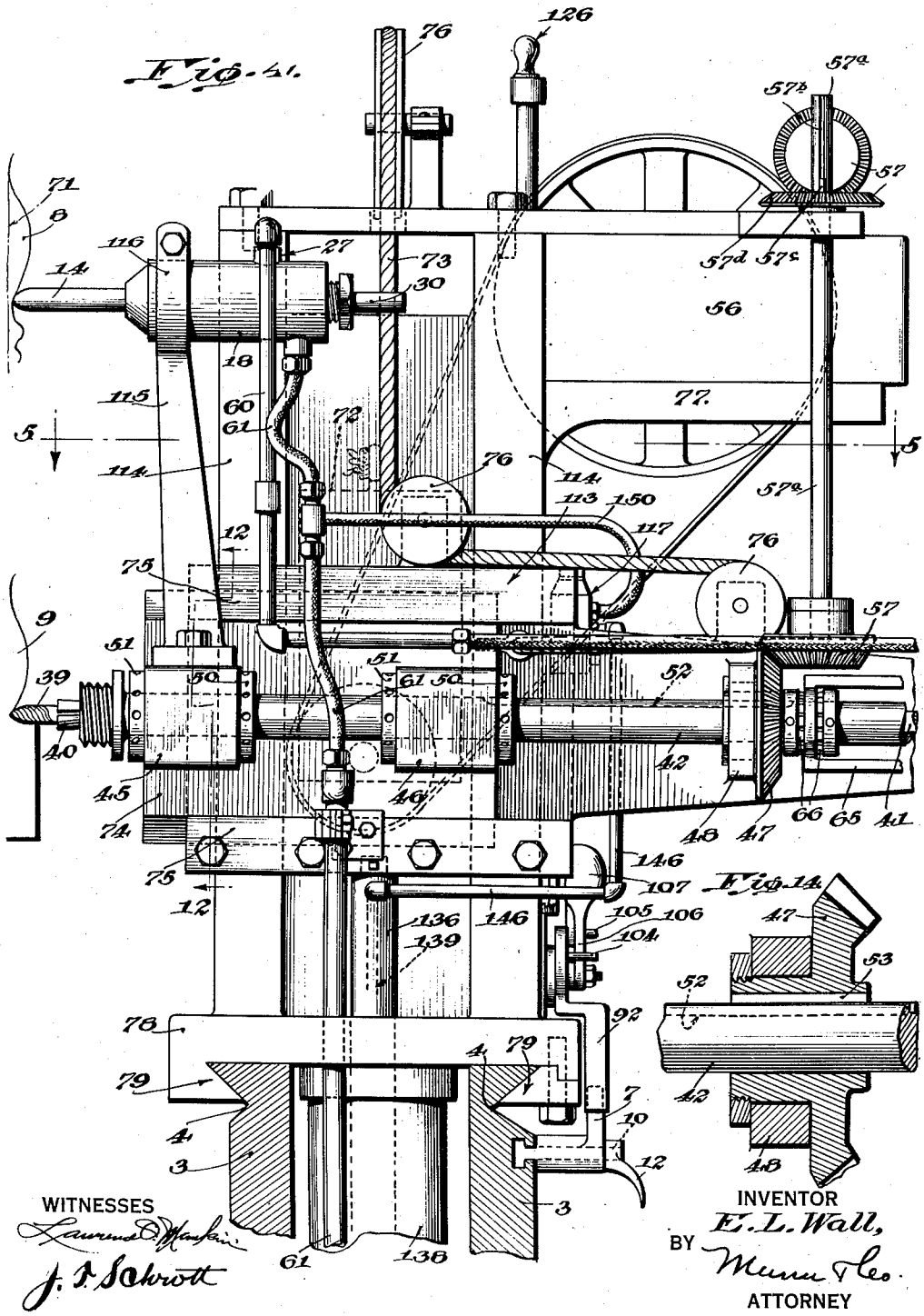


Fig. 14.

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DUPLICATING MACHINE

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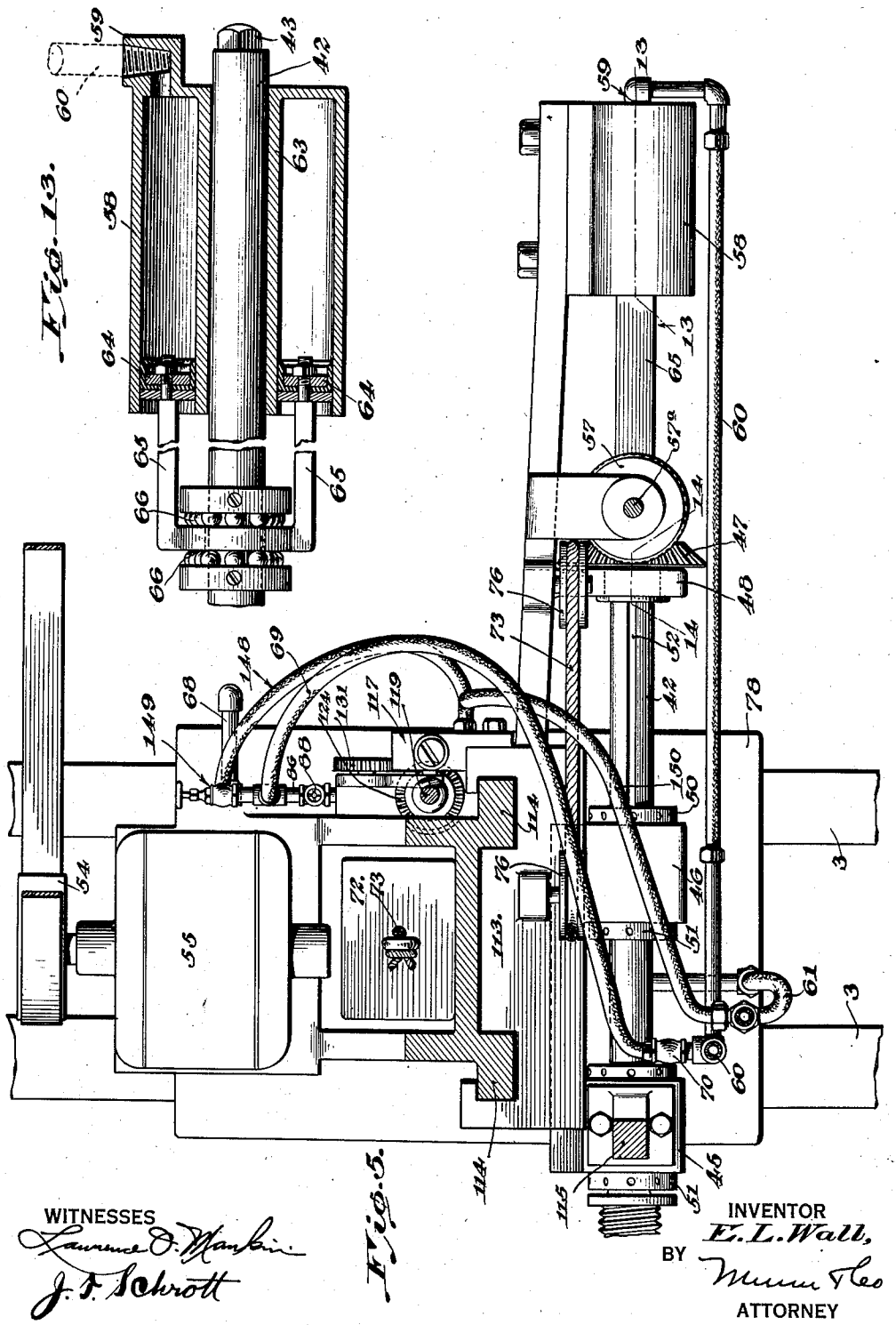


Fig. 13.

Fig. 5.

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DUPLICATING MACHINE

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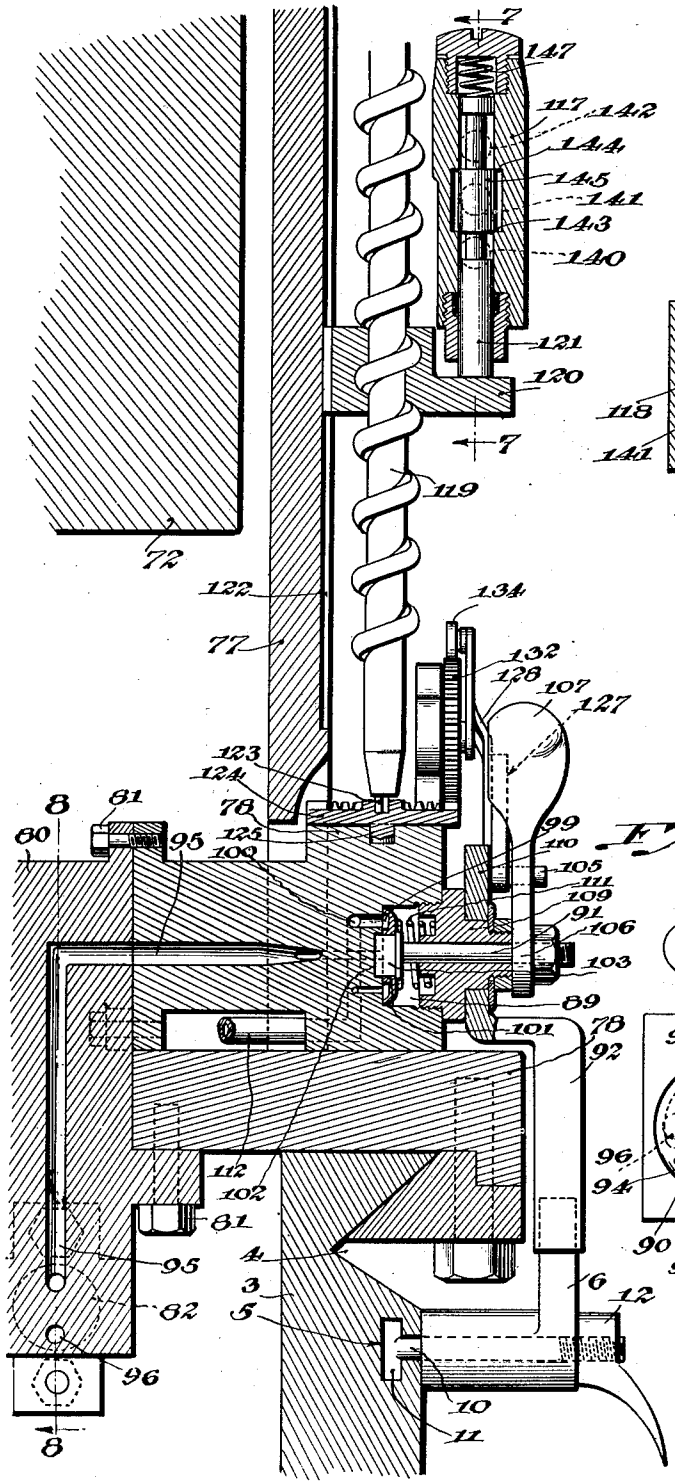


Fig. 7.

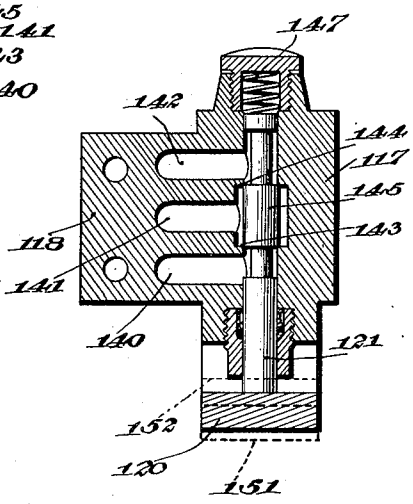
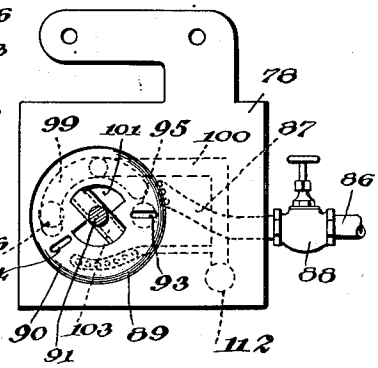


Fig. 6.

Fig. 15.



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DUPLICATING MACHINE

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Fig. 8.

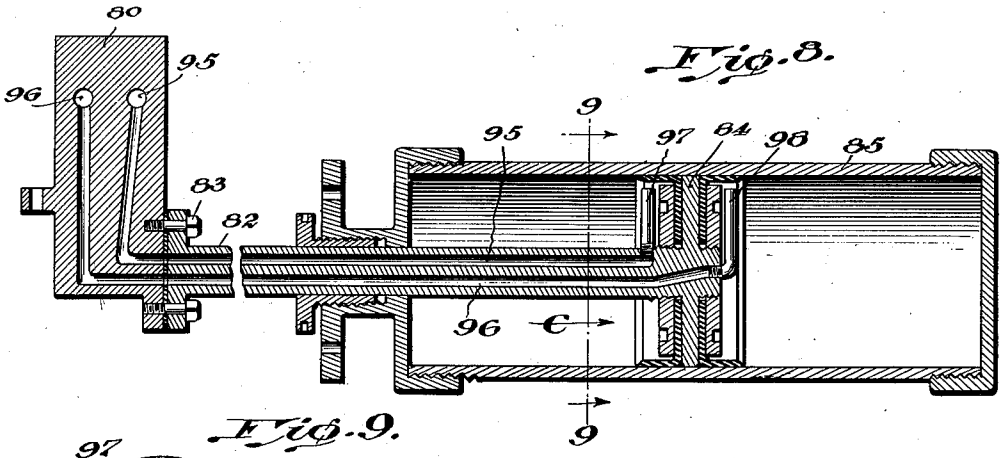


Fig. 9.

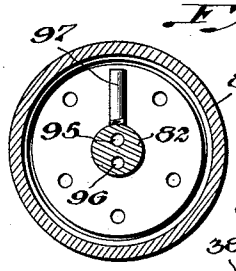


Fig. 10.

Fig. 11.

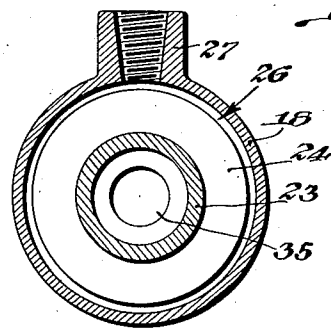
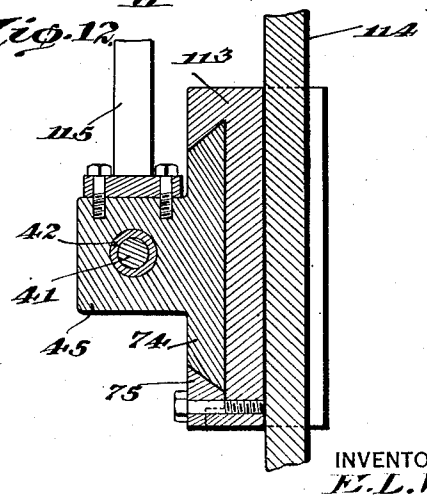


Fig. 12.



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Patented July 9, 1935 2,007,231

UNITED STATES PATENT OFFICE

2,007,231

DUPLICATING MACHINE

Edmund Leo Wall, Detroit, Mich., assignor, by direct and mesne assignments, to R. W. Glasner, Chicago, Ill.

Application February 26, 1931, Serial No. 518,528

20 Claims. (Cl. 90—13.5)

This invention relates to improvements in duplicating machines, and it consists of the constructions, combinations and arrangements herein described and claimed.

An object of the invention is to provide a duplicating machine which is mechanically controlled and operated, an outstanding purpose being to enable the reproduction in steel or other material either hard or soft of a pattern made of a relatively soft substance, this advantage being possible by virtue of the low tracer pressure which enables the traversing of the pattern by the tracer without marring the contours thereof, no matter how delicate.

Other objects and advantages will appear in the following specification, reference being had to the accompanying drawings in which

Figure 1 is a front elevation of the improved duplicating machine.

Figure 2 is a detail sectional view of the chuck for the milling cutter, parts being shown in elevation.

Figure 3 is a somewhat enlarged front elevation of the machine particularly showing the movable carriage and its carried parts.

Figure 4 is an end elevation of the machine, a part of the bed frame being shown in section.

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

Figure 6 is a vertical section taken on the line 6—6 of Figure 3.

Figure 7 is a vertical section taken on the line 7—7 of Figure 6.

Figure 8 is a section taken substantially on the line 8—8 of Figure 6, particularly illustrating the means for reciprocating the main carriage (Fig. 1).

Figure 9 is a cross section taken on the line 9—9 of Figure 8.

Figure 10 is a longitudinal section of the tracer mechanism, parts being shown in elevation.

Figure 11 is a cross section taken on the line 11—11 of Figure 10.

Figure 12 is a cross section taken on the line 12—12 of Figure 4.

Figure 13 is a detail longitudinal section of the cylinder operating in conjunction with the work cutter, taken substantially on line 13—13 of Figure 5.

Figure 14 is a detail section taken on the line 14—14 of Figure 5, illustrating the swivel mounting of the bevel gear by which the cutter spindle is driven.

Figure 15 is a detail elevation of the reversing valve.

One of the specific purposes of the duplicating machine is that of die sinking, and although this is used for the instant illustration, the purpose is not to be construed as thus limited because the machine can be employed whenever it is desired to reproduce a given pattern. The prevailing practice in machines of this kind is to require a pattern of hardened steel so that the relatively high pressure imposed on the tracer may not spoil the characteristics of the pattern and thus produce faulty work.

Although the instant machine embodies a number of novel features which have distinct advantages in its operation, yet the outstanding purpose is to make possible a reproduction in hard steel or other hard material from a relatively soft pattern such as a plaster of Paris cast. This facility obviates the need for a hardened steel pattern, and it also carries with it the requirement that the tracer pressure shall be such as not to mar the contour of the pattern. Notwithstanding the delicacy of touch of the tracer, its coupled cutter is made to always maintain a proper working position against the work or reproduction.

The foundation of the machine comprises a table 1 (Fig. 1) which is supported above the floor by legs 2. A pair of parallel rails 3 (Fig. 4) is fixedly mounted on this table. The outer faces of these rails are provided with V-grooves 4 (Figs. 4 and 6) which extend full length (Fig. 1) thereof. A T-slot 5 in the foremost rail (Fig. 1) and coextensive therewith provides the means for adjustably securing right and left stops 6, 7.

These stops will be adjusted in accordance with the length of the pattern 8 (Fig. 4) which is intended to be traced for the reproduction of the work 9. Each stop is provided with a bolt 10 (Fig. 6), the head 11 of which occupies and rides the slot 5. A nut 12 on the threaded end of the bolt enables clamping the respective stop in position.

An upright 13 (Fig. 1) provides the mount for the pattern 8 and work 9 (Fig. 4). The upright 13 is fixedly supported by the table 1 in any appropriate way. The upright might be independent of the table, but in any case it should be heavy enough and secured tightly enough to remain absolutely firm during the operation of the machine. This is necessary in order that the work 9 (Fig. 4) may be a faithful reproduction of the pattern 8.

The details of both the pattern 8 (Fig. 4) and work 9 are purposely omitted because of the wide variety of forms that these may take in practice. For the present consideration it is sufficient to say that the pattern 8 is composed of some rela-

tively soft material, for example a plaster cast. On the other hand, the work 9 is regarded as a steel block.

The manner in which the pattern 8 (Fig. 4) is traced is as follows:—A tracer 14 (Figs. 4 and 10) is made to bear at its point on the surface of the pattern by a spring 15 (Fig. 10) which acts through the medium of a number of interposed elements and abuts a barrel 16 which is adjustable so that the spring tension can be varied.

The barrel 16 is screwed into a head 17 which closes the right end of a cylinder 18 (Fig. 10). The left end of this cylinder is closed by a cap 19 (Fig. 10) which has an enlarged opening 19a providing adequate clearance for the necessary side motion of a protruding shank 20 by which the tracer 14 is removably carried. It is necessary to replace the tracer 14 when different shapes and sizes are required.

A combined piston and balanced valve occupies the cylinder 18 between its end closures. The piston components are denoted 21, 22. These are integral with a sleeve 23 which carries a circular valve plate 24. This valve plate occupies an annular chamber 25, and it is against one edge 26 that the valve plate seats in order to cut off the flow of pressure fluid. The edge 26 is, therefore, a valve seat. The cap 19 is additionally used for adjusting the valve plate 24 at the seat 26. The cap 19 is secured in position by a lock nut 19b (Fig. 10).

An inlet 27 (Fig. 10) communicates with the chamber 25. Fluid is thus introduced into the cylinder 18 between the piston components 21, 22. Since the upright portions of the component 21 and plate 24 as well as that part of the sleeve 23 occurring therebetween constitute movable walls of the chamber 25 it follows that a movement of the so-called piston-valve may occur to the right without the necessity of the valve plate 24 having to act against fluid pressure.

In other words, when the valve plate 24 is seated (Fig. 10) the various walls consisting of parts of the component 21, sleeve 23, cylinder 18 and plate 24 will confine a volume of pressure fluid which is readily displaced by a movement of the tracer 14 to the right, the only resistance being the tension of the spring 15. Therefore, when the tracer encounters a raised place in its horizontal travel along the pattern 8 (Fig. 4), the tracer 14 will be displaced with the utmost ease. The pressure of the tracer 14 is regulated by the barrel 16 (Fig. 10), and may be made so light that even the softest pattern ordinarily employed can be traced without injury.

A fluid outlet 28 (Fig. 10) communicates with the cylinder 18 on the right side of the piston component 21. The base 29, of which a guide stem 30 is a part, is peripherally smaller than the bore of the cylinder 18 so that there may be no obstruction of fluid flow through the holes 31 to the outlet 28. The base 29 is screwed into the component 21 as shown.

An opening 32 (Fig. 10) completes the passageway for the fluid. When the valve plate 24 is unseated there will be a flow of fluid from the inlet 27 into the cylinder 18, through the opening 32 into the sleeve 23 and out of both the holes 31 and outlet 28. A cup 33 (Fig. 10) has a rim with a sharp seating edge bearing against the disc 34 of the shank 20. A part of this cup has an opening 35 which provides a drain passage to accommodate oil seeping past the sleeve 23 at the component 22.

There is a separation between the cup 33 and disc 34 (Fig. 10) but the two parts are generally kept in contact by virtue of the engagement of the tracer 14 with the pattern and the pressure of the spring 15 in that direction. The tendency of the spring is to keep the disc 34 pressed against the flange 36 (Fig. 10) of the cap 19. A bushing 37 clamps a flexible washer 38 in place, the purpose of this being to prevent the leakage of fluid.

It is conceivable that in tracing the pattern the tracer 14 will suddenly ride upon an eminence and drop into an adjacent depression as suddenly. In the first instance a bodily movement to the right occurs in the direction of arrows *a*, but the spring 15, having to move the interposed mass of the sleeve 23 and its appurtenances might not be prompt enough to fill the sudden requirement of the tracer 14. The valve 88 (Fig. 3) is adjusted to such a position by the operator as to diminish the speed of the carriage 78 (Figs. 3 and 4) relatively to the extreme movements of the tracer 14 (Fig. 10), the spring 15 immediately following and preventing a complete gap between the bearing points of the cap 33 and disc 34 as well as flange 36. Thus it can be seen that there is a harmonious action between the spring 15 and the pressure of the tracer 14 against the pattern 8. The point of the tracer must always be kept against the pattern.

The manner in which the cutter is made to keep pace with the tracer 14 is as follows:— The cutter 39 (Fig. 4) may be regarded as any type of cutter suitable to remove material from the work 9. Since the latter is regarded as consisting of steel, the cutter 39 will be a milling cutter. This cutter is held in position by the jaws of a chuck 40 (Fig. 2) which is operated by a draw bar 41. This draw bar is only slightly shorter than a hollow spindle 42 (Fig. 5) in which it can be turned by means of a head 43 (Figs. 1 and 13) in front of the machine. The spindle includes a tapering bore 44 (Fig. 2) into which the shank of the chuck is drawn when the head 43 is turned in one direction. The result is a clamping of the cutter 39.

Bearings 45, 46 (Fig. 4) support the spindle 42 which is revolved by a bevel gear 47 swivelly supported by a third bearing 48. The spindle carries bushings 49 (Fig. 2) at each of the bearings, these bushings revolving in the bearings. Both the bushings and the corresponding bores are tapering. Nuts 50, 51 on the exposed ends of each bushing (Fig. 2) provide for adjustments of the bushings in reference to the bearings, the nut 51 also serving to clamp the split end of the respective bushing in position on the spindle 42.

A longitudinal keyway 52 (Fig. 5) in the spindle 42 receives a key 53 (Fig. 14) in the hub of the gear 47. This connection compels the revolution of the spindle 42 yet permits the necessary sliding in reference to the axially stationary gear. Rotary motion is derived from the pulley 54 (Fig. 1) of a motor 55, this being transmitted through a speed reducer 56, and gear and shaft connections commonly denoted 57. One of the shaft components 57a (Figs. 1 and 3) has a longitudinal groove 57b receiving a spline 57c of its companion gear 57d. This arrangement compels turning but permits relative axial movement of the shaft 57a. The spindle 42 and consequently the cutter 39 are thus rotated during the operation of the machine.

A cylinder 58 (Fig. 13) has a boss at one end with an opening 59 both for the inflow and outflow of fluid. This cylinder has only this one fluid opening and it is connected by means of a

pipe 60 (Fig. 1) with the inlet 27 (Fig. 10) of the cylinder 18. The outlet 28 of the cylinder 18 has connection by means of piping 61 (Fig. 1) with a sump 62 into which exhaust fluid is discharged.

The cylinder 58, which may be identified as the cutter cylinder by virtue of its association with the cutter 39 contains a sleeve 63 (Fig. 13) in which the spindle 42 is slidable, and a piston 64 which works in the annular space between the bore of the cylinder and the outside of the sleeve 63. This piston has connection with the spindle 42 by means of a yoke 65. The place of connection is made through a ball thrust bearing 66 which works with equal effectiveness in either axial direction.

An appropriate pump 67 (Fig. 1) recirculates the fluid in the sump 62, discharging this fluid into a main pipe stand 68 (Fig. 1) from which a branch 69 supplies the pipe 60. A valve 70 is connected in this branch, enabling a regulation of the pump pressure in the pipe 60 and consequently in both the cylinders 18 (Fig. 10) and 58 (Fig. 13).

Fluid in the pipe 60 (Fig. 1) under pump pressure keeps the piston 64 (Fig. 13) pressed to the left and the cutter 39 (Fig. 4) against the work 9, and the manner in which the cutter 39 recedes from the work in agreement with the recession of the tracer 14 is as follows:—Assume the tracer point to be occupying the low normal plane 71 (Fig. 4). This is as low as the tracer point will go. The valve 24 (Fig. 10) is closed on its seat 26. Fluid under pump pressure keeps the cutter 39 pressed against the work through the medium of the piston 64 (Fig. 13) as already outlined.

The travels of the tracer 14 are horizontal. Suppose that it rides up on a high place. The valve 24 (Fig. 10) becomes unseated correspondingly, and fluid immediately flows through the cylinder 18 and out at the outlet 28 into the piping 61 (Fig. 1), hence to the sump 62.

This reduces the pump pressure in the pipe 60. A weight 72 (Fig. 1) is connected by means of a cable 73 with a slide plate 74 (Fig. 4) which is transversely slidable in ways 75. The cable is guided over sheaves 76. These, as well as most of the remaining supports are mounted on a longitudinally movable carriage 77. This carriage includes a base 78 (Figs. 4 and 6) with appropriately shaped tongs 79 riding in the V-grooves 4 of the rails 3.

The weight 72 always tends to pull the cutter 39 away from the work. Fluid pressure in the cylinder 58 (Fig. 13) tends to prevent this. Reverting to what was said before, unless there is some pressure relief in the pipe 60, the weight will not draw the cutter away from the work. When the pressure is relieved, as previously stated, the cutter 39 will recede from the work a distance agreeable with the amount of relief, and this distance will be the same as the amounut of recession of the tracer point 14.

Should the tracer point rise higher or recede farther from the pattern 8, the correspondingly greater pressure relief in the pipe 60 would enable a correspondingly greater recession of the cutter 39 from the work 9. Should the tracer point drop low again, the restriction of the fluid flow set up between the valve 24 and its seat 26 (Fig. 10) would increase the fluid pressure in the pipe 60 so that the piston 64 (Fig. 13) and consequently the cutter 39 (Fig. 4) would be driven to a new forward position. It is thus that a faithful fluctuation of position of the cutter 39 occurs in agreement with the tracer 14 through the medium of an intervening fluid column, the pressure of which is controlled by the tracer.

The tracer 14 and cutter 39 (Fig. 4) are caused to traverse the pattern 8 and work 9 (Fig. 4) along horizontal and parallel lines, and the manner in which this is accomplished is as follows:—The carriage 77 includes a head 80 (Fig. 3) which is permanently secured in or to the base 78 (Fig. 6) by any conventional means such as machine screws 81. This head has a rod 82 (Figs. 3 and 8) connected to it as at 83. This rod carries a double headed piston 84 (Fig. 8) which works back and forth in a driver cylinder 85. This cylinder is fixed on the table 1.

A branch 86 (Figs. 1 and 3) delivers fluid at pump pressure to an inlet channel 87 (Fig. 15) inside of the head 80. A valve 88 controls the inflow. The channel 87 communicates with a chamber 89 (Figs. 6 and 15) in which a valve disc 90 turns. This disc has a stem 91 which loosely carries a tripper 92. The tripper is engageable with the stops 6, 7 (Fig. 1) when the carriage 77 nears the end of its movements, thus turning the disc 90 (Fig. 15) to new positions.

Right and left ports 93, 94 (Fig. 15), extending completely through the disc 90, alternately provide communication of the chamber 89 with right and left passages 95, 96 (Fig. 8) in the head 80. These passages connect with longitudinal passages in the rod 82 (Fig. 8). The longitudinal passes terminate at opposite sides of the double headed piston 84 where they are fitted with outlets 97, 98 which are directed upwardly.

The passages 95, 96 are narrowed where they connect with the chamber 89 (Fig. 6) to the approximate shape of the ports 93, 94. Therefore, when the latter communicate with the passages 95, 96 the pressure fluid will be introduced directly into one or the other of the passages, with no possibility of leakage to an exhaust channel 99 on back of the disc 90, or to an exhaust passage 100 with which the channel 99 is in constant communication.

The channel 99 is arcuate in shape. It covers the inlet to one of the passages 95, 96 while the other is in registration with one of the ports 93, 94. For example, the present setting of the disc 90 (Fig. 15) is that of registration of the right port 93 with the right passage 95. The left port 94 is out of registration with the inlet to the left passage 96 but this is covered by the exhaust channel 99. Pressure fluid is, therefore, admitted to the channel 95. This is discharged into the cylinder 85 (Fig. 8) at the outlet 97. Pressure at the left side of the piston 84 drives this to the right, arrow *c*, consequently moving the carriage 77 to the right (Fig. 1), arrow *d*. The motion of the carriage will be reversed when the tripper 92 strikes the stop 6. This will reverse the valve disc 90 (Fig. 15).

A double arc-shaped hole 101 (Fig. 15) in the valve disc 90 and a matching recess 102 (Fig. 6) in the base 78 receive the narrow blade 103 of the stem 91. The blade has lost motion in the hole and recess. The purpose is to delay the switching of the pressure fluid to the left passage 96 (for example) until the full motion of the carriage 77 (Fig. 1) to the right has been completed. The initial rocking of the tripper 92 (Fig. 1) upon engagement with the stop 6 will be absorbed in loosely turning the blade 103 in the hole 101 (Fig. 15). The turning of the disc 90 will be sudden. The pressure fluid will be switched to the left passage 96 and the carriage 77 will be reversed immediately.

Shifting of the stem 91, consequently of the disc 90, is accomplished by the tripper 92 through the medium of pins 104, 105 (Fig. 3) which are engageable with the arm 106 of a weight 107, the arm being secured to the stem 91. Assume the tripper 92 (Fig. 3) to be riding against the stop 6 (Fig. 1). The pin 104 will elevate the weight 107 until it reaches dead center. The blade 103 will turn loosely in the hole 101 (Fig. 15).

When the dead center is passed, the weight 107 will fall to the right. The blade 103 will suddenly turn the disc 90 so as to switch the pressure fluid to the left passage 96, whereupon the carriage 77 will be suddenly reversed. In falling over, the arm 106 will strike the pin 105 (Fig. 3) and suddenly move the tripper 92 to its opposite angular position 108 (Fig. 1) which position was previously vacated by the riding of the tripper 92 against the stop 7.

A bushing 109 (Fig. 6) provides a bearing both for the stem 91 and the tripper 92. For the purpose of this bearing the tripper 92 is formed into a plate 110 which is not only a complement to the bearing but also a mount for the pins 104, 105. A spring 111 (Fig. 6), fitted between the bushing 109 and valve disc 90, presses the latter to its seat on the bottom of the chamber 89. The exhaust passage 100 (Figs. 6 and 15) discharges to the sump 62 by means of a pipe 112.

The tracer 14 and cutter 39 (Fig. 4) are simultaneously lowered or spaced downwardly a predetermined distance at the end of each right and left movement of the carriage 77 (Fig. 1), and the manner in which this is accomplished is as follows:—The previously mentioned slide plate 74 (Fig. 4) is carried by a head 113 (Figs. 5 and 12) of which the ways 75 are a part. This head travels up and down on guide ribs 114 (Figs. 4 and 5). These ribs are a part of the carriage 77. The tracer 14 and cutter 39 are firmly connected by a coupling bar 115 (Fig. 4). This is secured to the bearing 45 (or elsewhere on the slide plate 74) and has a clamp 116 in which the tracer cylinder 18 is rigidly gripped.

A control valve 117 (Figs. 3 and 6) occurs as an extension of the head 113 for which purpose it includes a flange 118 (Figs. 3 and 7) through which connection is made to the head 113. A screw shaft 119, immediately behind the control valve 117, carries a nut 120 which coacts with one end of a valve member 121 (Figs. 6 and 7). The nut 120 rides in a groove 122 (Fig. 6) in the adjacent carriage 77 and is thus kept from turning.

The bottom end of the screw shaft 119 is squared at 123 (Fig. 6). This square end fits in a corresponding recess in a step gear 124. This gear has bearing at 125 on the base 78. The bearing of the gear is, therefore, the bottom bearing of the screw shaft. The upper part of the shaft has bearing elsewhere on the carriage 77 (Fig. 3), and this part carries a crank 126 by which the shaft is manually turned to the right (looking down), thus to elevate the nut 120 and the head 113 to the starting position of the tracer 14 and 39 at the top of the pattern 8 and work 9.

Intermittent turns to the left (looking down) are imparted to the screw shaft 119 by a link 127 (Fig. 3) which connects the plate 110 with an actuator 128. The left end of the link 127 is permanently pivoted to the plate 110, but the pivot 129 at the right end is variously adjustable at 130 so that the uniform stroke of the link 127 may be varied in its effect on a pair of meshing gears 131, 132, the last of which meshes with the step gear 124.

Dogs 133, 134 engage the respective gears 131, 132 as shown. These are carried by articulated connections 135 of which the actuator 128 is a part. A rocking motion of the actuator 128 in either direction will revolve the step gear 124 to the left (looking down) with the result that the head 113 is lowered in even stages, the successive lowering movements occurring at the ends of the longitudinal movements of the carriage 77.

It is not to be understood that the counter-clockwise turning of the screw shaft 119 of its self forces the head 113 down. This turning of the screw shaft 119 causes an operation of the control valve 117, and this operation of the control valve causes the head 113 to lower. To this end the head 113 surmounts a hollow piston rod 136 (Fig. 4), which has a piston 137 (Fig. 1) operating in a fixed cylinder 138. The passage 139 of the hollow rod communicates with the space below the piston, and this space is filled with fluid. As long as a given volume of fluid remains constant in the cylinder and the passage 139 remains closed, the piston 137 and its appurtenances will be immovably supported.

Ducts 140, 141, 142 in the control valve 117 (Fig. 7) are arranged to have certain communication through openings or seats 143, 144. The valve member 121 has a valve to normally engage both seats 143, 144, that is to say, while the carriage 77 is in the course of one of its longitudinal movements, but also to engage only one of the seats at a time, for example, 143 as in the lowering of the head 113 and 144 as in the raising thereof. The central duct 141 has permanent communication with the passage 139 (Fig. 3) by the medium of a pipe 146. A spring 147 (Figs. 6 and 7) presses on the valve member 121 and keeps it in contact with the nut 120. Fluid under pump pressure is delivered to the duct 140 by way of piping 148 (Fig. 3). The supply may be cut off by a valve 149. Exhaust fluid is delivered to the sump 62 (Fig. 1) from the duct 142 (Fig. 7) by way of piping 150 (Fig. 3) which makes connection with the piping 61.

Assume the control valve 117 and the head 113 (Fig. 3) to be at rest so far as vertical movement is concerned. The valve part 145 assumes the medial position between the seats 143, 144, closing both (Fig. 7) and thus preventing an escape of fluid from the cylinder 138 (Fig. 1) by way of the passage 139, piping 146 (Fig. 3) and duct 141 (Fig. 7). This is the normal position of the valve member 121, and the head 113 is sustained by the incompressible temporarily fixed-volume fluid column.

Assume that the carriage 77 has reached the end of its movement to the right (arrow *d*, Fig. 1). The same action of the tripper 92 which causes the reversal of the valve 90 (Fig. 15), hence of the carriage 77, also imparts a counter-clockwise turn to the screw shaft 119. The nut 120 (Fig. 7) tends to depart from the valve member 121, but the valve member follows by virtue of the spring 147. Assuming the nut to have lowered to the position 151 (Fig. 7), the valve part 145 will be correspondingly lowered so that communication of the duct 141 is established with 142 through seat 144.

Inasmuch as the weight of the head 113 and its carried parts is concentrated on the piston 137 (Fig. 1) it follows that fluid will be discharged up the passage 139, through the pipe 146 and ducts 141, 142 into the sump 62 by way of piping 150,

61. The result is a lowering of the head 113. The control valve 117 lowers with it. The nut 120 makes but a limited downward movement, hence becomes a fixed abutment for the valve member 121. When the seat 144 (Fig. 7) reaches the valve part 145, communication with the duct 142 is cut off, hence the head 113 again becomes immovable.

When the head 113 has finally reached its lowermost level it will become necessary to raise it to the starting position, and this is accomplished in the following manner:—The crank 126 is continuously turned clockwise during the raising action. The consequent clockwise turning of the screw shaft 119 (Fig. 6) keeps the nut 120 pressed up in the approximate position 152 (Fig. 7). The valve part 145, being raised in reference to the seat 143 admits fluid from the duct 140 at pump pressure to the duct 141 and ultimately to the bottom of the cylinder 138 (Fig. 1). The pressure elevates the piston 137 and its superimposed head 113.

Upon ceasing to turn the crank 126 and screw shaft 119 there will be a brief departure of the control valve 117 (Fig. 7) from the now stationary nut 120, this by virtue of the pressure fluid still entering the duct 141 and cylinder 138, whereupon a closure of the seats 143, 144 will soon occur with a consequent stopping of the movement of the head 113.

The operation is readily understood. A pattern 8, (Fig. 4) of any description is suitably mounted on the upright 13 (Fig. 1) in common with the work 9 which may be a block of steel or such other material in which the pattern is desired to be reproduced. The carriage 77 as a whole is moved back and forth along the parallel rails 3. The movement of each direction is automatically stopped by the rocking of the tripper 92 (Fig. 1) when engaging the stops 6, 7 at the extremities of the right and left movement. These stops are adjustable by means of the nuts 12 so that the amplitude of the carriage movement can be made as great or as small as the longitudinal dimension of the pattern 8 demands.

Assume the carriage 77 to be traveling toward the right (arrow *d*, Fig. 1). Turning of the tripper 92 causes the pin 104 to raise the arm 106 to the erect position. Considerable lost motion is taken up in the double arc-shaped hole 101 (Fig. 15) of the valve 90, but as soon as the arm 106 reaches the dead center it will fall over and quickly reverse the position of the valve 90. Up to this time pressure fluid admitted at the inlet 87 (Fig. 15) enters the passage 95 (Figs. 6 and 8) by way of the registering port 93 (Fig. 15), but as soon as the valve 90 is reversed, as just stated, the pressure fluid is directed to the passage 96, whence it is discharged in the right end of the cylinder 85 (Fig. 8) and forces the piston 84 to the left. The carriage 77 is reversed as a consequence.

Simultaneously with the reversal of the carriage 77 the tracer 14 and cutter 39 (Fig. 4) are dropped as a unit. Such a drop occurs at the end of each longitudinal movement of the carriage 77. The cutter 39 thus operates on the work 9 during each stroke of the carriage. The drop is caused by a shift in the position of the valve member 121 (Fig. 7).

Normally the valve part 145 (Fig. 7) of this member closes the seats 143, 144 so that no fluid can escape from the bottom of the cylinder 138 (Fig. 1). The piston 137 thus has a solid rest, and the superimposed head 113 and its carried parts are held stationary insofar as vertical movement is concerned.

But upon a downward shift of the valve member 121, communication is established with the duct 142 (Fig. 7) so that fluid escapes from the cylinder 138 (Fig. 1) and the sump 62. The resulting lowering of the head 113 is promptly checked when the original and normal relationship of the valve part 145 with the seats 143, 144 (Fig. 7) is reassumed. It is thus understood that the tracer 114 and cutter 39 are successively lowered with a step motion, the steps occurring at the ends of each movement of the carriage 77.

Neither the movements of the carriage 77 nor of the head 113 have anything to do with the transverse movements of the tracer 14 and cutter 39. The line 71 (Fig. 4) is regarded as a low normal plane which when touched by the point of the tracer 14 finds the valve 24 (Fig. 10) of the cylinder 18 closed against the seat 26. When the tracer 14 rides upon an eminence, the opening of the valve 24 lets fluid through to the piping 61 so that a corresponding diminution of pressure in the pipe 60 (Fig. 3) enables a recession of the piston 64 (Fig. 13) by virtue of the constant pull of the weight 72 (Fig. 3) upon the slide plate 74 (Fig. 4). This slide plate is indirectly connected with the piston 64 by means of the yoke 65 with which the thrust bearing 66 of the spindle 42 engages.

The spring 15 (Fig. 10) is adjustable by means of the barrel 16 to any desired tension so that the pressure of the tracer 14 against the pattern will be substantially limited to any wanted pressure-setting of the spring. For general purposes the tension of the spring 15 is set at approximately one pound. This setting of the spring has no relationship whatsoever to the pressure in the fluid system. The presence of fluid under pressure in the chamber 25 (Fig. 10) might at first indicate a tendency to assist in pressing the sleeve 23 to the left, but inasmuch as the confronting surfaces of the piston 21 and valve plate 24 are the same in area there will be an equalization of the fluid pressure against these surfaces and the valve sleeve 23 assumes a balanced condition as a consequence. The same condition obtains in the exhaust chamber at the left of the plate 24 when the valve plate has become unseated from its seat 26.

From the foregoing description it will be understood that the valve 24 is subject to being unseated by a direct axial pressure on the tracer 14. In other words, if the push is directly inward in line with the axis the valve 24 will become unseated. But the tracer 14 is also subject to deflections in every radial direction as denoted by the broken lines in Figure 10.

When such deflections occur the tracer 14 partakes of a rocking motion. This rocking motion is sufficient to displace the cup 33 inwardly and consequently disengage the valve 24 from its seat 26. Any point around the rim of the flange 36 may thus become the fulcrum on which the tracer 14 rocks, and when the valve 24 is displaced as stated such displacement will occur against the tension of the spring 15.

There will be continuous vibrations of the valve 24 (Fig. 10) in reference to its seat 26 in agreement with the vibrations of the tracer 14 while horizontally traversing the pattern 8. There are also movements of the cylinder 18, consequently of the cutter 39, relatively to the valve 24 (Fig. 10) because when the valve 24 is

displaced by virtue of the tracer 14 riding upon an eminence the consequent pressure reduction in the cylinder 58 (Fig. 13) momentarily enables a relative shifting of the slide 74 and cylinder 18 (Fig. 4) to the right by virtue of the weight 72 so that the former relationship of the valve 24 to its seat 26 is reassumed. Should the tracer 14 next drop into a depression, which it is as likely to do as to ride upon a further eminence, the fluid pressure in the cylinder 58 (Fig. 13) would drive the piston 64 forward to the left and cause the cutter 39 to continue drilling into the work 9 (Fig. 4) until the tracer point reaches the bottom of the depression where the tendency of the fluid pressure to press the piston 64 and cutter 39 farther to the right would immediately be terminated by an opening of the valve 24 (Fig. 10) and a consequent diminution of the pressure in the cylinder 58.

Of course when the tracer 14 traverses a level place the valve 24 will remain still. In any case the volume of fluid passing the valve 24 is controlled by the position of the valve, the result being an exact correspondence of position of the cutter 39 with that of the tracer 14. The cutter is maintained in position between the opposing forces on the piston 64 (Fig. 13) of the weight 72 on one hand and the pressure fluid on the other.

The side motion of the shank 20 and tracer 14 (Fig. 10), made possible by the opener 19a, is needed to allow full adaptation of the tracer to the pattern. When the tracer 14 reaches a projection which extends out beyond the point of the tracer said projection will cause a slight side movement of the shank 20 which must be compensated for and is compensated for by the opening 19a.

When desiring to raise the head 113 to its top position, a continuous clockwise turning of the crank 126 and screw shaft 119 (Figs. 3 and 6) causes a continuous upward pressure on the valve member 121 with the result that the duct 140 (Fig. 7) is placed in communication with the duct 141. Fluid under pump pressure is thereby delivered to the bottom of the cylinder 138 (Fig. 1) with the result that the head 113 and its carried parts are raised.

While the construction and arrangement of the improved duplicating machine is that of a generally preferred form, obviously modifications and changes may be made without departing from the spirit of the invention or the scope of the claims.

I claim :—

1. In a duplicating marhine, a slide plate, pulling means tending to pull the plate in one direction, a revoluble cutter journaled on the plate, a fixed cylinder, a piston in the cylinder having means connecting the piston and slide plate together, a line connected to one end of the cylinder introducing pressure fluid against the piston to resist said pulling means, a tracer cylinder connected in said line and carried by the slide, a tracer movably carried by said cylinder, and a valve in the tracer cylinder operable by the tracer to vary the pressure of fluid in said line, hence the effectiveness of said pulling means.

2. In a duplicating machine, a coupled pattern tracer and work cutter, inert means tending to pull the couple in one direction, pressure fluid actuator means tending to push the couple in the opposite direction, a valve for controlling the fluid pressure, and opposed means for moving the valve in opposite directions, one of the said opposed means being directly controlled by the tracer for regulating the applied fluid pressure, hence the effectiveness of said inert means.

3. In a duplicating machine, a work cutter, a connected weight tending to pull the cutter away from the work, pressure fluid apparatus resisting the weight and tending to push the cutter toward the work, said apparatus including a pressure fluid line, a pattern tracer coupled with the cutter but having limited vibratory motion in reference to the cutter, a valve connected in said line being subject to the vibrations of the tracer to increase and decrease the effectiveness of said apparatus, hence decrease and increase the effectiveness of the weight, tension means for pressing the tracer against the pattern, and means for varying the tension of said means.

4. In a duplicating machine, a carriage, fluid pressure operated means for rectilinearly moving the carriage in opposite longitudinal directions, means on the carriage operable on the end of each movement to control the pressure to reverse the driving means hence the carriage, a pattern tracer and work cutter, a head on the carriage by which said tracer and cutter are carried, and means embodying fluid pressure actuated means operable with the reversing means, for moving the head in a transverse direction upon the aforesaid reversal of the carriage.

5. In a duplicating machine, a carriage, driver means for longitudinally and rectilinearly moving the carriage in opposite directions, a pressure fluid cylinder mounted on the carriage, a piston in the cylinder, a head superimposed on the piston, a pattern tracer and work cutter carried by the head, reversing means on the carriage acting on the driver means to reverse the driver means and periodically reverse the movement of the carriage, and valve means associated with the reversing means causing a limited fluid discharge from the cylinder upon reversal of the carriage and a consequent lowering of the head.

6. In a duplicating machine, a fixed driver cylinder to which pressure fluid is admissible, a second fixed cylinder from which previously admitted pressure fluid is releasable, a movable carriage, a piston in the driver cylinder having connection with the carriage, a head movable on the carriage, a piston in the second cylinder having connection with the head, a valve operable to admit pressure fluid in one end of the driver cylinder and so move the carriage in one direction, a second valve operable to release fluid from the second cylinder, and means actuated during said movement of the carriage to operate both valves respectively to switch the flow of pressure fluid to the other end of the driver cylinder and to release a portion of fluid from the second cylinder.

7. In a duplicating machine, a gravitating head, a piston and rod attached to the head having a passage opening on one plane face of the piston, a fixed cylinder in which the piston fits, containing an impounded volume of fluid on which said face rests to support the head, a valve carried by the head to control the passage, a member holding the valve hence the passage closed, and means for periodically displacing the member causing periodic opening and closing of the valve during the resulting step gravitation of the head.

8. In a reproducing machine, a gravitating head, an attached rod and piston having a passage opening on one plane face of the piston, a fixed cylinder containing a volume of fluid supporting the head on said plane face, a valve carried by the head to control the escape of fluid

from the passage, a screw shaft having a member acting on the valve to hold it and the passage closed, and means for periodically turning the shaft to displace the member from the valve for an opening thereof until the succeeding movement upon the member by the valve.

9. In a duplicating machine, a gravitating head, means impounding a fluid column to support the head, a valve carried by the head to control the escape of fluid from said column, and means operating with a step motion in the direction of gravitation of the head, causing periodic openings of the valve and closings thereof as the head catches up with the last said means.

10. In a duplicating machine, a head, a tracer and cutter couple carried by the head, and an attached rod and piston, a fixed fluid containing cylinder in which the piston is movable, a valve to control the volume of fluid in the cylinder and being carried by the head, a screw shaft having a member to engage and close the valve, means to turn the shaft in one direction thus to periodically displace the member and cause successive openings of the valve for a release of fluid from the cylinder, a source of pressure fluid, and means to turn the shaft in the other direction thus shifting the valve to a pressure-conducting position for filling the cylinder and elevating the head.

11. In a duplicating machine, a work cutter, means tending to pull the cutter away from the work, pressure fluid apparatus resisting said means and tending to push the cutter toward the work, said apparatus including a pressure fluid line, a pattern tracer coupled with the cutter but having limited vibratory motion in reference to the cutter, a valve connected in said line, and yieldable means tending normally to move the valve in one direction, said valve being subject to the vibrations of the tracer to increase and decrease the effectiveness of said apparatus, hence decrease and increase the effectiveness of said means.

12. In a duplicating machine, a work cutter, fluid pressure apparatus to push the cutter against the work, means tending to act oppositely on the cutter and push it away from the work, a pattern tracer subject to axial and radial vibrations by virtue of the intricacies of a pattern, and a valve device for controlling said fluid pressure, said valve device being associated with and directly operated upon by the pattern tracer for causing the release from or impounding of pressure fluid in respect to said apparatus to produce movements of the cutter in either axial direction.

13. In a duplicating machine, a work cutter, a piston coupled with the cutter, a cylinder containing the piston, a pipe line communicating at one end with the cylinder, a valve with which the other end communicates, a fluid pump connected in the pipe line imposing pressure on the piston to keep the cutter against the work, and a pattern tracer which is subject to vibration by the intricacies of a pattern to variably open the valve and cause variable drops of pressure in the pipe line.

14. In a metal forming machine, a tool to cut into the work and a support for the tool, a weight normally tending to move the tool away from the work and connections between the weight and said support, pressure fluid means normally tending to move the tool toward the work, said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to variably by-pass the pressure fluid from the pressure fluid means as said apparatus is vibrated by the pattern to cause the weight to predominate variably.

15. In a metal forming machine, a tool to cut into the work and a support for the tool, a weight normally tending to move the tool in one direction with respect to the work and connections between the weight and said support, pressure fluid means normally tending to move the tool in the opposite direction with respect to the work, said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to variably by-pass the pressure fluid from the hydraulic means as said apparatus is vibrated by the pattern to cause the pressure fluid means and weight to predominate alternately.

16. In a metal working machine, a tool to cut into the work and a support for the tool, a framework on which the support is movably mounted, a weight carried by the framework normally tending to move the tool with respect to the framework and work and connections between the weight and said support, pressure fluid means also mounted on the framework normally tending to move the tool in the opposite direction with respect to the work and framework, said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to variably by-pass the pressure fluid from the pressure fluid means as said apparatus is vibrated by the pattern to cause the weight and pressure fluid means to predominate alternately.

17. In a duplicating machine, a work cutter, means tending to pull the cutter away from the work, pressure fluid apparatus resisting said means and tending to push the cutter toward the work, said apparatus including a pressure fluid line, a pattern tracer coupled with the cutter but having limited vibratory motion in reference to the cutter, a valve connected in said line, tension means tending normally to move the valve in one direction and for pressing the tracer against the pattern, said valve being subject to the vibrations of the tracer to increase and decrease the effectiveness of said apparatus, hence decrease and increase the effectiveness of the said pulling means, and means for varying the stress of the said tension means.

18. In a metal forming machine, a tool to cut into the work and a support for the tool, means operating upon and normally tending to move the tool away from the work, pressure fluid means normally tending to move the tool toward the work, the last said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to

variably by-pass the pressure fluid from the pressure fluid means as said apparatus is vibrated by the pattern, to cause the first said means to predominate variably.

19. In a metal forming machine, a tool to cut into the work and a support for the tool, means operating upon and tending to move the tool in one direction with respect to the work, pressure fluid means normally tending to move the tool in the opposite direction with respect to the work, the last said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to variably by-pass the pressure fluid from the pressure fluid means as said apparatus is vibrated by the pattern to cause the pressure fluid means and the first said means to predominate alternately.

20. In a metal working machine, a tool to cut into the work and a support for the tool, a frame-work on which the support is movably mounted, means mounted upon the frame-work to move the tool with respect to the framework and work, pressure fluid means also mounted on the frame-work normally tending to move the tool in the opposite direction with respect to the work and framework, the last said means including a pressure fluid supply line and connections to the support, a tracer mechanism to follow the profile of a pattern through which mechanism the pressure fluid line is adapted to be by-passed, said mechanism having connections to the support, and a valve apparatus included in said mechanism to variably by-pass the pressure fluid from the pressure fluid means as said apparatus is vibrated by the pattern to cause the first said means and said pressure fluid means to predominate alternately.

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