April 18, 1933. W. F. BABCOCK 1,904,975

METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

Filed Oct. 25, 1930 8 Sheets-Sheet 1

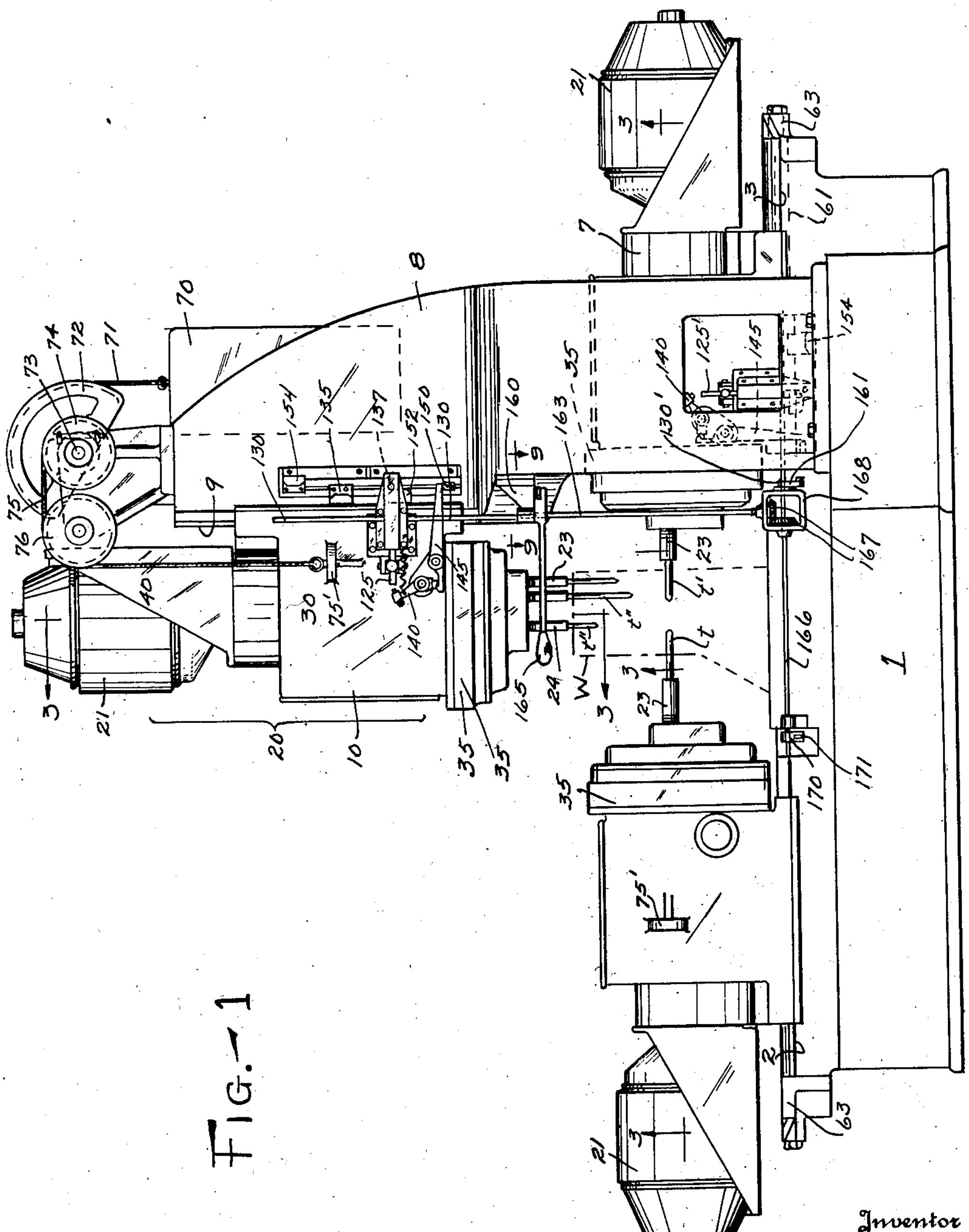

FIG.-1

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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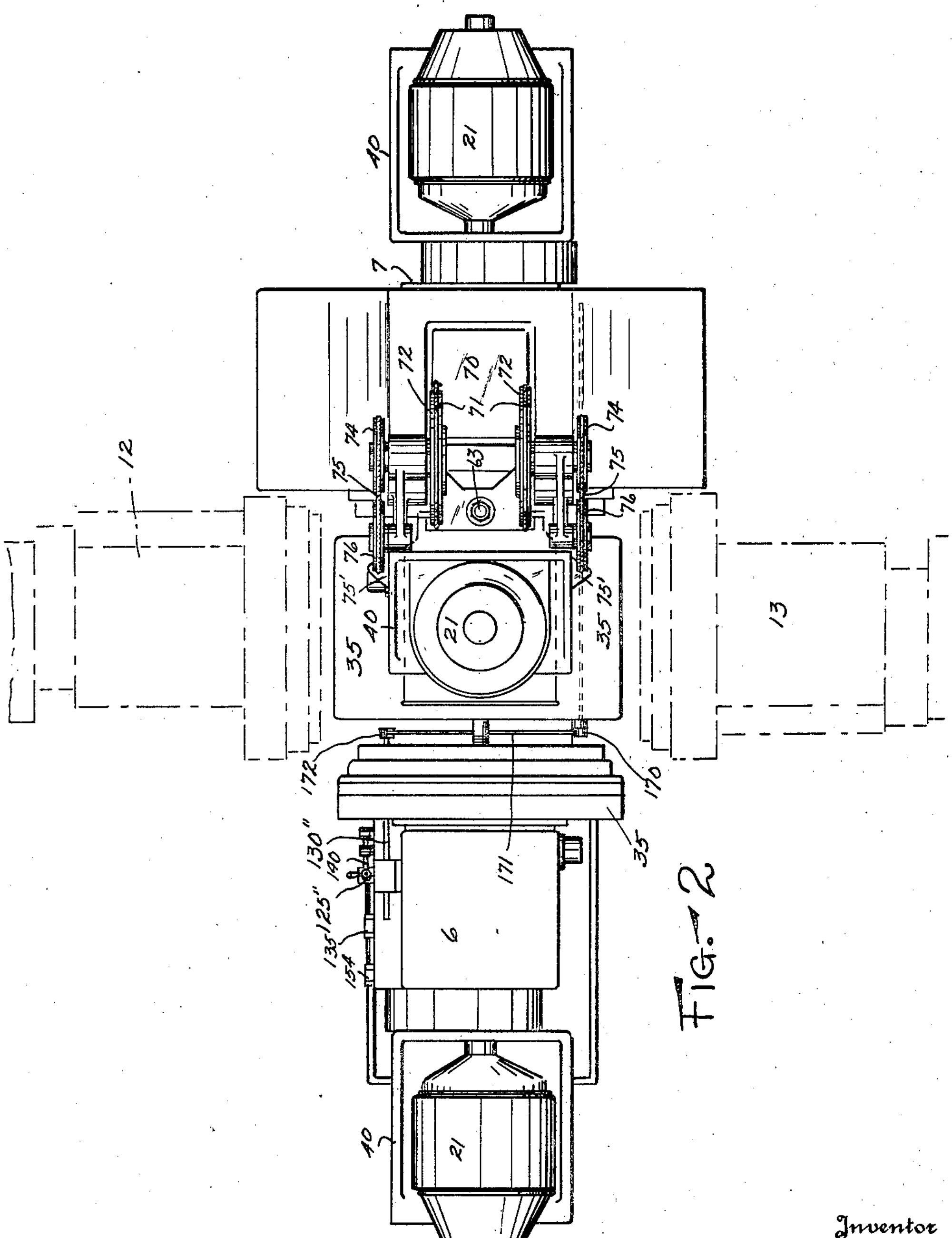


FIG. 2

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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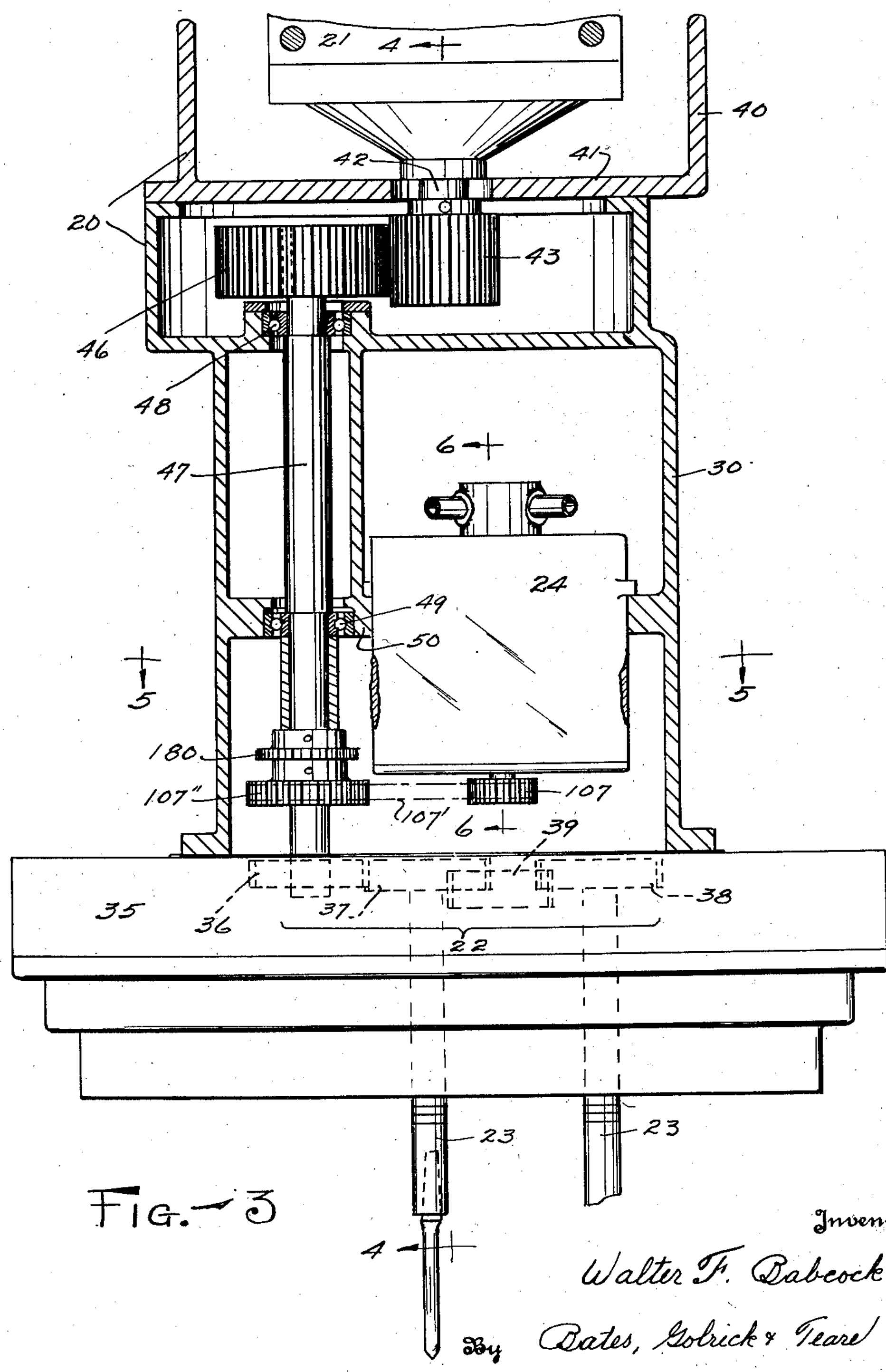


FIG. 3

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR



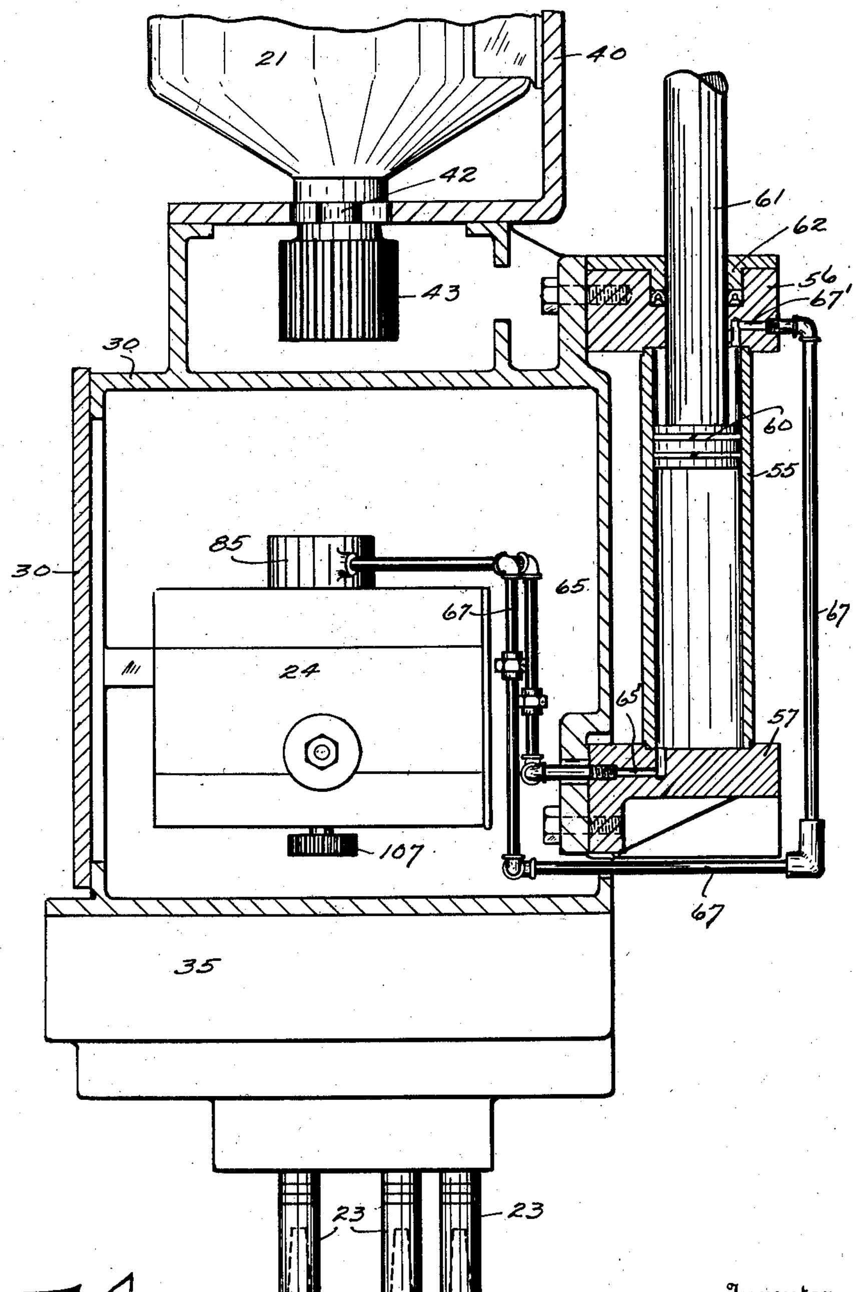


FIG. — 4

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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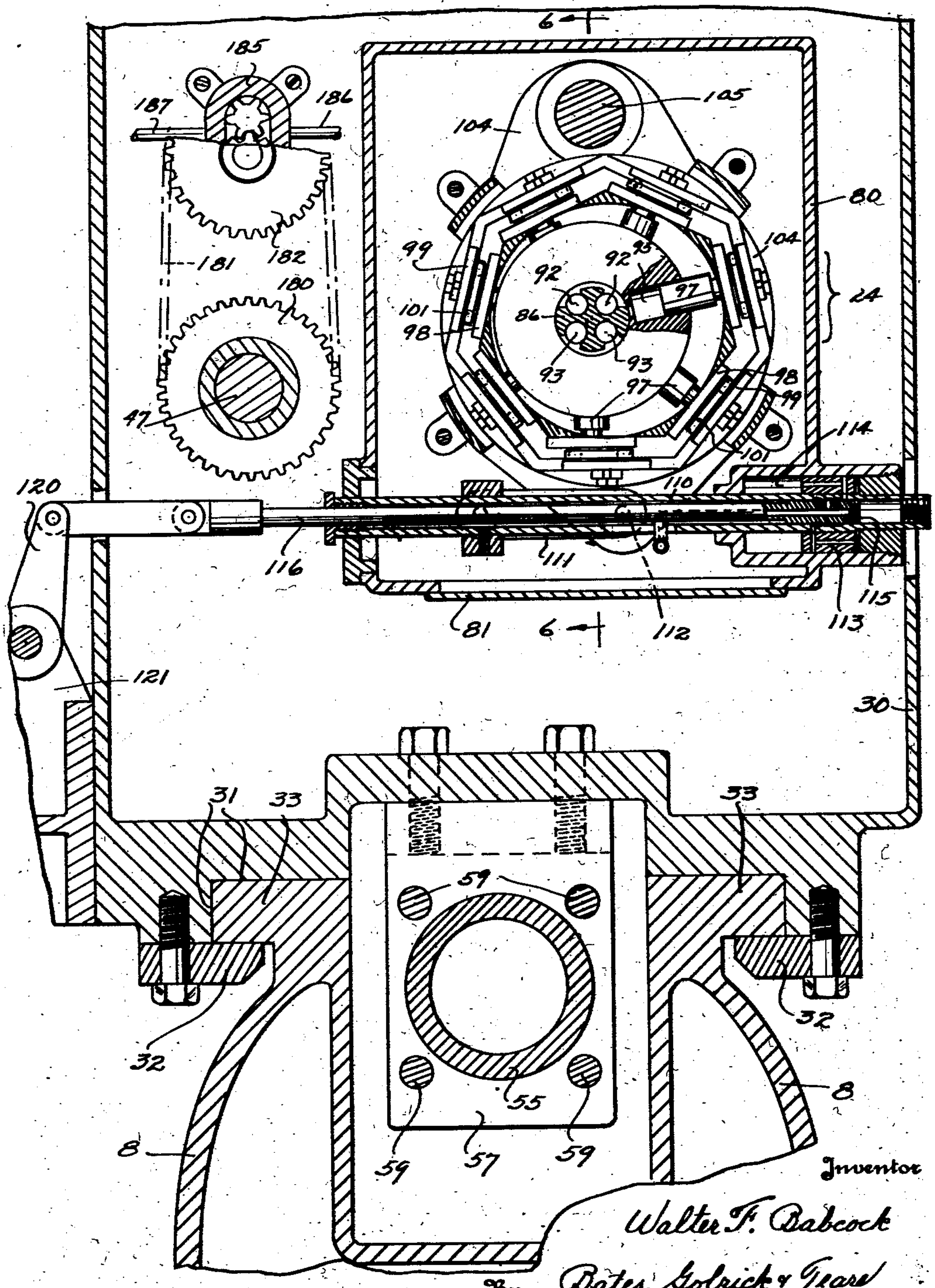


FIG. 5

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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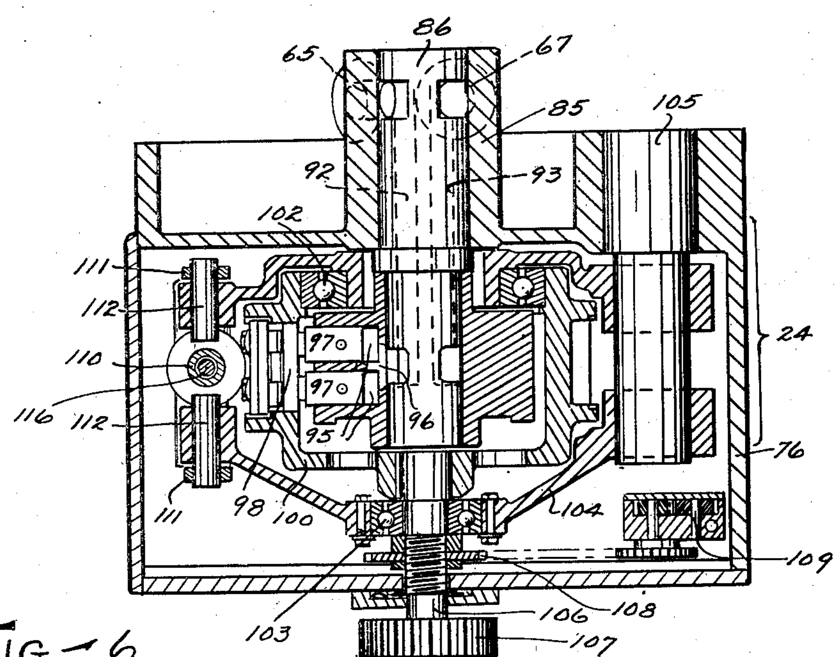


FIG.-6

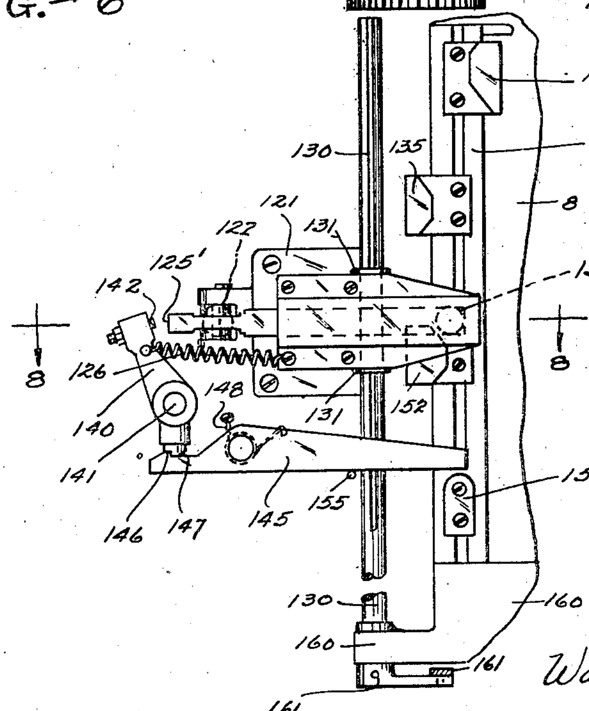


FIG.-7

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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FIG. 8

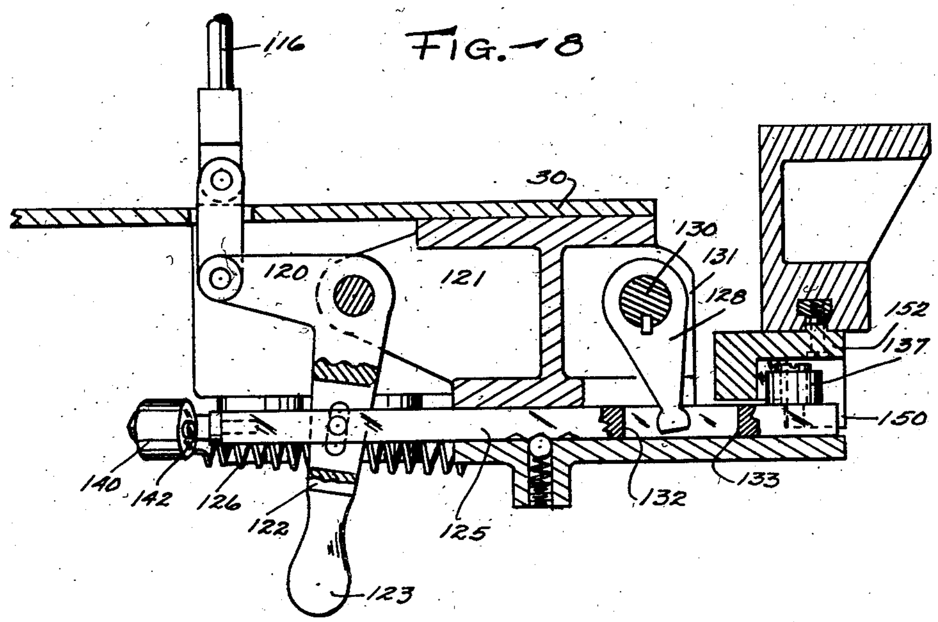
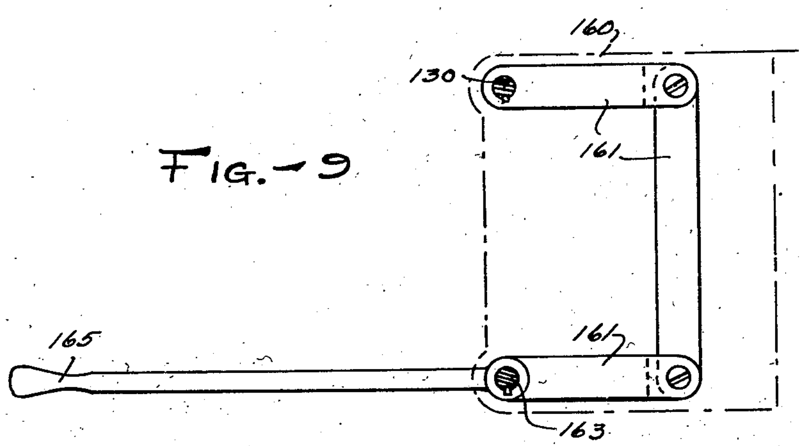



FIG. 9

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METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

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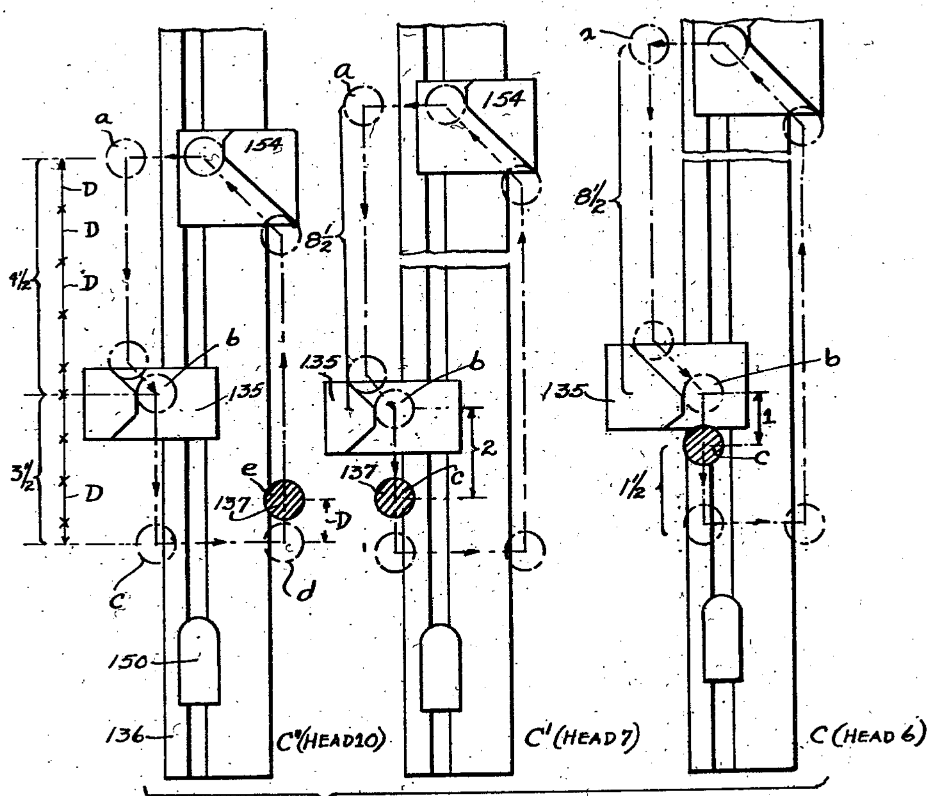


FIG.-10

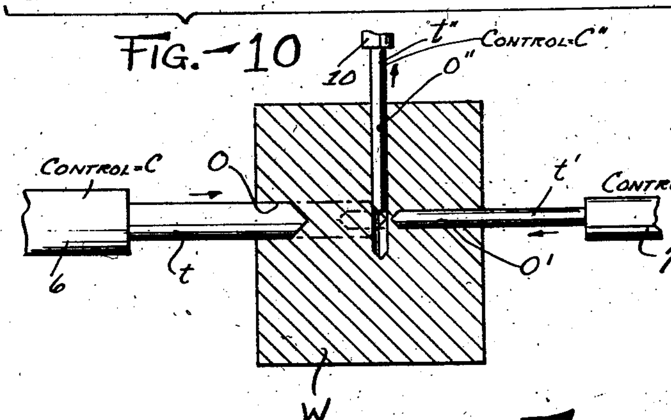


FIG.-11

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Patented Apr. 18, 1933 1,904,975

# UNITED STATES PATENT OFFICE

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## METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR

Application filed October 25, 1930. Serial No. 491,174.

The general object of this invention is to provide an automatic machine tool by which a large number of different operations may be performed on a given piece of work in a shorter period of time than by the use of previous machines adapted for similar uses. Specifically, an object is to provide a boring or drilling machine of the multiple-head type by which a number of drilling, counter-sinking and like operations may be performed with relation to various surfaces of a piece of work, in a definite order, but requiring only one initiating operation on part of the attendant or operator.

An object is to provide a metal cutting machine by which intersecting cuts may be made in a piece of work and in which the feed of the cutting tools will be adjustable in such manner that one tool will be automatically retracted from the point of intersection before another tool reaches such point.

More specifically, an object is to provide an improved multiple spindle drilling machine which will have a plurality of substantially independent tool carrying and operating heads, independently movable in respective planes, all under a single control system.

Further objects include the provision of an improved, novel and efficient operating system for a multiple-head machine tool. Another object is to provide a machine tool in which one or more tool supporting heads will have respective efficient and flexible power plant units supported thereby and movable therewith at all times.

Further objects and features of the invention will become apparent from the following description relating to the accompanying drawings, which show a preferred form of machine incorporating the invention. The essential characteristics are summarized in the claims.

In the drawings, Fig. 1 is a side elevation of a drilling or boring machine having three tool supporting and driving heads; Fig. 2 is a plan view thereof, showing two additional heads in broken lines; Fig. 3 is a sectional view of one of the heads substantially according to the line 3—3 on Fig. 1; Fig. 4 is a sectional view of one of the heads substantially according to the line 4—4 on Fig. 2; Fig. 5 is a sectional plan view through one of the heads, according to the line 5—5 on Fig. 3; Fig. 6 is a detail sectional view of a pump mechanism taken along the lines 6—6 on Figs. 3 and 5; Fig. 7 is a fragmentary side elevation of a portion of the control mechanism of one of the heads; Fig. 8 is a sectional view thereof substantially according to the line 8—8 on Fig. 7; Fig. 9 is a detail view according to the line 9—9 on Fig. 1, and Figs. 10 and 11 are work and tool diagrams.

In the machine illustrated herewith, there is a base 1 having horizontal guideways 2 and 3 slidably carrying respective tool supporting and driving heads 6 and 7, and an upstanding frame member or column 8 having a guideway 9 for carrying a tool-supporting and driving head 10. The heads 6, 7 and 10 are, as shown, substantially alike and, in general, the description below directed particularly to the head 10 will suffice for all these heads. As shown in Fig. 2, two additional heads and guiding supports are shown diagrammatically at 12 and 13.

Bearing in mind that each of the heads are substantially alike, these comprise main frames 20, preferably made up of suitable castings, and arranged to support electric motors 21, spindle-driving gearing 22 (Fig. 3) with spindles 23 for tools *t*, *t′* and *t″* respective to the various units, and a pump unit 24, all of which generally described parts will be hereinafter more fully described.

The pump mechanisms are of a generally known type, (see U. S. Patent 1,485,595, for example) but specifically adapted for the purpose of the present invention. These pumps are driven from the respective motors 21 and operate as variable speed gearing devices between the motors and the ways 2, 3, 9, etc. to drive the heads 6, 7 and 10 toward and from the work at selectively different speeds, as desired. In general, the operation is to advance the heads toward the work at a comparatively rapid speed until the tools *t*, *t′* or *t″* approach to their operating position with respect to the work, and thereafter the advancing speed is slowed down during the subsequent work of the tools. As the work is accomplished, the pumps operate to automatically reverse the direction of movement of the heads, and the return speed of the heads to starting position is preferably also relatively rapid, in order to speed up the production of the machine. The means whereby the above stated objects are carried out, and the various outlined operations performed, will now be described in detail, but with reference particularly to the head 10, its upright support and associated mechanisms.

The character of the various members comprising frame 20 of the head is best understood with reference to Figs. 1, 3 and 5. There is a main or central housing section 30, directly supported on the guideway 9 as shown in Fig. 5, this housing member having machined surfaces at 31 and heavy plates or strips 32 forming a dovetail channel. The machined surfaces and plates 32 embrace oppositely extending machined flange formations 33 on the column 8, which flanges 33 form the guideways 9.

At one end of the housing section 30 (the lowermost end with reference to the head 10) is a spindle drive gearing housing 35, which contains and supports the spindles 23 and associated parts. As shown, by way of example, these parts comprise a main driving gear 36, spindle gears 37 and 38, one meshing with the gear 36, and an idler gear 39 between the gears 37 and 38. A greater or lesser number of spindles may be provided on the various heads, as will be obvious.

Surmounting the housing section 30, as shown in Fig. 3, there is a bracket member 40, the lower wall 41 of which, forms a cover for the housing section 30, through which the drive shaft 42 of a suitable motor 21, supported on the bracket 40, extends. This shaft 42 carries a gear 43 disposed within a suitable oil casing provided partly by reason of a horizontal partition 45 in the housing section 30. The gear 43 in turn drives a larger gear 46, also disposed in the oil casing just mentioned, and this larger gear, through the intermediacy of a vertical shaft 47 drives the previously mentioned gear 36 of the spindle gearing mechanism 22. The shaft 47 has suitable bearings 48 and 49, carried by the partition member 45, and a bracket formation 50, located intermediately of the ends of the housing section 30. Incidentally, the pump unit 24 may also be carried on this bracket formation 50, as will be seen from Fig. 3.

For raising and lowering the head 10, by means of the oil gear 24, which is operated from the shaft 47, as will be presently shown, I provide a fixed piston, operating in a cylinder that is mounted on the housing section 30, and arranged to extend parallel to the movement of the head on its guideway. The pump, as will be hereinafter shown, is arranged to deliver oil under pressure alternately below and above the piston to raise and lower the head as desired. The piston cylinder indicated at 55, is supported between upper and lower brackets 56 and 57 on the housing section 30, which extend into the confines of the column 8 which is made hollow, as shown in Fig. 5. The brackets are secured in the usual way to the housing section 30, and may be drawn toward each other to seal the ends of the cylinder and hold it in place, as by means of vertical clamping and securing rods, the positions of which are shown in Fig. 5 at 59. The piston within the cylinder is shown in Fig. 4 at 60, and its connection to the column 8 comprises simply a cylindrical heavy shaft or rod 61, extending through suitable passages 62 in the bracket 56, forming one of the cylinder heads, the upper end of the piston rod 61 being rigidly secured to the column in any suitable manner. Reference is directed to the bracket member 63 associated with the guideway 3, which illustrates a suitable means for securing the piston rod 61′ to the base 1, which same device may be used in connection with the upright column 8.

As shown in Fig. 4, there are conduit lines 65 and 67, including suitable passageways 65′ and 67′ in the respective bracket members 57 and 56, which conduct oil from the pump 24 to the opposite ends of the cylinder 55. These conduits 65 and 67, of course, lead from the delivery means of the pump, which will be hereinafter described.

In order to relieve strain on the pump, the head 10, which travels vertically, has a counter-weight mechanism associated therewith. This, as shown, comprises a counter-weight 70 partly enclosed by the column 8. The supporting cable for the counter-weight extends as at 71 over a suitable groove in the rocker sheave, 72, to which the cable is suitably attached. The rocker sheave is rigid on a shaft 73, which, as shown in Fig. 2, carries at its opposite ends, grooved wheels 74 connected, as by means of cables 75 running over grooved wheels 76, with the housing section 20.

Referring now to the pump 24, (see Figs. 3, 5 and 6 particularly) it will be seen that this pump has a generally box-like casing 76 suitably closed on all sides, to contain an adequate supply of oil. The top wall of the casing has an enlarged tubular formation at 85, through the walls of which portions of the conduits 65 and 67 extend. Rigidly supported within the formation 85 is a heavy pintle 86, recessed to form continuations of the conduits 65 and 67. As shown, the pintle contains two pairs of ducts 92 and 93, one pair, 92, communicating with the conduit 65, the other pair with the conduit 67. Suitably carried for rotation on the inwardly extending end of the pintle 86 is a generally cylindrical barrel, having generally radially extending cylinder bores, the inner ends of which periodically communicate with the ducts 92 and 93. The cylinder bores are indicated at 95, and are arranged radially in pairs. Each cylinder bore has a port at 96, which is brought into communication with one or the other pair of ducts, 92 and 93, during rotation of the barrel. A piston 97 is mounted for reciprocation in each cylinder, each pair of pistons being integrally connected with a cross head 98, which bears against a reaction plate 99, removably secured in the periphery of a rotatable impelling ring 100. Appropriate anti-friction means 101 may be interposed between each cross-head and its corresponding reaction plate 99, in order to prevent free lateral movement therebetween.

The impelling ring 100 is journalled in suitable bearings 102 and 103 in a cradle 104, mounted to rock about a pintle 105 secured within the upper part of the casing 76. Rotation of the impelling ring 100 is effected through a drive shaft 106, keyed thereto and extending outside of the oil gear casing. This shaft, as shown, carries a suitable sprocket gear 107 connected as by means of a suitable driving chain 107′, to a sprocket 107″ on the shaft 47. Incidentally, the shaft 106 may also carry a sprocket 108 for driving an oil pump 109 to actuate a piston (to be later described), which moves the cradle 104 to its various operating positions.

It will be seen that when the cradle 104 is in an intermediate position, so that the impelling ring is concentric with the pintle 86, rotation of the impelling ring will cause the pistons 97 to travel about the pintle 86 without reciprocation within their respective cylinders 95. In this position, no liquid is delivered by the pump. By rocking the cradle in one direction or another, from a neutral position, such as just stated, the impelling ring will be made to assume an eccentric position with respect to the pintle, and by its rotation cause a reciprocation of the pistons within their cylinders, thus causing the production of a steady flow of liquid in opposite directions through the pairs of ducts 92 and 93, at a rate and in a direction dependent upon the extent and direction of eccentricity of the impelling ring.

For actuating and controlling the cradle 104, I have shown a plunger 110, connected through links 111, with the end of the cradle opposite the pintle 105, as indicated at 112. The plunger 110 is actuated by a piston 113, mounted in a cylinder 114 within the oil gear casing. Movement of the piston 113 is controlled by a pilot valve 115, reciprocably mounted within the plunger 110, and provided with a valve stem 116, extending longitudinally of and beyond the plunger. The arrangement is such that when the pilot valve 115 is shifted in either direction, fluid pressure is applied to one or the other side of the piston 113 to cause the plunger 110 and cradle 104 to shift in a corresponding direction, to an extent dependent upon the extent of movement of the pilot valve.

As has been previously set forth, all of the heads are controlled for their reciprocating movement toward and away from the work by substantially identical means, including the pump 24, associated with each head. It has been shown that the oil gears are driven by the respective motors 21 through suitable driving connections. To initiate and operate the pumps, I provide a system of controls, including individually settable cams, adjustably positioned on the main frame parts, and pump controlling devices actuated thereby.

Description of the various parts of one of these mechanisms just outlined will suffice for all, since they are identical with certain exceptions, which will be hereinafter brought out.

The link 116, see Figs. 5 and 8, which operates the pilot valve 115 to thus control the pump, is connected through the wall of the housing section 10 with an operating lever in the nature of a bell crank 120. This may be mounted on a suitable bracket 121 attached to the housing section 10. The bell crank 120 has an outwardly extending arm 122 provided with a handle 123 by which the bell crank may be operated manually in case of emergency, such as jamming of parts or stopping of the heads in the wrong or abnormal positions.

Slidably mounted in the bracket 121 is a control bar 125 having pin and slot connection with the arm 122 at 126. The bar 125 is initially moved to throw the pump from a neutral position into a forward driving position by an arm 128 splined to a shaft 130. The arm 128 slides on the shaft 130 and is embraced by suitable ears 131 on the bracket 121, the ears being positioned above and below the arm 128. The arm 128 has a lost motion connection by reason of a slot in the bar 125 forming operating abutments 132 and 133, which engage the arm.

Assuming the head is in its uppermost position and that the pump is in neutral, the bar 125 may now be moved to the limit of its leftward movement (referring to Figs. 1 and 8), by operation of the arm 128 against the abutment surface 132. This will cause the valve piston to assume the position shown in Fig. 5, at which position the head is driven downwardly at its highest speed.

Referring now to Figs. 1, 7 and 8, it may now be seen that just before the foremost tool $t''$ contacts with the work, a suitable cam 135, adjustable on a fixed support 136, at the side of the column, coacts with a suitable roller 137 on the bar 125 to move the above stated control connections to slow down the operation of the pump and to thereby slow down the head to the desired working progress of the tool.

Now, continued downward movement of the head is limited by a latch and trigger which serves to move the bar 125 to its extreme right-hand position (referring to Fig. 8), which movement causes the pump valve mechanism 113 to be shifted to a position which causes the pump unit to reverse the direction of movement of the head and at the greatest speed the pump is capable of. The latch and trigger mechanism, just mentioned, is shown best in Figs. 1, 7 and 8. The bar, as shown in Fig. 7, projects outwardly from the bracket 121, providing an end abutment surface at 125′. Suitably arranged on the side of the head is a trip hammer 140, pivoted as at 141, the upper end of which is adjustably arranged as by means of a screw 142 to engage the surface 125′. In order that the hammer will give the bar a percussion blow when released, the member 140 is stressed toward the bar, as by a suitable spring 143, connected between the member 140 and the bracket 121. Swingably mounted below the hammer 140 is a trigger 145, the left-hand end of which, as shown in Fig. 7, has a latch 146 engaging a cooperating latch 147 on the lower end of the hammer 140. The trigger is normally swung to hold the latch devices just described in engagement with each other, as by a suitable spring arrangement 148. The right-hand end of the trigger 145, as shown in Fig. 7, is positioned to engage a suitable stop 150. The stop 150 is adjustably positioned on the cam support 136 and extends outwardly beyond the various cam members, as shown in Fig. 8, in order that the trigger will pass all the cams.

It will be seen that as the head reaches a predetermined lowermost position, the lower end of the cutting stroke, the trigger is moved to release the latch 147, causing the instantaneous action of the hammer 140 by reason of the spring 143. This moves the bar 125 to the extreme right-hand position (referring to Fig. 8), thereby causing the return movement of the head.

As a precaution measure, in the event the latch and trigger mechanism fails to operate for any reason, continued movement of the head past the releasing position of the latch and trigger, will bring the roller 137 into contact with a cam member 152 on the support 136, which will positively move the bar 125 to such position that the pump will be thrown into neutral, thereby stopping the head. Thereafter, the operator may, by reason of the manual control member 123, operate the head to advance or retract it at the desired speed.

Assuming the trigger and latch mechanism has properly functioned as described, the head goes all the way back to starting position and is stopped by a suitably positioned cam 154, which contacts with the roller 137 to move the bar 125 to throw the pump into neutral position. The latch mechanism is now reestablished for subsequent operation at the end of the working stroke of the head, by reason of turning the shaft 130, as will be presently described, to again start the head downwardly to perform its operation on a new piece of work.

It will be seen that turning of the shaft 130 in a counter-clockwise direction (Fig. 8) will, by virtue of the arm 128 engaging the abutment surface 132, move the bar 125 to restore the hammer 140 to the position shown in Fig. 7. The trigger arm 145 has been retained in its normal position by a suitable stop 155 on the side of the head, and in repositioning the hammer 140, the latch members 146 and 147 simply cam over each other, as the right-hand end of the trigger 145 is lifted off the stop, the trigger being then swung back to the latching position shown in Fig. 7 by the spring.

The shaft 130 is supported at its lower end in a suitable bracket 160 on the column 8 and is connected by a suitable parallel motion linkage 161, see Fig. 9, with another shaft 163, parallel to the shaft 130, but offset outwardly therefrom in order to clear the head 7. The shaft 163 may be considered simply an extension of the shaft 130. The shaft 163 carries a suitable main control arm 165, see Fig. 1, which is manually shiftable to start the head. This lever also acts to start the other heads into operation, by virtue of the various bars 125 and latch members associated with these heads, and which, as previously stated, are virtually identical with those on the head 10, above described in detail.

The shaft 163, upon movement of the arm 165, turns a horizontal shaft 166 through a bevel gearing 167 in a suitable cage or support 168 on the base 1. The rocking motion of the shaft 166 is transmitted to the bar 125′ of the head 7 through a parallel motion connection 161′, essentially similar to that shown in Fig. 9, except that the operating handle 165 which is associated with the parallel motion linkage 161 is omitted.

To transfer the rocking motion of the shaft 166 to the control bar 125″ (Fig. 2) of the head 6, I may provide a connection means, including a downwardly extending arm 170 on the shaft 166, an upwardly extending arm 172 on the shaft 130″ of the controlling mechanism of the head 6, and a link 171 connecting the two arms. The linkage described is such that the rotation of the shaft 130″ will cause the movement of the lever 128 of that unit to be in a clockwise direction, similar to the movements in other units described.

It may be mentioned here that the cylinders 55, as heretofore described, have been secured to their respective heads, while the pistons 60 are fixed to the frame of the machine. The cylinders therefore travel on their respective pistons. I find this construction is extremely advantageous in that it permits short leads from the pump to the cylinder and obviates the necessity for flexible connections which would be required were the positions of the cylinder and piston reversed. This greatly increases the efficiency of the pump units by decreasing losses due to leakage, which, since the pressures in the conduits are comparatively great, are difficult to eliminate entirely.

An advantage of the present arrangement not heretofore mentioned is that the heads 6, 7 and 10 are, or may be, completely identical in construction, whereby any one of the heads may be substituted for another, with substantially no modification thereof. For this purpose, the attachment devices 75′ for the counter-weight cables 75 may be provided on all the heads. Fig. 1 illustrates one of these attachment devices formed on the main casing section of this head.

It is, of course, understood that a suitable arrangement for supplying cutting lubricant is provided. As shown, each head may include its own pumping system within the casing sections 30 (see Figs. 3 and 5). The vertical shaft 47 carries a sprocket gear 180 which, through the intermediacy of a suitable chain 181 drives a gear 182, comprising the essential driving member of a suitable constant pressure pump 185. This is suitably mounted within the casing section 30 and has inlet and outlet lines 186 and 187 communicating with any suitable oil supply and suitable discharge means (not shown) to direct the cutting lubricant to the work and tools.

Referring now to Figs. 10 and 11, it will be demonstrated how the various controls, initiated by the control linkages, including the starting arm 165, may be set and operated to perform work in a single operation, notwithstanding the fact that the paths of the cutting tools intersect. In Fig. 11, the work W may be considered as a block to be drilled with openings at O, O′ and O″. Suppose, for example, the opening O′ has to be counterbored on a larger diameter. The smaller opening O′ may be drilled with the tool *t*′ of the head 7; the counter-bore may be formed with the tool *t* of the head 6, and there may also be a transverse bore or hole which opens into one or the other of the openings O and O′, which transverse hole may be formed by one of the tools *t*″ on the head 10. Now, for convenience, let us take the automatic control mechanisms, including the cams and trigger operating devices of the various heads and set these instrumentalities for performing the operations just given. The three sets of cam and trigger operating instrumentalities are shown, for convenience side by side, in Fig. 10. The control assembly is indicated at C for the head 6, C′ for the head 7 and C″ for the head 10.

For convenience, we may start with the setting of the controls at C″ for the head 10, this having the slowing down cam at 135, the tripper 150 for the trigger and latch mechanisms and the stopping cam 154, all arranged to act on the roller 137, as previously described.

Assuming that the head 10 may be started in its downward path with the cam roller 137 in the position shown at *a*, it is, for the moment, unimportant how far this roller must travel before it engages the cam 135 to slow down the speed of operation of the head, but suppose this movement requires 4½ units of the length shown at D in the dimension line. The roller will be cammed over and the head slowed down to working speed, which we have assumed is half of the initial advancing speed, when it reaches the position shown at *b*, adjacent the cam 135. The drill *t*″ has now reached the work and subsequent progress of the roller from the position *b* to the position *c* is determined by the depth it is desired to drill the hole O″. This depth of hole having been determined, the operator simply sets the trigger operating device 150 so that the movement of the roller 137 will be reversed at position *c*. It will be remembered that the operation of the stopping device 150 on the trigger mechanism is such that the bar carrying the roller 137 is thrown rapidly to the right, carrying the roller to the position *d* with reference to the cam support 136.

If the length of the hole O″ is in scale with the control diagram C″, it will be seen that the working stroke of the head 10, is approximately 3½ units D in distance. Now, in terms of time, and because the speed of the head 10 is slowed down to half speed to bring the roller from position *b* to the position *c*, this distance from *b* to *c* actually represents, in terms of time, 7 units. Assuming now that the trigger mechanism has engaged the stop 150, the head now travels upwardly at full speed. At a total time period of 12½ units, the roller 137 will be brought to the position *e* shown in full lines. This position *e* of the roller corresponds to the position of the drill *t*″ shown in full lines in Fig. 11, the drill moving in the direction of the arrow, shown adjacent the drill.

Referring now to the control diagram portion above the legend "C′ (head 7)", it will be seen that the tool *t*′ must be operated in such manner that it will cut its hole O′ and back out before the tool *t*″ is in finishing position, or the reverse must obtain, that is to say, tool *t*″ must have finished its work in the region in which the holes O′ and O″ intersect. To effect the first stated condition, the stop 135 may be located, as shown on the intermediate portion of the diagram Fig. 10, so that the distance from position $a$ of the roller 137 to its position $b$ will be 8½ units. This is at full speed. The tool $t'$, therefore, starts cutting the work as illustrated in Fig. 11 with the corresponding roller 137 in this position $b$. Assuming now that the head travels two distance units at half speed (the equivalent of four units, in terms of time), the location of the end of the drill $t'$ at the end of 12½ units (in terms of time) will be that illustrated at $c$ in full lines in the diagram. Thus it will be seen that the drill $t''$ has reached its lowermost position and has backed up to the position shown in full lines before the working end of the tool $t'$ has reached the position of the opening O''. The remaining positions of the roller 137 are material only in that they show the path of the roller as it goes back to starting position when the pump is thrown into neutral by the stop 154. These various positions will, therefore, not be described in detail.

Referring now to the extreme right-hand part of the diagram above the legend "C (head 6)", it will be seen that the counterboring tool $t$, at approximately 8½ units at high speed, will have reached the position $b$, carrying the end of the tool $t$ into contact with the work as the speed of the head 6 is slowed down. Actually, since counter-boring with a considerably larger tool, requires a much slower speed of operation, the cam 135 used in this case, moves the roller a much greater distance toward neutral than do the cams 135 shown in the other parts of the diagram. It may be assumed that the tool now moves at one-half the speed of the other tools for their working stroke or one-third of full speed, and a measured distance of one unit, therefore, requires, in terms of time, four times that of a single unit D. It will therefore be seen that at the end of 12½ units, measured in terms of time, the roller 137 will have reached the position $c$ at the right hand side of the diagram, whereby the drill $t'$ will have entered the work and backed out to the position shown in full lines in Fig. 11 (corresponding to position $c$ on the intermediate portion of the diagram, Fig. 10), before the counter-boring tool has reached the position of the working end of the tool $t$ when farthest into the work, as illustrated by the broken lines in alignment with the tool $t'$.

I claim:—

1. In a metal cutting machine, a frame, a plurality of tool driving and supporting carriages slidably mounted on the frame, cylinders fixed to respective carriages, pistons fixed to the frame and operating in respective cylinders to advance and retract the carriages toward and from their operating positions, pumps mounted on respective carriages, connections between the pumps and their respective cylinders, valve control mechanisms mounted on respective carriages to control the action of their respective pumps, means interconnecting the valve control mechanisms to cause their respective pumps to initiate the movement of each head simultaneously, and motors on respective carriages to drive respective pumps and tools.

2. In a metal cutting machine, a frame, a plurality of tool driving and supporting carriages slidably mounted on the frame, cylinders fixed to respective carriages, pistons fixed to the frame and operating in respective cylinders to advance and retract the carriages toward and from their operating positions, variable displacement fluid pumps mounted on respective carriages and directly connected to opposite ends of their respective cylinders, a valve control mechanism for each pump mounted on respective carriages to control the rate and direction of flow of fluid in respective pumps, means interconnecting each of the control mechanisms to cause their respective pumps to initiate the movement of each head simultaneously, each of said controls comprising a fluid valve and an independent pump therefor mounted in said carriage, and a motor mounted on each carriage and drivingly connected to operate the control pump the carriage operating pump and drive the tools.

3. In a metal cutting machine, a main frame, a tool driving and supporting carriage slidably mounted on the main frame, a cylinder secured to the carriage, a piston secured to the main frame and operating in said cylinder to advance and withdraw the carriage from the work, said carriage including a housing, a motor supported by said housing, a variable displacement pump within said housing, mechanism within the housing to control the displacement of the pump to vary the flow from the pump to the cylinder, a shaft drivingly connected to said motor, gearing connecting said shaft to said pump, tool spindles rotatably mounted in said housing and arranged to carry the metal cutting tools, gearing drivingly connecting said shaft to said spindles and means acting on said displacement control mechanism to vary the speed of travel of said carriage relative to the frame while maintaining the driving connections between the motor and the pump and the motor and the spindles.

4. In a metal cutting machine, a main frame, a tool driving and supporting carriage slidably mounted on the main frame, a cylinder secured to the carriage, a piston secured to the main frame and operating in said cylinder to advance and withdraw the carriage from the work, said carriage including a housing, a motor supported by said housing, a variable displacement pump within said housing and connected to opposite ends of said cylinder, fluid operated mechanism within the housing to control the displacement of the pump to vary the rate and

direction of flow through the pump to the cylinder, a second pump arranged to supply fluid pressure to said control means, a shaft drivingly connected to said motor, gearing connecting said shaft to both of said pumps, tool spindles rotatably mounted in said housing and arranged to carry metal cutting tools and gearing drivingly connecting said shaft to said spindles and whereby the speed and direction of travel of said carriage relative to the frame may be varied while maintaining the driving connections between the motor and both of said pumps and the tools.

5. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame, a metal cutting tool rotatably mounted on said carriage, an electric motor mounted on said carriage and operatively connected to rotate the tool, a pressure pump mounted on said carriage, means drivingly connecting the motor to the pump whereby the pump and tool are driven simultaneously by the motor, hydraulically responsive means connected to said carriage and to the frame and adapted to reciprocate said carriage, and a hydraulic connection between said means and said pump.

6. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame, a metal cutting tool rotatably mounted on said carriage, an electric motor mounted on said carriage and operatively connected to rotate the tool, a pressure pump mounted on said carriage, means drivingly connecting the motor to the pump whereby the pump and tool are driven simultaneously by the motor, hydraulically responsive means connected to said carriage and to the frame and adapted to reciprocate said carriage, a hydraulic connection between said means and said pump, control means carried by the carriage and operated by elements carried by the frame, and a connection between the pump and the control means.

7. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame, a cutting tool rotatably mounted in said carriage, an electric motor mounted on said carriage and operatively connected to rotate said tool, a pressure pump mounted on said carriage, means connecting said motor to drive said pump, a hydraulically responsive means connected to said frame and the carriage to reciprocate said carriage and interposed between the pump and said hydraulically responsive means, a valve mounted on said carriage to control the displacement of said pump, and means stationarily mounted on the main frame to operate said valve when said hydraulically responsive means reciprocates said carriage.

8. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame, a cutting tool rotatably carried by said carriage, a pump mounted on said carriage, a motor for driving the pump, means drivingly connecting the motor to the pump and to the tool and, wherein the axis of the motor and the tool and the pump are parallel to the plane in which the carriage reciprocates, a hydraulic ram disposed in a plane parallel to the plane in which the carriage reciprocates, and a hydraulic connection between the pump and said hydraulically responsive means.

9. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame comprising a housing, a cutting tool rotatably mounted on said carriage at one end of said housing, a motor mounted on said carriage at the opposite end of said housing and operatively connected to rotate said tool, a pump mounted on said carriage within a secondary housing comprising a fluid reservoir, means disposed within the first-named housing and connecting said motor to drive said pump, of hydraulically responsive means disposed between the first-named housing and said frame to reciprocate said carriage, a valve mounted on said carriage and within said housings and arranged to control the displacement of said pump, and means carried by the main frame to control said valve.

10. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said frame, a cutting tool rotatably carried by said carriage, a pump mounted on said carriage, means including an intermediate shaft drivingly connecting the motor to the pump and to the tool, said shaft extending parallel to the shaft of the pump, hydraulically responsive means powered by the pump to reciprocate the carriage and a hydraulic connection on the carriage and extending through the carriage to connect between the pump to said hydraulically responsive means.

11. In a metal cutting machine, a main frame, a carriage reciprocably mounted on the frame, a metal cutting tool spindle rotatably mounted at one end of the carriage, an electric motor mounted on the carriage, a hydraulically responsive piston and cylinder operatively interposed between the said frame and the carriage, a pump mounted on the carriage between the motor and said tool spindle, a shaft rotatably supported by the carriage to extend alongside of said pump, speed reduction means connecting the shaft of the motor and said shaft, a driving connection between said shaft and the pump, a gear drive connecting said shaft to said tool spindle, and a hydraulic connection on the carriage extending between said pump and said piston and cylinder.

12. In a metal cutting machine, a main frame, a carriage mounted for automatic reciprocation upon the frame, a metal cutting tool spindle rotatably mounted at one end

of the carriage, an electric motor mounted on the opposite end of the carriage, a hydraulically responsive piston and cylinder respectively connected to the frame and the carriage, a variable displacement pump mounted on the carriage between the motor and said tool spindle, a shaft rotatably supported by the carriage to extend alongside of said pump and serving to drivingly connect the motor and said spindle, said shaft and pump being supported by a common housing comprising part of the carriage, a driving connection disposed within the housing and operatively extending between said shaft and the pump, a hydraulic connection on the carriage extending through the housing to connect said pump and said piston and cylinder, a valve in said hydraulic connection and valve operating means mounted upon one side of the housing for causing the valve to operate whereby pressure from the pump will cause one complete cycle of reciprocations of the carriage automatically.

13. In a metal cutting machine, a main frame, a carriage reciprocably mounted on the frame, a metal cutting tool spindle rotatably mounted at one end of the carriage, an electric motor mounted on the opposite end of the carriage, a housing structure comprising part of the carriage and disposed between said spindle and said motor, a hydraulic cylinder connected to the underside of the housing, a piston within the cylinder and connected to the said frame, a pump mounted on the carriage within the housing, a shaft rotatably supported within the housing to extend alongside of said pump, speed reduction means connecting the shaft of the motor and said shaft, a driving connection between said shaft and the pump, a gear drive connecting said shaft to said tool spindle, and a hydraulic connection extending through the housing connecting said pump to said cylinder.

14. In a metal cutting machine, a main frame, a carriage reciprocably mounted on said main frame, a cutting tool rotatably mounted in and carried by the carriage, fluid pumping means mounted on the carriage, said pumping means being adapted to deliver a liquid at high speed and low pressure and at low speed and high pressure, an electric motor mounted on said carriage and drivingly connected through means on the carriage to rotate said tool, means on the carriage connecting said motor to drive said pumping means, a hydraulically responsive means connected to said frame and to the carriage to impart fast and slow reciprocating movements to said carriage, said pumping means serving to deliver high pressure and slow movement to said hydraulically responsive means, only during the cutting operation of said tool and greatly increased volume of said liquid at low pressure during the major reciprocating movements of the carriage, a valve mechanism mounted on said carriage and interposed between the pump and said hydraulically responsive means to control the pressure and displacement of said pump during the reciprocating movements of the carriage and means stationarily mounted on said main frame to operate said valve mechanism when said hydraulically responsive means reciprocates said carriage.

15. In a metal cutting machine, a main frame, a carriage mounted on said main frame, and to be reciprocated at varying speeds, a plurality of cutting tools rotatably mounted in and carried by the carriage, a fluid pumping means mounted on the carriage, said fluid pumping means being adapted to deliver a liquid at high speed and low pressure and at low speed and high pressure, an electric motor mounted on said carriage and drivingly connected through means on the carriage to rotate said tools, means on the carriage for connecting said motor to drive said pumping means at a constant speed, a hydraulically resistant piston connected to said frame and a cylinder cooperating with the piston and fixed to the carriage to reciprocate said carriage, said pumping means serving to deliver high pressure and slow relative movement to the piston and cylinder only during the cutting operations of said tools, and low pressure and greatly increased movement during the major reciprocating movements of the tool, a valve mechanism mounted on said carriage and interposed between the pump and said hydraulically responsive means to control the pressure and displacement of said pump and means stationarily mounted on said main frame to operate said valve when said hydraulically responsive means reciprocates said carriage, whereby the load on said motor may be substantially uniform during the driving of the pumping means when the carriage is being reciprocated at high speed and when the carriage is moved at low speed and the tools are cutting.

In testimony whereof, I hereunto affix my signature.

WALTER F. BABCOCK.

# DISCLAIMER

1,904,975.—*Walter F. Babcock*, Detroit, Mich. METAL CUTTING MACHINE AND CONTROL SYSTEM THEREFOR. Patent dated April 18, 1933. Disclaimer filed August 7, 1933, by the assignee, *The Foote-Burt Company*.

Hereby enters this disclaimer by disclaiming from claims 5, 6, 7, 8, and 15 any metal cutting machine, when such a machine does not have a "pump" or "pumping means" disposed within a secondary housing upon the carriage thereof.

[*Official Gazette August 29, 1933.*]