April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 1

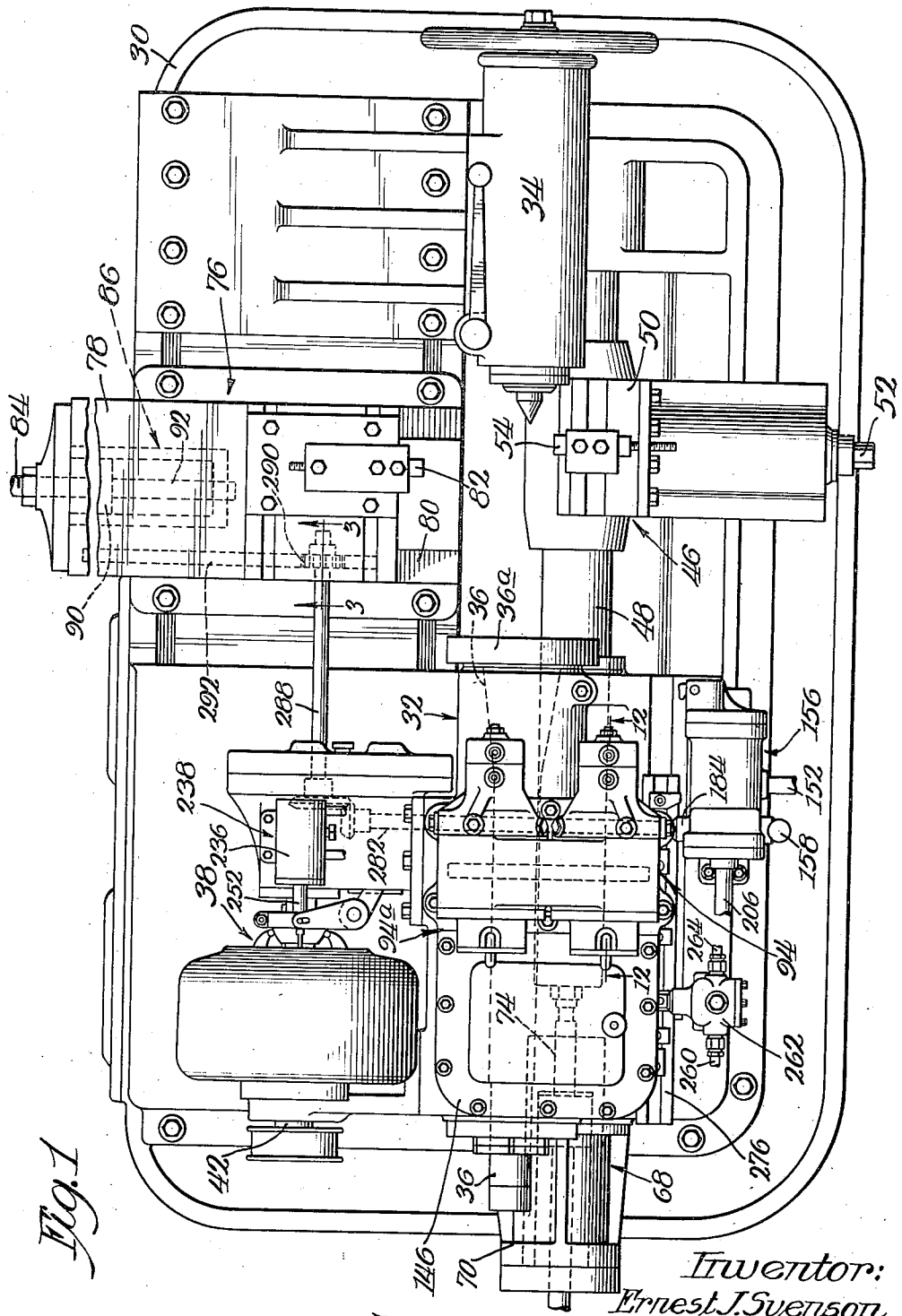


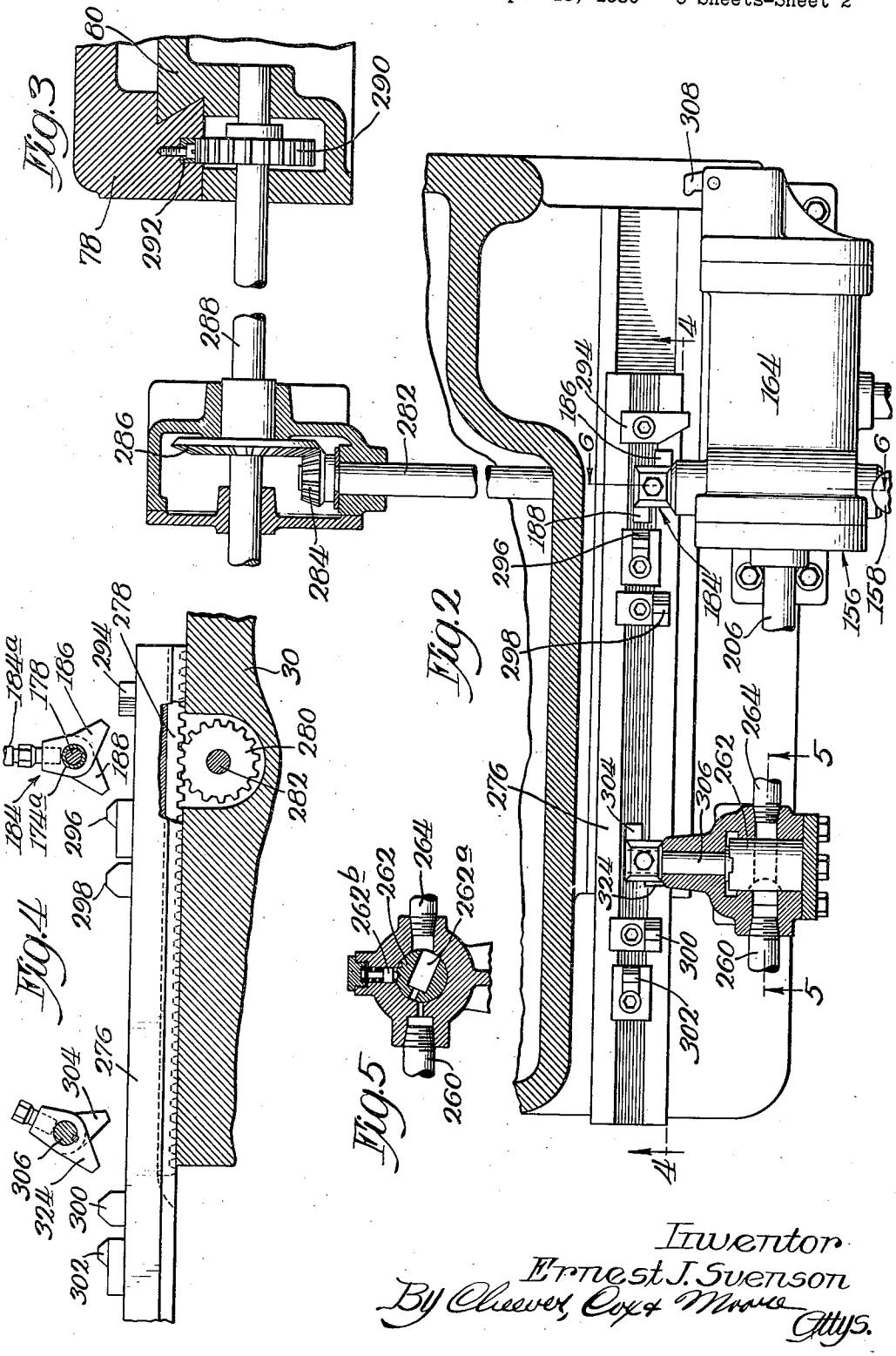
Fig. 1

Inventor:
Ernest J. Svenson
By Cleaves, Cox & Moore, Attys.

April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 2

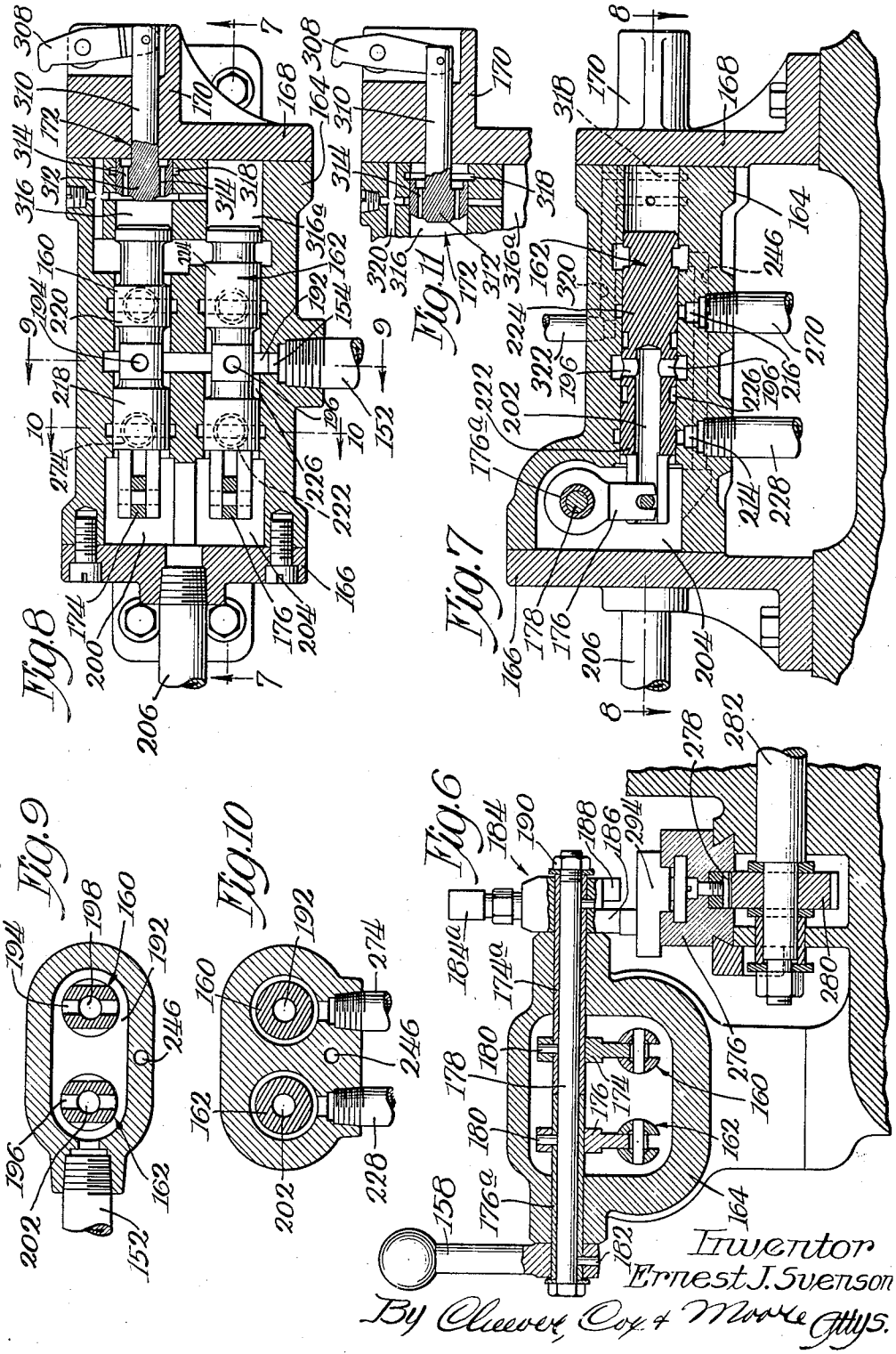


Inventor
Ernest J. Svenson
By Chesver, Cox & Moore Attys.

April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 3



April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 4

Fig. 12

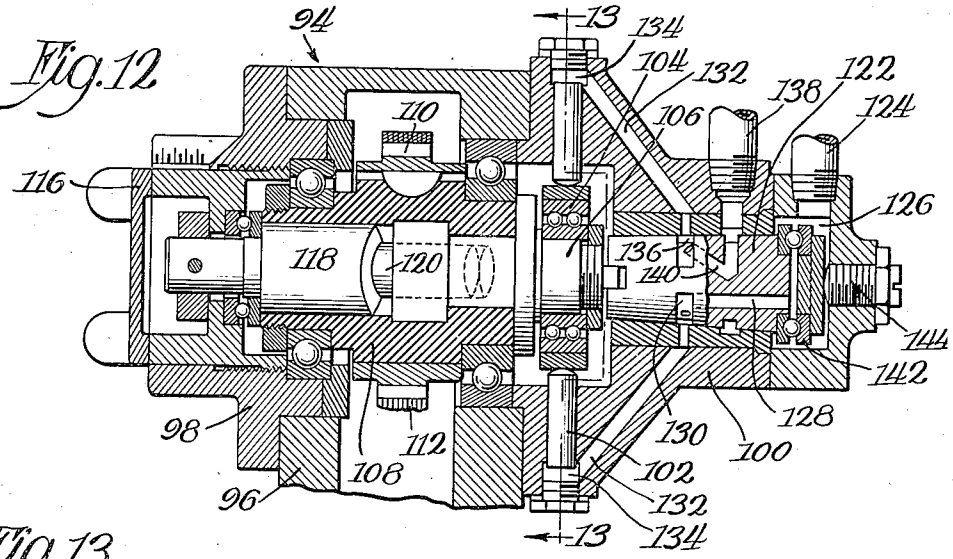


Fig. 13

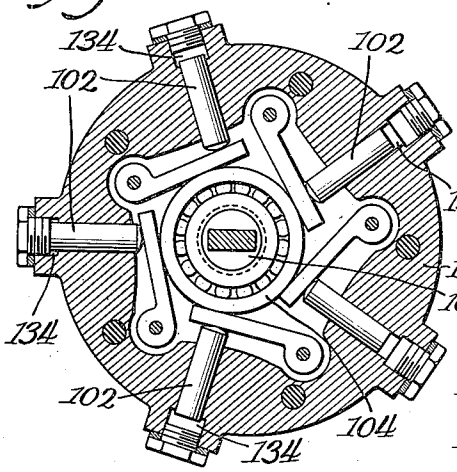


Fig. 14

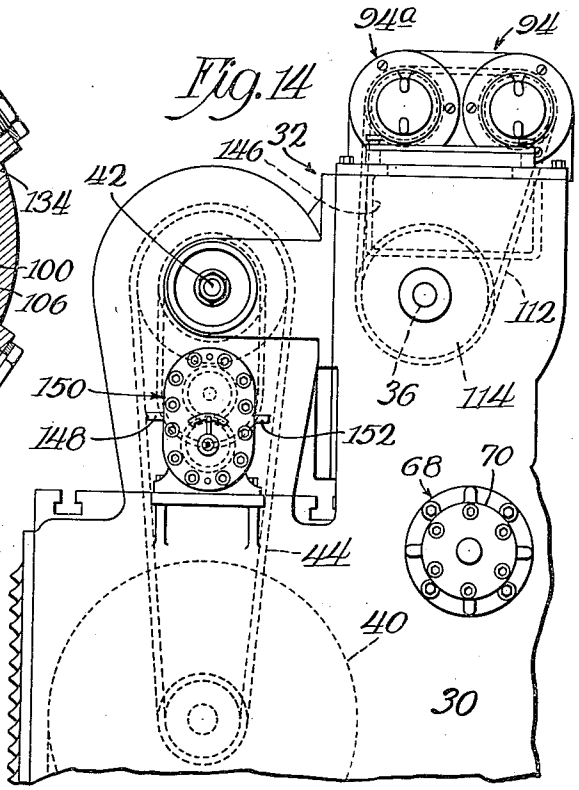
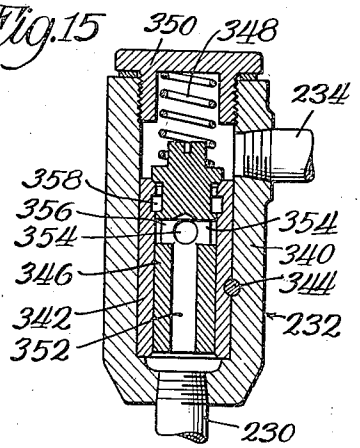


Fig. 15



Inventor
Ernest J. Svenson
By Cleaves, Cox & Morse Attys.

April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 5

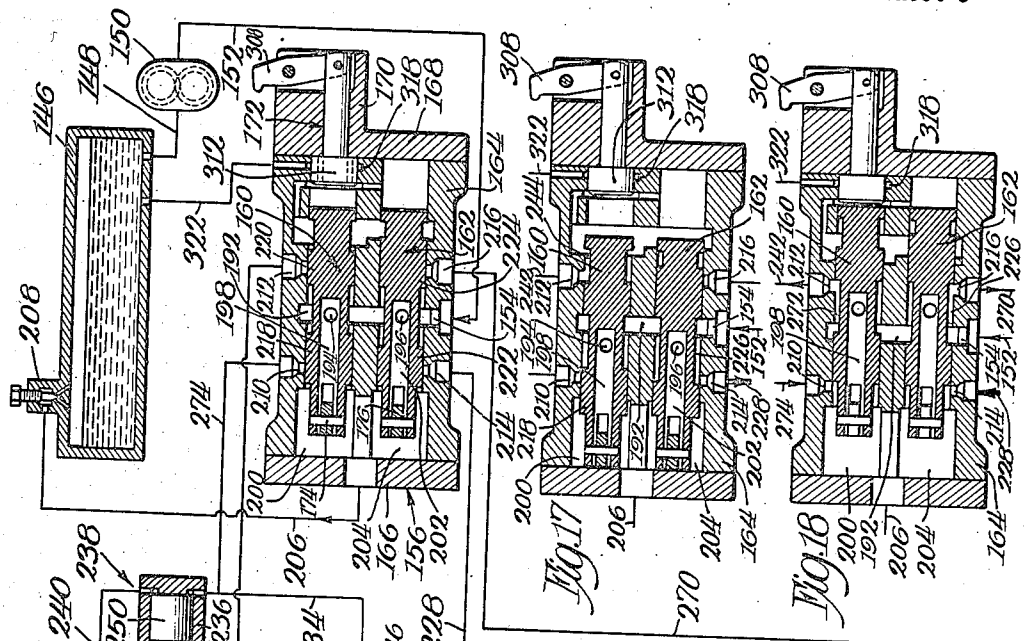


Fig. 17

Fig. 18

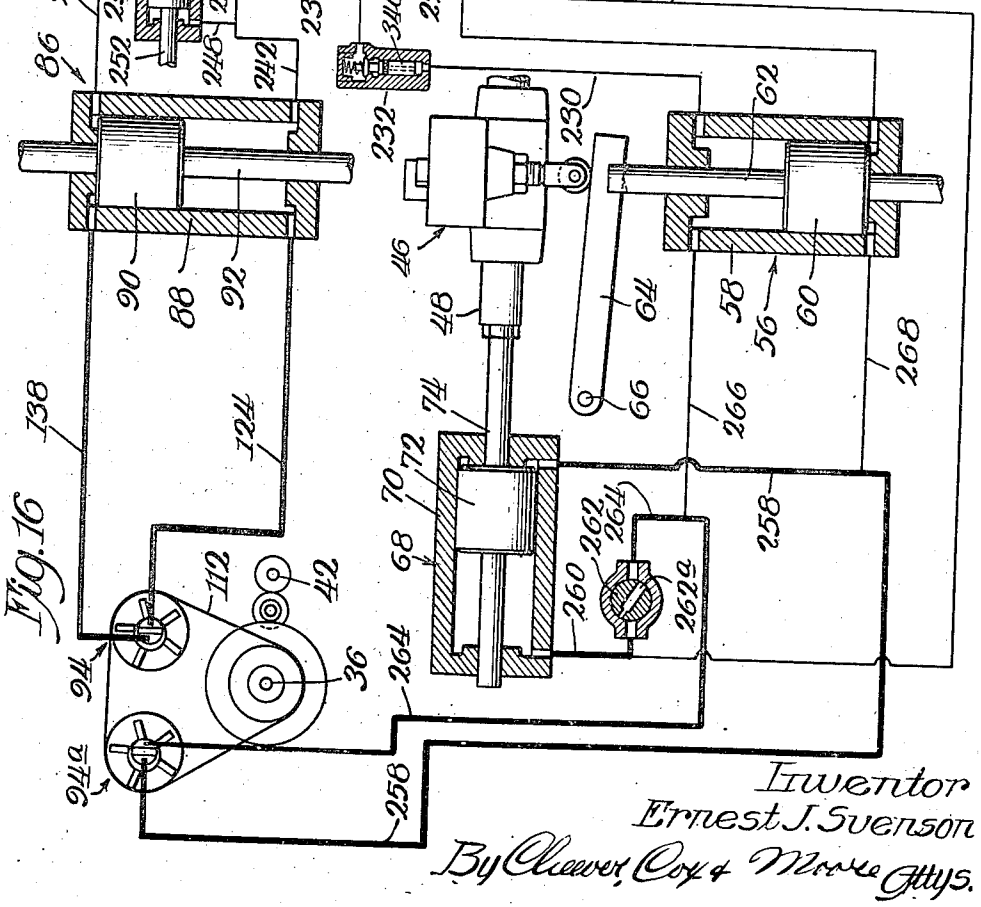


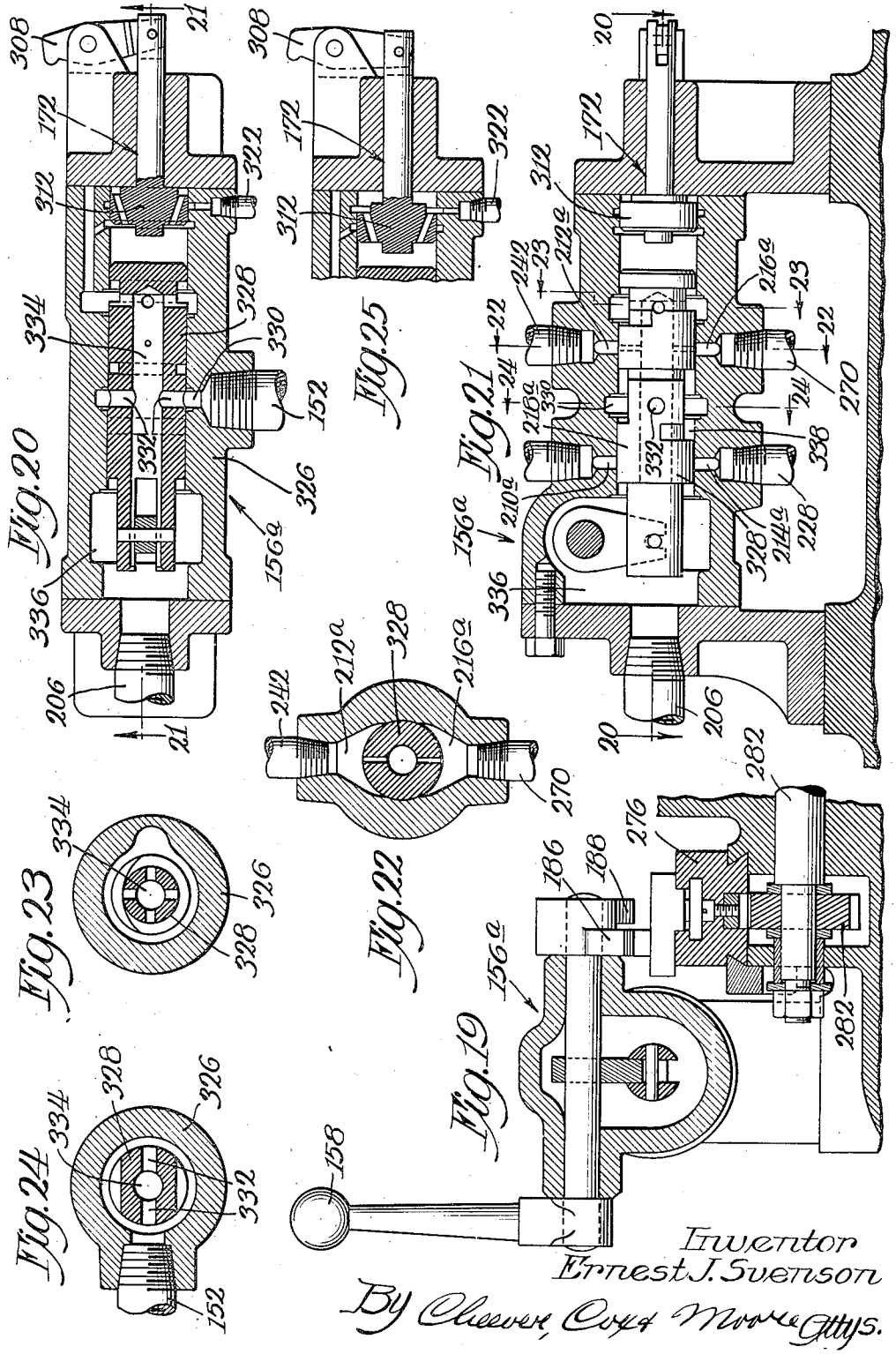
Fig. 16

Inventor
Ernest J. Svenson
By Cleaver, Cox & Moore Attys.

April 27, 1937. E. J. SVENSON 2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Original Filed Sept. 13, 1930 6 Sheets-Sheet 6



Patented Apr. 27, 1937 2,078,696

UNITED STATES PATENT OFFICE

2,078,696

HYDRAULIC MATERIAL WORKING APPARATUS

Ernest J. Svenson, Rockford, Ill.

Application September 13, 1930, Serial No. 481,742
Renewed February 3, 1937

108 Claims. (Cl. 82—2)

My invention relates generally to hydraulic material working apparatus, and more particularly to apparatus such as automatic lathes and the like which are equipped with hydraulic systems of control.

In using conventional types of material working apparatus, such as automatic lathes having a plurality of movable tool carriages, considerable difficulty has been experienced in controlling the movements of tools. This fact is particularly true in connection with the hydraulic control of a plurality of carriages. In other words, it has been found difficult to control the movements of a plurality of machine carriages so that each carriage is moved to a predetermined position with respect to the other carriage or carriages during a predetermined interval of time.

It is one of the primary objects of my present invention to overcome difficulties heretofore experienced by providing a hydraulic system of control which will serve to accurately and positively position one carriage with respect to another during each successive cycle of operation of the machine.

More specifically, it might be stated that my invention contemplates the provision of a new and improved hydraulic system of control which is so arranged that a plurality of shiftable tools, as for example, tools on front and rear carriages of an automatic lathe, may be brought into engagement with a rotating work piece at a proper predetermined time during each successive cycle of operation of the machine.

Another object of my present invention is to provide in a hydraulic system of control as above set forth, a single control means of extremely simple and practical construction, whereby the movements of the hydraulically operated machine parts may be conveniently controlled.

In order to bring about the above mentioned accurate control of the movements of a plurality of machine carriages or the like, I propose to so arrange the hydraulic system of control that the hydraulic mechanism for shifting one carriage is controlled directly by the mechanism which hydraulically actuates another carriage. In other words, I propose to operate one of said hydraulic mechanisms directly in response to the actuation of another carriage operating mechanism.

A still further object of my present invention is to provide, in combination with the hydraulic system of control just set forth, an improved control valve of extremely simple construction, said valve in one shifted position serving to direct fluid from a suitable source of supply to the hydraulic mechanism which controls the actuation of a second hydraulic mechanism, and in another shifted position serves to direct fluid for rapid traverse purposes to both of said hydraulic mechanisms. In other words, my invention contemplates the provision of a system of control for a plurality of hydraulic actuators, in which a valve serves to initially direct fluid to one of the actuators only, and subsequently to direct fluid to all of the actuators in order to effect rapid reverse traverse of said actuators.

Another object of my present invention is to provide, in combination with the hydraulic system of control above set forth, a plurality of closed hydraulic circuits, whereby feeding movement is imparted to the actuators.

In addition to providing improved hydraulic circuits, my invention contemplates the provision of improved mechanical control devices, whereby the shifting of carriages, such as the front and rear carriages of a lathe, may be effectively governed.

The foregoing and numerous other objects and advantages will be more apparent from the following detailed description when considered in connection with the accompanying drawings, wherein—

Figure 1 is a plan view of an automatic hydraulically controlled lathe which is constructed in accordance with the teachings of my present invention;

Figure 2 is an enlarged plan view of the dog carrying slide and associated valve mechanisms, a portion of said structure being shown in section in order to more clearly set forth the general arrangement thereof;

Figure 3 forms a continuation of Figure 2 and discloses fragmentarily the portion of the rear tool carriage slide as viewed along the line 3—3 of Figure 1;

Figure 4 is a fragmentary vertical sectional view taken longitudinally of the slide substantially along the line 4—4 of Figure 2;

Figure 5 is a transverse sectional view of the rotary control valve for the front carriage circuit, said view being taken substantially along the line 5—5 of Figure 2;

Figure 6 is a transverse vertical sectional view of the control valve and the associated portions of the dog carrying slide, said view being taken substantially along the line 6—6 of Figure 2;

Figure 7 is a transverse vertical sectional view taken along the line 7—7 of Figure 8;

Figure 8 is a horizontal sectional view taken substantially along the line 8—8 of Figure 7;

Figure 9 is a transverse sectional view of the control valve taken substantially along the line 9—9 of Figure 8;

Figure 10 is a similar transverse sectional view taken along the line 10—10 of Figure 8;

Figure 11 is a fragmentary detail sectional view of the unbalancing mechanism, said mechanism being shown in position to unbalance the fluid pressure within the chambers of the valve mechanism shown in Figure 8;

Figure 12 is a transverse vertical sectional view of one of the variable displacement, high pressure plunger pumps which is employed for feeding purposes, said view being taken substantially along the line 12—12 of Figure 1;

Figure 13 is a transverse vertical sectional view of said pump taken substantially along the line 13—13 of Figure 12;

Figure 14 is a fragmentary end elevational view of the automatic lathe as viewed from the left end of Figure 1;

Figure 15 is a central transverse sectional view of the check valve which is employed in the low pressure fluid circuit;

Figure 16 is a circuit diagram of my improved hydraulic system of control, said system including the double control valve structure shown in Figures 6 to 10 inclusive, said valve being shown in neutral position;

Figure 17 is a sectional view of the valve mechanism similar to the section shown in Figure 16, disclosing the rapid approach position of said valve mechanism;

Figure 18 is a similar view disclosing the reverse rapid traverse position of said valve mechanism;

Figure 19 is a transverse sectional view similar to Figure 6, of a modified control valve;

Figure 20 is a horizontal sectional view taken substantially along the line 20—20 of Figure 21;

Figure 21 is a vertical section of the control valve taken substantially along the line 21—21 of Figure 20;

Figure 22 is a transverse section of the valve mechanism taken substantially along the line 22—22 of Figure 21;

Figure 23 is a similar transverse vertical sectional view taken along the line 23—23 of Figure 21;

Figure 24 is also a transverse sectional view taken along the line 24—24 of Figure 21; and

Figure 25 discloses a shifted position of the unbalancing device of Figure 20.

Referring now to the drawings more in detail, it will be observed that like numerals have been employed to designate similar parts throughout the various figures.

For the purpose of disclosing one practical application of my hydraulic system of control, I have selected an automatic lathe, which is clearly shown in plan in Figure 1.

This lathe is structurally similar in many respects to the lathe which is described and claimed in my co-pending applications, Serial No. 391,130, filed September 9, 1929, and Serial No. 439,306, filed March 27, 1930, and therefore a detailed description of the various elements which constitute the lathe structure proper is not essential to a complete understanding of the present invention.

However, enough of the structures of the lathe elements are disclosed in the present application to enable a clear understanding of the combination thereof with my improved hydraulic system of control so as to clearly set forth at least one practical application of my invention. In order to more readily understand my present invention I shall first proceed to briefly designate certain structures of the lathe, and subsequently describe these structures in connection with my improved mechanism for controlling the operation of these lathe elements.

Referring to Figures 1 and 14, it will be seen that I have disclosed an automatic lathe which includes a suitable base or bed 30, which supports a head stock designated generally by the numeral 32, and a tail stock which is designated generally by the numeral 34. Mounted within this head stock 32 is a suitable work spindle 36, and this spindle 36 is connected with and driven from a clutch mechanism 38. This clutch mechanism 38 serves to connect and disconnect the spindle 36 with a suitable source of power supply, for example, with an electric motor 40 shown in Figure 14. This electric motor 40 is connected with a rear drive shaft 42 through the agency of a suitable chain belt 44. Thus, the motor 40 may be continuously operated so as to rotate the drive shaft 42, and when it is desirable, power from the drive shaft 42 is imparted to the spindle 36 by manipulating the clutch mechanism 38.

Mounted upon the front side of the lathe is a tool carriage which I have designated generally by the numeral 46. This carriage 46 is clamped at its lower end upon a cylindrical bar 48 and is capable of being oscillated with the bar 48 about the axis thereof toward and away from a work piece (not shown), which work piece is adapted to be supported between the tail stock 34 and a face plate 36a of the spindle 36. This front carriage 46 includes an upper slide 50 which is adjustable toward and away from the work piece by means of a suitable screw 52, and this slide supports a suitable tool 54. The oscillation of the carriage 46 with the support bar 48 is controlled by means of a hydraulic mechanism or actuator which I have designated generally by the numeral 56 in Figure 16. This actuator 56 is positioned immediately beneath the outer end of the carriage 46, and includes a cylinder 58 which reciprocably supports a piston 60. This piston is vertically reciprocable within the cylinder 58 and is mounted upon a suitable piston rod 62 which extends on both sides of said piston.

The upper extremity of the piston rod 62 supports the free extremity of a guide bar 64 which is pivotally mounted at 66 on the front side of the machine in any suitable manner. The upper surface of the guide bar 64 serves as a rest for the outer portion of the oscillatory front carriage 46, as shown fragmentarily in Figure 16. Obviously, when the piston 62 experiences an upward movement, the carriage 46 will be swung with the support bar 48 so as to carry the tool 54 into operative association with the work piece.

Longitudinal movement of the tool 54 and the carriage 46, upon which it is mounted, is occasioned in response to the actuation of a hydraulic mechanism or actuator 68, Figures 1 and 16. This actuator 68 includes a cylinder 70 and a piston 72 which is horizontally reciprocable within said cylinder. A piston rod 74 serves to connect the piston 72 with one extremity of the cylindrical bar 48. Thus, when movement is experienced by the piston 72, a corresponding longitudinal movement will be imparted thereby to

the bar 48, and this bar, as set forth above, carries the carriage 46.

The automatic lathe also includes a rear tool carriage which I have designated generally by the numeral 76. This tool carriage includes a slide 78 which is reciprocable upon a guide frame 80, Figures 1 and 3, toward and away from the work piece. The slide 78 also supports a tool 82, and by means of a suitable screw 84, Figure 1, the slide 78 may be adjusted toward and away from the work piece. This carriage 76 is arranged to move said tool transversely of the work piece. Movement is imparted to the slide 78 through the agency of a suitable hydraulic mechanism or actuator which is designated generally by the numeral 86. This actuator includes a cylinder 88 and a piston 90, which is horizontally reciprocable within said cylinder. A piston rod 92 is provided for the purpose of connecting the piston with the slide 78. Thus, it will be apparent that the actuator 56 controls the oscillation of the front tool carriage, while the actuator 68 controls the longitudinal movement of said front carriage, and the actuator 86 controls the transverse reciprocation of the rear tool carriage 76.

Pumps

Mounted upon the upper portion of the head stock 32 is a pair of fluid propelling mechanisms or pumps 94 and 94*a*. These pumps are identical in structure and the pump mechanisms per se do not form a part of the present invention, except as said elements enter into the general combination of my improved hydraulic system of control.

Referring to Figures 12 to 14 inclusive, it will be seen that each of these pumps includes a central casing 96, an end casing member 98 on one side thereof, and a second casing section 100 secured to the opposite side of the central casing 96. This casing section 100 provides a support for a plurality of radial pistons 102, and movement is imparted to these pistons through the agency of a driving ring or annulus 104. This driving ring 104 is mounted on anti-friction bearings supported by a rotatable driving member 106, and this driving member is driven by and laterally adjustable within a sleeve member 108. Keyed to this sleeve member 108 is an annular sprocket 110, connected by means of a chain 112 with a companion sprocket 114, Figure 14, which is mounted upon the work spindle 36. Thus it will be apparent that the pumps 94 and 94*a* are driven directly from the work spindle of the lathe.

The driving ring 104 of each of the high pressure plunger pumps may be laterally adjusted by turning an adjusting nut 116. This nut is connected with a cylindrical member 118 which is provided with an angularly disposed projection 120 which extends into a companion opening in the driving member 106. Thus, by rotating the nut 116, the eccentricity of the driving ring 104 may be varied. The casing section 100 also serves to support a tapered rotary valve 122 which is adapted to control the flow of fluid toward and away from the outer ends of the pistons 102. Fluid is directed into the pump through a pipe 124 which communicates with a chamber 126, and from this chamber fluid passes through a valve passage 128 to a peripheral valve port 130. This valve port 130 successively registers with radial passageways 132 which communicate at their outer extremities with chambers 134 at the outer ends of the pistons 102. Fluid is withdrawn during the compression stroke of the pistons through passageways 132 which register with a peripheral valve port 136. This port communicates with a pipe line 138 through the agency of a valve passage 140. The tapered valve 122 is secured against longitudinal displacement to the right, Figure 12, by means of an antifriction thrust bearing 142 and an abutment screw 144. This tapered valve 122 positively prevents leakage of fluid to the left along the surface thereof, and thus renders the pump particularly adaptable for use in connection with closed fluid circuits. In other words, the pipe lines 124 and 138 form two sides of a closed circuit, about to be described. These pumps 94*a* and 94 respectively are adapted to supply fluid at high pressure to the actuator 68, which longitudinally moves the front tool carriage, and to the actuator 86 which moves the rear tool carriage transversely of the work piece.

A reservoir 146 positioned at the upper portion of the machine contains a supply of fluid, and fluid from this reservoir is directed through a pipe line 148 to the intake side of a gear pump 150. Fluid from the discharge side of the gear pump 150 is directed through a pipe line 152 to the intake port 154 of a valve mechanism which I have designated generally by the numeral 156. This gear pump 150 is constantly driven from the shaft 42, as clearly shown in Figure 14, and provides the means for supplying low pressure fluid at increased displacement to the actuators for the purpose of imparting rapid movement thereto.

Control valve

I shall now proceed to describe the valve mechanism 156, and in order that the operation of this valve mechanism may be more readily understood, I shall describe the same in connection with the fluid circuit which includes the actuators 56, 68, and 86. This valve mechanism 156, as clearly shown in Figures 1 and 2 and Figures 6 to 11 inclusive, is mounted upon the front side of the machine and is located in a convenient position for manual manipulation by the machine operator. Manual manipulation of this valve is controlled through the agency of a control handle 158, and this control handle serves to reciprocate valve members 160 and 162 which are movable within a casing 164. The valve members 160 and 162 are also adapted to be automatically shifted within the casing and this automatic control will be later described. One end of the casing 164 is closed by a cover plate 166 and the opposite end is closed by a cover plate 168. This cover plate 168 is provided with a boss 170 which serves as means for supporting a balancing mechanism 172, which will be described later.

The left extremity of the valve member 160 is pivotally connected to the lower end of a crank 174, and the left extremity of the valve 162 is connected to a similar crank 176. The upper portion of these cranks are mounted upon sleeves 174*a* and 176*a* respectively, Figure 6, and these sleeves are, in turn, mounted upon a shaft 178 which extends on opposite sides of the valve casing 164. The cranks 174 and 176 are secured to their respective sleeves by means of suitable pins 180. The control handle or lever 158 is secured to the outer end of the sleeve 176*a* by means of a pin 182, and the outer extremity of the sleeve 174*a* supports a block 184, which is formed with a pair of dog engaging fingers 186 and 188. These fingers cooperate with mechanisms later to be described, for automatically controlling the shifting of the valve members.

A nut 190 carried at the outer extremity of the shaft 178 is adapted, when tightened in position, to urge the sleeves 174a and 176a into firm abutment, and thus bind said sleeves and shaft together as a unit. When these sleeves and shaft are thus secured, movement of the single control handle 158 will cause the simultaneous actuation of both of the valves 160 and 162. If it is desirable to manually operate one of the valves independently of the other, it is only necessary to loosen the nut 190. It will be noted that the block 184 is provided with a knurled upwardly extending handle 184a, which serves as a convenient means for manually manipulating said block.

In Figures 6 to 8 inclusive, as well as Figure 16, I have shown the valves 160 and 162 in their neutral position. When these valves occupy this neutral position, it will be observed, by referring particularly to Figures 8 and 16, that fluid from the low pressure pipe line 152 will pass through the intake port 154 of the valve casing, and thence into a passageway 192, and it will be seen by referring to Figure 9 that this passageway 192 extends from one side of the valve casing to the other, or, in other words, encircles both of the valves 160 and 162. In this neutral position of the valve members, the passageway 192 communicates with radial ports 194 in the valve 160 and similar ports 196 in the valve 162. The ports 194 communicate with a central longitudinal valve passage 198 which opens into an end chamber 200, while the radial ports 196 communicate with a similar longitudinal passage 202 which opens into a chamber 204. These chambers 200 and 204 are connected to a pipe line 206, and the upper end of this pipe line is connected to a mechanism 208 having an adjustable restricted orifice. Fluid passes through this restricted orifice and is thus returned to the reservoir 146. Thus, it will be apparent that, when the valve members occupy their neutral position, fluid from the low pressure source of supply will circulate therethrough and will not be distributed through any of the ports 210, 212, 214, and 216 provided within the valve casing 164. It will be noted that the ports 210 and 212 are closed by the valve sections 218 and 220 respectively, while the ports 214 and 216 are closed by valve sections 222 and 224 respectively.

Consider now that the valve members are shifted to the position shown in Figure 17, which will hereinafter be referred to as the rapid approach position. In this position low pressure fluid from the pipe line 152 passes through the valve port 154 and into the passageway 192, as previously described. However, when the valves occupy this shifted position, the radial ports 194 and 196 thereof are closed, thereby preventing the circulation of incoming fluid through the longitudinal passageways 198 and 202 back to the reservoir 146. The incoming fluid, however, is directed through a lateral port 226 in the valve member 162 to the port 214, and from this port the fluid is conducted through a suitable conduit or pipe 228 to the lower extremity of the cylinder 58 of the actuator 56. It is to be noted that, when the valve members occupy this rapid approach position, the section 218 of the valve member 160 closes the port 210, thereby preventing the low pressure fluid from passing outwardly through said port. In other words, when the valve members occupy the position shown in Figure 17, fluid is directed by the valve through a single outlet port, namely, the port 214 and thence through the pipe line 228.

Fluid entering the cylinder 58 causes the piston 60 to move upwardly, thereby effecting the swinging of the front tool carriage 46 and its supported tool 54 toward the work piece. Fluid from the advancing side of the piston 60 passes out of the upper end of the cylinder 58, Figure 16, through a pipe 230, and this pipe connects with one end of a check valve 232 of improved practical construction, which will be described later in detail. It will suffice to say that this valve 232 prevents the reversal of fluid flow into the pipe 230. The other end of the check valve 232 connects with a pipe 234, and this pipe is connected to one extremity of a cylinder 236 of a hydraulic clutch operating mechanism, which I have designated generally by the numeral 238. Fluid entering the cylinder 236 from the pipe 234 passes outwardly through a pipe 240, which connects with one extremity of the cylinder 88. Thus forward movement is imparted to the piston 90 in the cylinder 88 in response to the upward movement of the piston 60. In this manner I am able to cause the piston 90 to move a predetermined distance during a corresponding movement of the piston 60. Fluid from the advancing side of the piston 90 passes outwardly through a pipe 242 which connects with the valve port 212. At this time the valve port 212 communicates with an annular port or passage 244 of the valve member 160, Figure 17, and this port 244 communicates with a passageway 246, Figure 7, provided within the valve casing 164. This passageway 246 opens at its opposite extremity into the chambers 200 and 204, and thereby the fluid is returned through the pipe 206 to the reservoir 146.

At this point it should be noted in Figure 16 that the left end of the cylinder 236 of the hydraulic clutch control mechanism 238 is connected to the pipe 242 by means of a pipe 248. Thus, when the valve members are initially shifted to their rapid approach position shown in Figure 17, a piston 250 within the actuator cylinder 236 will be urged to the left, and fluid from the advancing side of this piston will be returned through the pipe 248. The piston 250 through its piston rod 252 is connected with the clutch mechanism 38 as shown in Figure 1, and the movement of this piston to the left will actuate said clutch mechanism so as to establish a driving connection between the work spindle 36 and the drive shaft 42. This causes the pumps 94 and 94a to be actuated. Fluid from the discharge side of the pump 94, Figure 16, passes through the pipe 138, which connects with the outer end of the rear carriage cylinder 88. The return pipe 124 connects the intake side of the pump 94 with the opposite extremity of the cylinder 88. The discharge side of the pump 94a is connected through a pipe 258 with the right end of the cylinder 70 of the actuator 68. The opposite end of the cylinder 70 is connected through a pipe 260, a rotary valve 262, and a pipe 264 to the intake side of the pump 94a. A pipe line 266 serves to connect the pipe line 264 with the upper end of the cylinder 58 of the actuator 56, while a pipe 268 serves to connect the lower end of said cylinder with the pipe 258.

From the foregoing it will be understood that when the valves 160 and 162 are simultaneously shifted from the neutral position shown in Figure 16 to the position shown in Figure 17, the actuators 56 and 86 will be operated so as to cause the rapid approach of the front tool 54

and the rear tool 82 toward the work piece. During this operation, fluid such as oil, passes outwardly through a single port, namely, the port 214, Figure 17, through the pipe 228 and into the cylinder 58, Figure 16. The fluid from the opposite end of the cylinder is forced through the action of the piston 60 through the pipe 230, the check valve 232, the pipe 234, and the pipe 240 into the rear extremity of the cylinder 88, thereby causing the forward movement of the piston 90. That is to say, the rapid approach of the rear tool carriage is effected by the rapid approach of the front carriage actuator. By having the proper relationship in size of the bores in the cylinders 58 and 88, any predetermined movement of the piston 90 may be obtained by a corresponding movement of the piston 60. In other words, if the cylinder bores are equal in size, the movement imparted to the piston 90 will be equal to the movement experienced by the piston 60. However, if the cylinder bore 88 is larger in diameter than the bore of the cylinder 58, the degree of movement of the piston 90 will be less than the movement of the piston 60. Thus, it will be apparent that by employing the teachings of my invention the degree of movement of one piston may be very accurately controlled by the movement of another piston.

In machines heretofore equipped with a plurality of actuators, the problem of accurately controlling the movement of these actuators has presented itself. In such conventional machines it requires very accurate adjustment between each actuator to enable the starting of cutting tools simultaneously. In my above mentioned co-pending applications I have disclosed a needle valve arrangement for controlling the load between the actuators, and it will be observed that by providing the circuit shown in the present application I do not depend on this needle valve arrangement for controlling both of the actuators 56 and 86 during the rapid approach movement. This is due to the fact that the actuator 86 is operable directly in response to the operation of the actuator 56.

As just described, the shifting of the valves 160 and 162 to the left causes the simultaneous rapid traverse of the tools 54 and 82 toward the work piece. The hydraulic clutch actuating mechanism 238 which is connected with the pipes 234 and 240 is also actuated during this interval. The piston 250 thereof is urged to the left, Figure 16, thereby connecting the main rear drive shaft 42 with the work spindle 36. The actuation of the hydraulic mechanism 238 may be timed so that the work spindle 36 begins to rotate and thereby actuates the plunger pumps 94 and 94a just as the front and rear tool carriages reach the limit of their rapid traverse movement toward the work piece. At this instant the valve members 160 and 162 are returned to the neutral position shown in Figure 16, and the rotary valve 262 is shifted so as to establish communication between the pipes 260 and 264. It will then be apparent that the plunger pumps 94 and 94a deliver fluid at high pressure to the actuators 68 and 86. Under these conditions the pump 94 is connected within a closed circuit which includes the pipe 138, the actuator 86, and the pipe 124, while the pump 94a is included within a closed circuit which includes the pipe 258, the actuator 68, the pipe 260, and the pipe 264.

When the tool carriages reach the limit of their advancing feeding movement, the valve members 160 and 162 are moved to the rapid traverse reverse position shown in Figure 18. When the valve members are shifted to this position the hydraulic clutch actuating device 238 is automatically operated so as to disconnect the work spindle 36 from the drive shaft 42, thereby interrupting the actuation of the plunger pumps. Fluid from the low pressure gear pump 150 is then directed from the pipe 152 through the valve port 154 and into the passage 192. The lateral passage 226 of the valve member 162 directs a portion of this fluid through the valve port 216, and thence outwardly through a pipe line 270 which is connected to the left end of the cylinder 70 through the pipe 260, Figure 16. This causes rapid reverse movement of the piston 72, and fluid from the advancing side of the piston is returned to the valve mechanism through a section of the pipe line 258, the pipe 268, and the pipe 228, said latter pipe connecting with the valve port 214. At this instant the valve port 214 communicates with the low pressure chamber 204 of the valve mechanism, Figure 18. At the same instant the remaining portion of the fluid from the passage 192 is conducted by a lateral port or passage 272 to the valve port 212 which connects with the pipe 242. Low pressure fluid is thus introduced within the rear carriage cylinder 88 so as to impart rapid reverse movement to the piston 90. Fluid from the advancing side of the piston 90 passes through the pipe 240, the actuator 238, and thence through a pipe 274 which connects with the valve port 210. This valve port 210 like the valve port 214 is connected with its companion low pressure chamber 200.

Attention is directed to the action which takes place at the instant the control valve is shifted to its rapid reverse position. At this time both the rear and front tools are operatively engaging the work piece. Due to the fact that the front carriage is mounted upon the oscillatory bar 48, the weight of the carriage will cooperate to reduce the power necessary to swing the tool 54 out of engagement with the work piece the instant that the control valve is thrown into reverse. In other words, the mechanical arrangement of the front carriage is such as to set up less resistance to reverse fluid action than the rear carriage. The rear tool, due to the mechanical load placed on the rear tool slide as a result of the connection which it makes with the automatic control slide, later to be described, and due to the fact that it is horizontally slidable will remain in contact with the work piece long enough to complete its cut and will not return until the rotation of the work spindle has been completely arrested. It will be noted that the work spindle in the disclosed lathe rotates in a direction which is opposite to the rotation of spindles in conventional types of lathes.

Automatic control mechanism

I shall now proceed to describe the means for automatically controlling the actuation of the valve members 160 and 162, as well as the rotary valve member 262. This mechanism includes a slide 276, Figures 1 to 4 inclusive, which is shiftable along the upper surface of the machine base 30 at the front side of the machine. A rack 278 secured to the underside of the slide 276 is driven from a pinion 280 mounted upon a shaft 282. This shaft carries a bevel gear 284 at its opposite extremity which meshes with a companion gear

286 on a shaft 288. Rotation is imparted to this shaft 288 through the agency of a gear 290 which meshes with a rack bar 292 secured to the underside of the rear carriage slide 78, Figure 3. Thus, when the rear tool carriage is reciprocated toward and away from the work piece, movement is imparted to the slide 276. This slide carries a plurality of dogs 294, 296, 298, 300, and 302. In the drawings the slide 276 is disclosed in the position which it occupies when the valve members 160 and 162 are in neutral position. The shifting of the valve members 160 and 162 to the left is occasioned by moving the control handle 158 to the right, Figures 1 and 2. This imparts a clockwise movement to the shaft 178, Figure 4, thereby causing the finger 186 to be swung downwardly. The shifting of the valve members to this rapid approach position causes the forward movement of the rear tool slide 78, as above set forth, and the actuation of this slide causes the slide 276 to be urged to the right, Figures 2 and 4. The dog 298 is so positioned on the slide that when it reaches the finger 186, the lathe tools will have been moved to their work engaging position in readiness to perform a cutting operation upon the work piece. The engagement of the dog 298 with the finger 186 causes the valve members 160 and 162 to be shifted to the neutral position shown in Figure 16. Simultaneously with the actuation of the valve members 160 and 162, or at any other desired interval, the dog 302 is carried into engagement with a finger 304 which is carried upon a shaft 306 extending inwardly from and secured to the rotary valve 262, Figures 4 and 5. This causes the valve 262 to be shifted from the position shown in Figure 5 in a counter-clockwise direction so as to establish communication between the pipes 260 and 264 through a valve passage 262a. The shifting of the valve 262 renders the closed circuit, which includes the pump 94a, functionally operative so as to effect the feeding movement of the piston 72 to the left, Figure 16. Thus it will be apparent that the dog 302 may be adjustably located upon the slide 276 so as to cause the actuation of the valve 262 at any desired interval of the cycle of operation.

The longitudinal feeding movement of the tool 54, as well as the transverse feeding of the tool 82, continues until the dog 294 carried at the advancing extremity of the slide 276 is moved into engagement with the free extremity of a pivoted finger or lever 308 of the balancing mechanism 172. The inner extremity of the finger 308 is pivotally connected to a shank 310, which is provided with a head 312 at its inner extremity. This head 312 is provided with longitudinal passageways 314, and when said head occupies the position shown in Figure 8, it serves to close communication between a valve chamber 316 and an annular port 318. This annular port 318 has an unrestricted connection with the reservoir 146 through a passageway 320, Figure 7, and a pipe 322, Figures 7 and 16. The engagement of the dog 294 with the finger 308 causes the head 312 to be shifted to the position shown in Figure 11, thereby uncovering the annular port 318 and thus connecting the chamber 316, as wall as a corresponding valve chamber 316a, with the reservoir 146. This causes an unbalancing of the fluid pressures upon the valve members 160 and 162 due to the fact that the fluid from the valve chambers 316 and 316a is now free to flow back to the reservoir 146. The pressure at the opposite extremities of the valve members causes the same to be automatically urged to the right, to the position shown in Figure 18. During this movement to the right the head 312 is engaged by the valve member 160, thereby causing said head to again close communication between the chamber 316 and the reservoir.

The sudden automatic reversal of the valve members causes fluid to be urged in a reverse direction to the actuators 68 and 86 as above described, thereby imparting a rapid reverse movement thereto. As the slide 276 moves to the left, the dog 296 eventually engages the finger 188, Figures 2 and 4, thereby causing the valves 160 and 162 to be shifted to neutral position. This shifting of the valve members takes place when the tool carriages have reached their initial or starting position. During the shifting of the slide 276 to the left, the dog 300 is also moved into engagement with a finger 324 of the valve mechanism 262, thereby automatically shifting said valve to the position shown in Figure 5. In this position communication is interrupted between the pipes 260 and 264, Figure 16, thereby rendering the closed circuit, including the plunger pump 94a, functionally inoperative until a second cycle of operation takes place, at which time the dog 302 causes the shifting of the valve 262 as above described. In order to more positively assure the proper positioning of the valve member 262, I provide a spring pressed plunger 262b, Figure 5, which is designed to co-operate with companion notches formed in the valve member 262.

Modified valve

Referring to Figures 19 to 24 inclusive, it will be seen that I have disclosed a modified valve construction, which is indicated generally by the numeral 156a. This mechanism 156a includes a valve casing 326, which slidably houses a single valve member 328. When this valve member 328 occupies the neutral position shown in Figures 20 and 21, fluid from the low pressure pipe line 152 passes through an annular valve port 330 and thence through radial ports 332, which communicate at their inner extremity with a central valve passage 334. The left end of this valve passage 334 communicates with a valve chamber 336, which communicates with the reservoir 146 through the pipe 206 in the manner previously described in connection with the valve mechanism 156. Thus, fluid circulates through the valve mechanism 156a when the valve member 328 occupies the position shown. However, when the valve member is shifted to the left (rapid approach position) in the manner described in connection with the valve mechanism 156, communication is interrupted between the radial ports 332 and the annular port 330. In this position the annular port 330 communicates with a lateral valve port 338, Figure 21, which communicates with a port 214a which corresponds to the port 214 of the valve 156. This port 214a may be connected with the actuator 56 by the pipe 228. It will be noted that in this shifted position of the valve member 328, a valve port 210a, which corresponds to the port 210 of the valve mechanism 156, is closed by a section 218a of the valve. In this rapid approach position a return valve port 212a, which corresponds to the port 212, permits the return of fluid from the pipe 242, which is directed through the longitudinal valve passage 334.

When the valve member 328 is automatically shifted to its rapid reverse position, said valve serves to permit the discharge of low pressure fluid through the ports 212a and 216a and the return of fluid

through the ports 210a and 214a. Thus, the single valve mechanism 156a corresponds in functional characteristics to the double valve mechanism 156 in that the rapid approach position of said mechanisms causes low pressure fluid from a single source of supply to be directed through a single valve port to a fluid actuator, which actuator in turn controls the functioning of a second actuator. Also, when said mechanisms occupy their rapid reverse position, fluid from said single source of supply is received through a plurality of ports and directed to a plurality of actuators for the purpose of rapidly shifting said actuators. One of the advantages resulting from the use of the double type valve mechanism 156 resides in the fact that any variation in pressure of the circuit controlled by one of the valve members will not affect the other valve member. It should be noted that the valve mechanism 156a is connected with two independent feeding circuits, while in the double type mechanism 156, the valve member 160 is connected with one of the circuits, and the valve member 162 is independently connected with another circuit.

Check valve

Particular attention is directed to the structure of the check valve 232, Figures 15 and 16. This valve includes a casing 340, one extremity of which is connected to the pipe 230 and the other to the pipe 234. A sleeve 342 is secured against longitudinal displacement within the casing 340 by means of a key 344, and longitudinally slidable within the sleeve 342 is a plunger 346. This plunger is urged downwardly within the casing 340 through the action of a coil spring 348 which is interposed between the plunger and a removable cap or plug 350. A central passageway 352 in the plunger receives fluid from the pipe 230, and this fluid is directed into radial ports 354. If the fluid from the pipe 230 is of sufficient pressure to overcome the action of the spring 348, the plunger 346 will be urged upwardly, and when radial ports 354 thereof are carried into communication with an annular passage 358, fluid from said annular passage 358 will flow into the pipe 234. This check valve is of improved practical construction and is particularly adaptable for use in connection with the fluid circuit described above. The check valve differs from the common forms of check valve in that a certain movement of the plunger thereof must take place before fluid will be directed from the pipe 230, to the pipe 234. It will also be observed that my improved check valve is completely sealed against leakage.

Summary

From the foregoing it will be apparent that my invention contemplates the provision of a metal working machine and a hydraulic actuator system in combination therewith, which is of improved practical design. Practical tests have shown that my improved circuit arrangement enables a plurality of machine tools to be very accurately and positively controlled. In the first place, by having one actuator directly responsive to another actuator, both of said actuators will begin movement simultaneously regardless of the load on the carriages. In the second place, the degree and speed of movement of these carriages are accurately controlled. In fact, the starting of the cutting action of a plurality of tools can be controlled with extreme accuracy, and these results are obtained without the necessity of employing auxiliary mechanisms. Furthermore, it is only necessary to employ a single source of fluid supply. It will be apparent that my invention provides a hydraulic actuator system, wherein fluid from a single source of supply is directed through a single valve to a single actuator, which actuator causes the movement of a second actuator. It will also be seen that the second actuator is connected with a control mechanism which timingly regulates the starting and stopping, as well as the speed of operation of both of said actuators. The type of control valve which I have described, presents a marked improvement over types which have been employed heretofore, in that the mechanism is self-contained. All of the shiftable parts are housed within a single casing, and the mechanisms for imparting movement thereto, namely, the shaft 178 and associated parts, Figure 6, are mounted within one extremity of the casing. The valve members are simple in construction and hence may be economically produced.

I have shown the pistons of the various actuators equipped with piston rods which extend on both sides thereof, so that equal volumes of fluid will be taken into and discharged from opposite sides of the pistons. Obviously this specific piston and piston rod construction is not necessary in instances where suitable vents or bleed passages are employed, such as those disclosed in one of my above mentioned co-pending applications. However, by using the type of construction shown in Fig. 16, I present a closed circuit arrangement whereby the same volume of fluid discharged by the high pressure pump to one side of the actuator piston, is received by said pump from the opposite side of said piston. In other words, the volume of fluid discharged from the advancing side of the actuator piston is just sufficient to charge the plunger pump. In view of the fact that I employ the type of plunger pump shown in detail in Figures 12 and 13, it is possible to eliminate the use of relief valves across the closed circuits. If an actuator piston, as for example, the piston 90 is suddenly interrupted in its movement, the plunger pump 94 is rendered functionally inoperative until the obstacle which causes the interruption of the piston movement, is removed. In other words, if the advancing end of the piston 90 is carried into contact with either end of the cylinder 88 and the spindle 36 continues to rotate, the sudden engagement of the piston will automatically render the pump 94 functionally inoperative. That is to say, the rotary mechanism within the pump will actuate without effecting reciprocation of the pump pistons.

It should also be noted in connection with my improved type of check valve, that it differs from conventional construction, in that, when pressure on the opposite sides of my valve is neutralized, the plunger of the valve will experience no movement, due to the fact that the spring is urging said plunger against the valve seating.

In conventional types of check valves, when the pressure on the opposite sides thereof, is equalized, said valves will not prevent the flow of fluid therethrough. However, in my invention, the flow of fluid from one side of the valve to the other, is positively prevented when the fluid pressure on the opposite sides thereof, is neutralized.

By having the rear carriage 78 coupled with

the dog carrying slide 276 through the agency of the rack 292, gear 290, shafts 288, 282, etc., said rear carriage is under a greater load during reversal than the front carriage 46. In other words, the front carriage 46 merely reverses along the bar 48 with very little frictional resistance to overcome whereas the rear carriage not only experiences the friction set up by the engagement of the slide or carriage 78 on the guide frame 80, but all the resistance or load which is established by the mechanism which connects the slide 276 with the rear carriage. With such a constructon, it will be apparent that under fluid pressure the front carriage will reach its starting position before the rear carriage. In this way I am able to accurately control the functioning of the control valve by the carriage which is normally under the greatest load during reversal, a condition which is most advantageous in using hydraulic circuits of the type described and claimed herein. Attention is also directed to the fact that in my machine the reservoir 146 is always positioned above the hydraulic actuators so as to preclude the entrance of air within the system.

While I have disclosed my invention as applied to an automatic lathe construction, it should be understood that said invention is by no means limited to such devices, but is capable of being used in any instance where it is desirable to accurately control the shifting of a plurality of actuators. Therefore my invention should be limited only by the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a hydraulic actuator system, a plurality of fluid operated actuators connectable with machine parts and the like, means for supplying fluid under pressure to one of said actuators for imparting movement thereto, means connecting said last mentioned actuator with a second actuator, whereby said first actuator serves to control the operation of said second actuator and thereby effect simultaneous action of said actuators irrespective of the resistance experienced by said actuators, and control mechanism for timingly governing the direction and extent of movement of said actuators with respect to each other.

2. In a hydraulic actuator system, a plurality of fluid operated actuators, each of said actuators including a cylinder and a piston reciprocable therein, means for supplying fluid under pressure to one of said actuators for effecting the shifting thereof, a duct connecting said last mentioned actuator with a second actuator, whereby fluid may be forced from said first actuator to effect the shifting of said second actuator, and control means for receiving fluid from said fluid supplying means and directing said fluid to at least one of said actuators in accordance with the desired direction of movement with respect to each other.

3. In combination with a plurality of shiftable machine elements, a fluid operated actuator for each of said elements, means for supplying fluid under pressure to one of said actuators to effect the movement of the machine element associated therewith, a duct for directing fluid from said last mentioned actuator to a second actuator, whereby said first actuator will control the actuation of said second actuator and thereby effect simultaneous action of said actuators irrespective of the resistance experienced by said actuators, and control mechanism for timingly governing the direction and extent of movement of said actuators with respect to each other.

4. In a hydraulic actuator system, a plurality of fluid operated actuators, fluid propelling means for supplying fluid under pressure to one of said actuators, means for conducting fluid from said last mentioned actuator to a second actuator, whereby the movement of the first actuator will effect the actuation of the second actuator, thereby causing the speed and starting of said second actuator to be accurately governed by fluid displaced from the advancing side of the first actuator, means for controlling the effective connection of the fluid propelling means with said first mentioned actuator, and means operatively coupling said control means with one of said actuators whereby said control means is governed in response to the actuation of one of said actuators.

5. In a hydraulic actuator system, a plurality of fluid operated actuators, fluid propelling means for supplying fluid under pressure to one of said actuators, means for conducting fluid from said last mentioned actuator to a second actuator, whereby the movement of the first actuator will effect the actuation of the second actuator, a shiftable valve mechanism for controlling the connection of the fluid propelling means with said first actuator, and means for operatively connecting said valve mechanism with one of said actuators whereby said valve mechanism is shiftable in response to the actuation of one of said actuators.

6. In combination with a plurality of shiftable tool carrying devices, a fluid operated actuator associated with each of said tool carrying devices, means for delivering fluid under pressure to the actuator associated with one of said tool carrying devices, a duct connecting said last mentioned actuator with the actuator of a second tool carrying device, whereby the speed of travel of said second tool carrying device is controlled in accordance with the displacement of fluid from the advancing side of the actuator associated with said first tool carrying device to thereby accurately govern the degree of movement of said second actuator, and fluid control means associated with one of said actuators whereby to initiate a change in the rate of fluid delivery after a predetermined amount of fluid has been displaced from the advancing side of the first actuator.

7. In a hydraulic system of control, a pump, a shiftable valve having a plurality of inlet and outlet ports, a plurality of fluid operated actuators, ducts connecting said shiftable valve with said actuators, said valve being adapted in one shifted position to receive fluid from said pump, direct said fluid to one of said actuators, and to receive fluid from a second of said actuators, said valve being shiftable in timed relation with the movement of one of said actuators and a duct connecting said first actuator with said second actuator, whereby said first actuator is adapted to hydraulically control said second actuator.

8. In a hydraulic system of control, a plurality of fluid operated actuators, means for supplying fluid under pressure, a valve mechanism connected with said fluid supplying means, said valve mechanism having a plurality of ports and shiftable to at least two positions in timed relation with the movement of one of said actuators ducts connecting said valve with said actuators, said valve in one shifted position be-

ing adapted to direct fluid from said supplying means to one actuator and to receive fluid from another actuator, and connecting means for rendering said last mentioned actuator operable in response to the actuation of said first mentioned actuator.

9. In a hydraulic system of control, a plurality of fluid operated actuators, means for supplying fluid under pressure, a valve mechanism connected with said fluid supplying means, said valve being shiftable to at least three positions and having a plurality of outlet and inlet ports, ducts connecting said valve with said actuators, said valve in one position interrupting communication between the supplying means and said actuators, and in a second shiftable position adapted to supply fluid to one of said actuators and receive fluid from another of said actuators, and a duct connecting said first actuator and said second actuator, whereby movement of said second actuator is occasioned in response to movement of said first actuator, said valve in a third shifted position being adapted to deliver and receive fluid from a plurality of said actuators.

10. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, means for supplying fluid under pressure, and a reservoir, a valve mechanism including a valve member shiftable to at least two positions, a port in said valve mechanism which is adapted, when the valve member is shifted to one position, to direct fluid under pressure to one of said actuators, and a second port for contemporaneously receiving fluid from another of said actuators and, for directing said fluid to said reservoir, said valve being adapted in another shifted position to direct fluid under pressure to a plurality of said actuators and to receive fluid from said actuators.

11. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, a pumping means, and a fluid reservoir, a valve mechanism having a valve member shiftable to various positions and having a plurality of inlet and outlet ports connectable with said actuators, said valve in one shifted position being adapted to receive fluid from said pump and dispatch said fluid to the reservoir, and in a second position to dispatch fluid under pressure to a single actuator and receive fluid from another single actuator, and in a third position to dispatch fluid to a plurality of actuators and receive fluid from a plurality of actuators.

12. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, a pump for supplying fluid under pressure, and a reservoir, a valve mechanism including a plurality of valve members shiftable within a casing, said mechanism being hydraulically connectable with the pump and said actuators, one of said valve members being adapted in one shifted position to direct fluid under pressure to a single actuator, and the other valve member being adapted the same instant to receive fluid from another actuator, said valve members in a second shifted position being adapted to dispatch fluid under pressure to a plurality of said actuators and to receive fluid from a plurality of said actuators.

13. In combination with a plurality of shiftable tool carrying devices, a fluid operated actuator associated with each of said tool carrying devices, a pump for supplying fluid under pressure, a valve for controlling the delivery of said fluid under pressure to a first of said actuators, fluid conducting means for effecting the starting and speed of a second of said actuators in response to the actuation of said first mentioned actuator, and means operable in response to the actuation of said second actuator for controlling the actuation of said valve.

14. In combination with a plurality of shiftable tool carrying devices, a fluid operated actuator associated with each of said tool carrying devices, a pump for supplying fluid under pressure, a valve for controlling the delivery of said fluid under pressure to one of said actuators, fluid conducting means for effecting the starting and speed of a second of said actuators in response to the actuation of said first mentioned actuator, and a member shiftable in response to the actuation of one of said actuators for controlling the actuation of said valve.

15. In a hydraulic actuator system, a plurality of fluid operated actuators, a machine element connected to each of said actuators and shifted thereby, pump means for supplying fluid under pressure, a valve for directing fluid under pressure to one of said actuators, a duct connecting said last mentioned actuator with a second actuator, whereby the speed of said second actuator is controlled by the fluid displaced from said first actuator, rotary work carrying means, driving means therefor, and means operable in response to one of said actuators for controlling the connection between the work carrying means and said driving means.

16. In a hydraulic actuator system, a plurality of fluid operated actuators, a machine element driven by each actuator, a single pumping mechanism for supplying fluid under pressure, a unitary valve mechanism for directing fluid under pressure to one of said actuators, means connecting said actuator with a second actuator, whereby to control the starting and speed of said second actuator, and means operated in timed relation with one of said actuators for controlling the actuation of said unitary valve mechanism.

17. In combination with a plurality of shiftable tool carriages, a fluid operated actuator connected with each tool carriage, a single source of fluid pressure supply effectively connectable with one of said actuators, a second of said actuators being connected with and operated by said last mentioned actuator, and means operated by one of said actuators for controlling the delivery of fluid from said single source of supply to another actuator.

18. In a material working apparatus of the class described, a plurality of shiftable machine elements, a fluid operated actuator connected with each element, a constantly driven large displacement pumping mechanism for supplying fluid under pressure, a valve mechanism for controlling the delivery of fluid from said constantly driven pumping mechanism to a first of said actuators, a duct connecting said last mentioned actuator with a second actuator, whereby the second actuator is driven by said first actuator, and a high pressure fluid propelling means connectable with one of said actuators for propelling said actuators at different speed.

19. In a hydraulic actuator system, a plurality of fluid operated actuators connectable with machine parts and the like, means for supplying fluid under pressure to a first of said actuators for imparting movement thereto, means connecting said last mentioned actuator with a second of said actuators, whereby said first actuator serves to

control the operation of said second actuator and travels simultaneously with said second actuator, means connecting said fluid supplying means with another of said actuators, and control mechanism for timingly governing the direction and extent of movement of said actuators.

20. In combination with a plurality of shiftable machine elements, a fluid operated actuator for each element including a piston within a cylinder, means for supplying fluid under pressure to one side of the piston in one of said actuators to effect the movement thereof in a given direction, a duct for directing fluid from the discharge side of said piston to the cylinder of a second actuator, whereby the movement of said second actuator will be controlled in response to the movement experienced by said first mentioned actuator, fluid conducting means connecting said fluid supplying means with another of said fluid operated actuator, and control mechanism for timingly governing the direction and extent of movement of said actuators.

21. In a hydraulic actuator system, large delivery pumping means for supplying fluid under low pressure, a fluid operated actuator, a valve mechanism for controlling the effective connection between said pumping mechanism and said actuator, a second fluid operated actuator, a duct connecting said first actuator with said second actuator, whereby the movement of said second actuator is controlled in response to the movement of the first actuator, a third actuator connectable with said source of low pressure fluid supply, a high pressure pumping mechanism connected with said second fluid operated actuator and a high pressure pumping mechanism connected with said third fluid operated actuator, the low pressure fluid serving to impart rapid traverse to said actuators, and the high pressure fluid serving to impart feeding movement to said actuators.

22. In material working apparatus of the class described, a plurality of fluid operated actuators, machine elements connected with said actuators and driven thereby, a single source of low pressure large displacement fluid supply, a valve mechanism for controlling the delivery of fluid from said source of supply to one of said actuators, means connecting said actuator with a second actuator, whereby fluid from the first actuator may be forced toward the second actuator for shifting same, a high pressure fluid displacing means connected with said second actuator, driving means for said high pressure fluid displacing means, and means for controlling the connection between said driving means and said high pressure displacing means, said controlling means operating to disconnect the driving means during the displacement of the low pressure fluid to said actuators.

23. In material working apparatus of the class described, a machine frame, rotary supporting means, an oscillatory and reciprocable tool support, a second reciprocable tool support, a fluid operated actuator connected with each tool support, means for supplying fluid under pressure to one of said actuators, means connecting said last mentioned actuator with the second actuator, whereby the movement of the second actuator is controlled by said first actuator, and means operable by the tool support associated with one of said actuators for controlling the connection between the source of fluid supply and said first actuator.

24. In material working apparatus of the class described, a tool supporting means, a bar providing an oscillatory support for said tool supporting means and adapted to reciprocate said tool supporting means longitudinally, a hydraulic actuator for effecting the oscillation of said tool supporting means, a second shiftable tool supporting means, a fluid operated actuator connected therewith, said last mentioned actuator being hydraulically connected and driven by said first mentioned actuator, and a source of fluid supply connectable with said first mentioned actuator.

25. In a hydraulic actuator system, a fluid operated actuator including a piston within a cylinder, a conduit having one end connected with one side of said cylinder, a pumping mechanism having the intake side connected with the opposite end of said conduit, and a second conduit extending from the discharge side of said pumping mechanism to the other side of said cylinder, the fluid discharged by one side of the piston being equal in volume to the fluid received on the opposite side of said piston and being sufficient to charge said pumping mechanism.

26. In a hydraulic actuator system, a fluid operated actuator including a piston within a cylinder, a conduit having one end connected with one side of said cylinder, a variable displacement pumping mechanism having the intake side connected with the opposite end of said conduit, and a second conduit extending from the discharge side of said variable displacement pumping mechanism to the other side of said cylinder, the fluid discharged by one side of the piston being equal in volume to the fluid received on the opposite side of said piston and being sufficient to charge said variable displacement pumping mechanism.

27. In a hydraulic actuator system, a fluid operated actuator including a cylinder, a piston therein, said piston having a piston rod section of equal size extending on opposite sides thereof, whereby fluid taken into one side of the cylinder will be equal in volume to the fluid discharged from the opposite side of said cylinder, a duct connected at one end to one side of said cylinder, a variable displacement pump having its intake side connected to the opposite end of said duct, and a second duct extending from the discharge side of said variable displacement pump to the other side of said cylinder, the fluid discharged from the side of the actuator being sufficient to charge said plunger pump.

28. In a material working apparatus of the class described, a shiftable machine element, a fluid operated actuator for shifting said element, said actuator including a piston within a cylinder, the volume of fluid adapted to be taken into one side of said cylinder being equal to the amount capable of being discharged at the opposite side of said cylinder, a duct connected at one end to one side of said cylinder, a variable displacement pump having its intake side connected to the opposite end of said duct, and a second duct extending from the discharge side of said pump to the other side of said cylinder, whereby fluid from the discharge side of said actuator serves as the sole charging fluid for said variable displacement pump.

29. In a hydraulic actuator system, a fluid operated actuator including a cylinder and a piston within said cylinder, a variable displacement pump, a closed duct connecting one side of said cylinder with the intake side of said pump, a closed duct connecting the discharge side of said pump with the other side of said cylinder, where-

by to present a closed fluid circuit, and a second fluid operated actuator connectable in series with the first mentioned actuator.

30. In a hydraulic actuator system, a plurality of fluid operated actuators, each of said actuators including a cylinder and a piston therein, means for supplying fluid under pressure to one of said actuators for effecting the shifting thereof, a duct connecting said last mentioned actuator with a second actuator, whereby fluid may be forced from said first actuator to effect the shifting of said second actuator, and a valve in said duct to prevent the reversal of flow of fluid into said first mentioned actuator.

31. In combination with a hydraulic circuit including a plurality of hydraulic actuators for propelling machine parts and the like, fluid conducting means connecting a pair of said actuators comprising a check valve including a casing, means at one end of said casing for connection with said circuit, means at the opposite end of said casing for connection with said circuit, and a shiftable member within said casing which is adapted upon being shifted a predetermined amount to establish communication between the opposite ends of said casing.

32. In combination with a hydraulic circuit including a plurality of hydraulic actuators for propelling machine parts and the like, fluid conducting means connecting a pair of said actuators comprising a check valve including a casing, means at one end of said casing for connection with said circuit, means at the opposite end of said casing for connection with said circuit, a shiftable member within said casing which is adapted upon being shifted a predetermined amount to establish communication between the opposite ends of said casing, and resilient means for urging said shiftable member in a given direction.

33. In combination with a hydraulic circuit including a plurality of hydraulic actuators for propelling machine parts and the like, fluid conducting means connecting a pair of said actuators comprising a check valve mechanism including a casing, a plunger within said casing, cooperative ports adapted to establish communication between opposite ends of the casing when said plunger has been shifted a predetermined amount, and resilient means for urging said plunger in a given direction.

34. In combination with a hydraulic circuit including a plurality of hydraulic actuators for propelling machine parts and the like, fluid conducting means connecting a pair of said actuators comprising a check valve mechanism including a casing having an intake port at one end thereof and a discharge port at the other end thereof, a plunger reciprocable within said casing, said plunger having a longitudinal passage and a radial port communicating therewith, and resilient means for urging said plunger toward one extremity of said casing.

35. In a hydraulic system for controlling a plurality of fluid operated actuators, a fluid pump mechanism for propelling one of said actuators at a feeding rate, a second fluid pumping mechanism for propelling another of said actuators at a feeding rate, a third fluid pumping mechanism for propelling said actuators at rapid traverse speed, one of said actuators being controlled directly in response to another of said actuators, a valve mechanism for selectively controlling the delivery of fluid from said pumping mechanism to said actuators, a member mechanism driven by one of said actuators, means on said member for timingly controlling the actuation of said valve mechanism, a second valve mechanism for independently controlling the fluid in connection with one of said actuators, and means on said member for timingly actuating said second valve mechanism.

36. In a hydraulic system for controlling a plurality of fluid operated actuators, a fluid pump mechanism for propelling one of said actuators at a feeding rate, a second fluid mechanism for propelling another of said actuators at a feeding rate, a third fluid pumping mechanism for propelling said actuators at rapid traverse speed, a valve mechanism for selectively controlling the delivery of fluid from said pumping mechanism to said actuators, a member mechanism driven by one of said actuators, means on said member for timingly controlling the actuation of said valve mechanism, a rotary valve mechanism for independently controlling the fluid in connection with one of said actuators, and means on said member for timingly actuating said rotary mechanism.

37. In a hydraulic valve mechanism for controlling the operation of a plurality of fluid operated actuators, including a casing, a plurality of shiftable valve members in said casing, arranged in substantial parallelisms, and means for connecting and disconnecting said valve members, whereby to render the same operable independently and also shiftable as a unit within said casing.

38. A valve mechanism for controlling the operation of a plurality of fluid operated actuators including a casing, a valve member shiftable to at least two positions in said casing, a port in said valve mechanism adapted when the valve member is shifted to one position, to direct fluid to a selected actuator, and a second port for contemporaneously receiving fluid from another actuator, said valve having a plurality of ports whereby when occupying another shifted position, said valve serves to contemporaneously direct fluid to a plurality of said actuators and to receive fluid from said actuators.

39. A system of hydraulic control including a plurality of hydraulic actuators, a relatively high pressure pumping mechanism, a second lower pressure pumping mechanism for propelling said actuator at a relatively rapid rate, shiftable control mechanism adapted in one shifted position to direct fluid from said high pressure pumping mechanism to one of said actuators independently of said second mentioned pumping mechanism, and fluid conducting means connecting a pair of said actuators, whereby the movement of one actuator is controlled by the fluid displaced from the other actuator.

40. A system of hydraulic control including a plurality of hydraulic actuators, a relatively high pressure feeding pump, a low pressure rapid traverse pump, control mechanism for rendering the rapid traverse pump functionally inoperative for propelling purposes with respect to at least one of said actuators during the functioning of the high pressure pump, and fluid conducting means extending between a pair of said actuators, whereby the movement of one actuator is controlled in accordance with the displacement of fluid from the other.

41. In a hydraulic actuator system for moving machine parts and the like, a plurality of hydraulic actuators connectable with said machine parts, each of said actuators including a piston

within a cylinder, fluid propelling means for imparting feeding movement to at least one of said actuators, a second fluid propelling means for imparting rapid traverse movement to at least one of said actuators, a valve for cutting off said second mentioned propelling means during the operative functioning of the other propelling means, and fluid conducting means extending between a pair of said actuators, whereby the movement of one actuator will control the movement of the other actuator in accordance with the displacement of fluid from one actuator to the other.

42. In material working apparatus of the class described, a prime mover, a hydraulic actuator including a piston within a cylinder, fluid propelling mechanism driven in timed relation with said prime mover and adapted to impart a linear speed to the actuator piston which is constantly proportional to the speed of travel of said prime mover, means connecting said fluid propelling mechanism with said hydraulic actuator, a second hydraulic actuator including a piston within a cylinder, and fluid conducting means extending between said actuators, whereby one actuator serves as an impeller for the other actuator.

43. In material working apparatus of the class described, a prime mover, a hydraulic actuator including a piston within a cylinder, fluid propelling mechanism driven in timed relation with said prime mover and adapted to impart a linear speed to the actuator piston which is constantly proportional to the speed of travel of said prime mover, means connecting said fluid propelling mechanism with said hydraulic actuator, means for imparting rapid movement to said actuator, a second hydraulic actuator including a piston within a cylinder, and fluid conducting means extending between said actuators, whereby one actuator serves as an impeller for the other actuator.

44. In material working apparatus of the class described, a frame, a spindle rotatably mounted in said frame, a tool carriage shiftable transversely of the spindle, a fluid actuator for moving said carriage, a variable displacement pump driven from the spindle for propelling said actuator, a second oscillatory carriage for moving a tool toward and away from the axis of the spindle and for moving said tool longitudinally of said spindle, a fluid actuator for longitudinally shifting said second carriage, a second variable displacement pump driven from said spindle for moving said second actuator, a third fluid operated actuator for shifting said carriage toward the spindle axis, means for imparting rapid traverse to said actuators, and means for selectively controlling the operative functioning of the variable displacement pumps and the means for imparting rapid movement to said actuators.

45. In a hydraulic actuator system for controlling the movement of and for actuating machine parts and the like, a plurality of hydraulic actuators, each including a piston within a cylinder, fluid propelling mechanism for delivering fluid under relatively high pressure for feeding purposes, a second fluid propelling mechanism for delivering fluid under lower pressure for rapid traverse purposes, a shiftable valve means including a plurality of valve members shiftable as a unit within a casing for selectively controlling the delivery of fluid from the low pressure fluid propelling means for rapid traverse purposes to said actuators, said valve means serving in one shifted position to operatively connect the low pressure propelling mechanism with the actuators and in another shifted position to render said propelling mechanism functionally inoperative for propelling purposes.

46. In a hydraulic actuator system for moving machine parts and the like, a plurality of hydraulic actuators each including a piston within a cylinder, a feed pump, a rapid traverse pump, a fluid reservoir connected with said rapid traverse pump, and shiftable means including a plurality of valve members shiftable as a unit within a casing for controlling the operative functioning of said pumps with respect to the actuators, said valve members being adapted in one shifted position to direct fluid discharged by said rapid traverse pump to the reservoir independently of the fluid discharged by the feed pump and in another shifted position serving to deliver fluid discharged by the rapid traverse pump for rapid traverse purposes to said actuators.

47. In a hydraulic actuator system for moving machine parts and the like, a plurality of hydraulic actuators each including a piston within a cylinder, a feed pump, a rapid traverse pump, a control device including a plurality of valve members shiftable within a casing, said valve members adapted to occupy one of at least three positions, namely, a neutral position, a forward position, and a reverse position, means connecting said valve members with said rapid traverse pump, said valve members being adapted in their neutral position to effect the circulation of fluid from said rapid traverse pump independently of the fluid discharged by the feed pump, the forward shifted position of said valve members serving to operatively connect said rapid traverse pump with said actuators and the reverse shifted position of said valve serving to direct fluid in a reverse direction to said actuators, and means for rendering the feed pump functionally inoperative during the operative functioning of said rapid traverse pump.

48. In a hydraulic actuator system for controlling the movement of machine parts and the like, a plurality of hydraulic actuators each including a piston within a cylinder, a pumping mechanism for supplying fluid under pressure, a shiftable control valve for controlling the delivery of fluid from said pumping mechanism to at least one of said actuators, and fluid conducting means extending between said actuators, whereby fluid may be delivered from one actuator to the other for controlling the movement thereof, said conducting means including a valve which is adapted when the control valve is positioned to direct fluid from said pump to at least one of said actuators to permit the flow of fluid through said connecting means in a given direction and when said valve closes communication between said pump and said actuator to prevent the flow of fluid through said connecting means in a reverse direction.

49. In metal working apparatus, means for rotatably supporting a work piece, a tool carriage shiftable toward and away from the work piece, a second shiftable tool carriage, a hydraulic actuator coupled with each carriage, a pump for supplying fluid to said hydraulic actuators, a valve mechanism for controlling the delivery of fluid from said pump to at least one of said actuators, and fluid conducting means extending between said hydraulic actuators, whereby the hydraulic propulsion of one carriage causes a displacement of fluid to effect the movement of the other carriage to thereby accurately control the

relative degree and rate of movement of said carriages.

50. In metal working apparatus, a rotatable work support, a front carriage shiftable toward and away from the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator coupled with each of said carriages for effecting the movement thereof, a pumping mechanism for supplying fluid under pressure, a valve mechanism for controlling receiving and thereby the delivery of fluid from said pump to said actuators, and fluid conducting means extending between said hydraulic actuators, whereby the actuator of one carriage serves as an impeller for the actuator of the other carriage.

51. In metal working apparatus, a rotatable work support, a front carriage shiftable toward and away from and longitudinally of the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator for shifting the carriage toward the work piece, a second hydraulic actuator for moving said carriage longitudinally of the work piece, a third hydraulic actuator for shifting the rear carriage, a pumping mechanism for supplying fluid under pressure, a valve mechanism for controlling the delivery of fluid from said pump to said actuators, and fluid conducting means extending between two of said hydraulic actuators, whereby the movement of one carriage may be accurately timed with respect to the movement of the other carriage.

52. In metal working apparatus, a rotatable work support, a front carriage shiftable toward and away from and longitudinally of the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator for shifting the carriage toward the work piece, a second hydraulic actuator for moving said carriage longitudinally of the work piece, a third hydraulic actuator for shifting the rear carriage, a pumping mechanism for supplying fluid under pressure, a valve mechanism for controlling the delivery of fluid from said pump to said actuators, and fluid conducting means extending between the first and third hydraulic actuators, whereby the movement of the rear carriage toward the work piece may be accurately timed with respect to the movement of the front carriage toward the work piece.

53. In metal working apparatus a rotatable work support, a front carriage shiftable toward and away from the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator connected with the front carriage, a second hydraulic actuator connected with the rear carriage, a rapid traverse pump, a feed pump, a valve for controlling the connection of the rapid traverse pump with said actuators, and connecting means extending between said actuators, whereby the actuator of one carriage serves as an impeller for the actuator of the other carriage when said valve is positioned to render the rapid traverse pump functionally operative.

54. In metal working apparatus, a rotatable work support, a front carriage shiftable toward and away from the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator connected with the front carriage, a second hydraulic actuator connected with the rear carriage, a rapid traverse pump, a feed pump, a valve for controlling the connection of the rapid traverse pump with said actuators, connecting means extending between said actuators, whereby the movement of one carriage will be accurately timed with respect to the other carriage when said valve is positioned to render the rapid traverse pump functionally operative, and means for preventing a reversal of fluid flow within said connecting means when the feed pump is rendered functionally operative.

55. In material working apparatus, a rotatable work support, a front carriage shiftable toward and away from and longitudinally of the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator for shifting the carriage toward the work piece, a second hydraulic actuator for moving said carriage longitudinally of the work piece, a third hydraulic actuator for shifting the rear carriage, pumping means for imparting feeding movement to the second and third hydraulic actuators, a rapid traverse pump, a valve mechanism for controlling the delivery of fluid from the rapid traverse pump to said actuators, and fluid conducting means extending between the first and third actuators, whereby the movement of one of said carriages may be accurately timed with respect to the movement of the other carriage when the valve mechanism is positioned for rendering the rapid traverse pump functionally operative.

56. In material working apparatus, a rotatable work support, a front carriage shiftable toward and away from and longitudinally of the work piece, a rear carriage shiftable toward and away from the work piece, a hydraulic actuator for shifting the carriage toward the work piece, a second hydraulic actuator for moving said carriage longitudinally of the work piece, a third hydraulic actuator for shifting the rear carriage, a feed pump for the second hydraulic actuator, a second feed pump for the third hydraulic actuator, a rapid traverse pumping mechanism, a valve mechanism for controlling the connection of the rapid traverse pumping mechanism with said actuators, and fluid conducting means extending between two of said hydraulic actuators, whereby the movement of one carriage may be accurately timed with respect to the movement of the other carriage.

57. In material working apparatus of the class described, a rotary spindle, a carriage shiftable transversely of the spindle, a second carriage shiftable transversely of said spindle, a hydraulic actuator connected with each carriage, a closed hydraulic circuit which includes one of said actuators and also includes a feed pump, a rapid traverse pump, means for controlling the operative functioning of said latter pump with respect to at least one of said actuators, and fluid connecting means extending between said actuators, whereby the movement of one carriage may be accurately timed with respect to the movement of the other carriage during the operative functioning of said rapid traverse pump.

58. In material working apparatus of the class described, a rotary spindle, a carriage shiftable transversely of the spindle, a second carriage shiftable transversely of said spindle, a hydraulic actuator connected with each carriage, a closed hydraulic circuit which includes one of said actuators and also includes a feed pump operable in synchronism with said spindle, a rapid traverse pump, means for controlling the operative functioning of said latter pump with respect to at least one of said actuators, and fluid connecting means extending between said actuators, where-

by the movement of one carriage may be accurately timed with respect to the movement of the other carriage during the operative functioning of said rapid traverse pump.

59. In material working apparatus of the class described, a plurality of shiftable machine elements, a hydraulic actuator connected with each of said elements, a pump, a valve mechanism for controlling the operative connection of the pump with said actuators, said valve mechanism including a plurality of shiftable valve members, and means for unbalancing the fluid pressure within said valve mechanism, whereby to effect the sudden shifting of said valve members.

60. In material working apparatus of the class described, a plurality of shiftable machine elements, a hydraulic actuator connected with each of said elements, a pump, a valve mechanism for controlling the operative connection of the pump with said actuators, said valve mechanism including a plurality of shiftable valve members, and means for reducing fluid pressure in a portion of said valve mechanism, whereby to enable the normal fluid pressure in another portion thereof to effect the sudden shifting of said members.

61. In material working apparatus of the class described, a shiftable machine element, a hydraulic actuator connected with each element, a pump, a valve mechanism for controlling the operative connection of the pump with said actuator, said valve mechanism including a cylindrical chamber and a valve member longitudinally shiftable within said chamber, and means shiftable longitudinally of said chamber to effect the unbalancing of fluid pressure therein and thereby cause a sudden shifting of said valve member.

62. In combination with a plurality of shiftable tool carrying devices, a fluid operated actuator associated with each of said tool carrying devices, a pump for supplying fluid under pressure, a valve for controlling the delivery of said fluid under pressure to one of said actuators, fluid conducting means for effecting the starting and speed of a second of said actuators in response to the actuation of said first mentioned actuator, and means shiftable in response to the actuation of one of said actuators for controlling the actuation of said valve.

63. In a hydraulic actuator system, a plurality of fluid operated actuators, a machine element connected to each of said actuators and shifted thereby, pump means for supplying fluid under pressure, a valve for directing fluid under pressure to one of said actuators, a duct connecting said last mentioned actuator with a second actuator, whereby the speed of said second actuator is controlled by the fluid displaced from said first actuator, rotary carrying means, driving means therefor, and means operable in response to one of said actuators for controlling the connection between the carrying means and said driving means.

64. In a hydraulic actuator system, a plurality of fluid operated actuators, a machine element driven by each actuator, a single pumping mechanism for supplying fluid under pressure, a unitary valve mechanism for directing fluid under pressure to one of said actuators, means connecting said actuator with a second actuator, whereby to control the starting and speed of said second actuator, and means operated in timed relation with one of said actuators for controlling the actuation of said unitary valve mechanism.

65. In combination with a plurality of shiftable tool carriages, a fluid operated actuator connected with each tool carriage, a single source of fluid supply connectable with one of said actuators, a second of said actuators being connected with and operated by said last mentioned actuator, and means operated by one of said actuators for controlling the delivery of fluid from said single source of supply to the other actuator.

66. In material working apparatus of the class described, a plurality of fluid operated actuators, machine elements connected with said actuators and driven thereby, a single source of low pressure large displacement fluid supply, a valve mechanism for controlling the delivery of fluid from said source of supply to one of said actuators, means connecting said actuator with a second actuator, whereby fluid from the first actuator may be forced toward the second actuator for shifting same, a high pressure fluid displacing means connected with said second actuator, driving means for said high pressure fluid displacing means, and means for controlling the operative functioning of said fluid displacing means, said controlling means operating to render the high pressure fluid displacing means functionally inoperative during a portion at least of the operating cycle of said actuators.

67. In material working apparatus of the class described, a machine frame, rotary supporting means, an oscillatory and reciprocable tool support, a second reciprocable tool support, a fluid operated actuator connected with each tool support, means for supplying fluid under pressure to one of said actuators, means connecting said last mentioned actuator with the second actuator, whereby the movement of the second actuator is controlled by said first actuator, and means operable by the tool support associated with one of said actuators for controlling the connection between the source of fluid supply and said first actuator.

68. In a hydraulic actuator system, a plurality of fluid operated actuators, each of said actuators including a cylinder and a piston reciprocable therein, means for supplying fluid under pressure to one of said actuators for effecting the shifting thereof, a duct connecting said last mentioned actuator with a second actuator, whereby fluid may be forced from said first actuator to effect the shifting of said second actuator, and valve means associated with said duct for controlling the direction of fluid flow between said actuators.

69. In a hydraulic system for controlling a plurality of fluid operated actuators, a fluid pump mechanism for propelling one of said actuators at a feeding rate, a second fluid pumping mechanism for propelling another of said actuators at a feeding rate, a third fluid pumping mechanism for propelling said actuators at rapid traverse speed, one of said actuators being controlled directly in response to another of said actuators, a valve mechanism for selectively controlling the delivery of fluid from said pumping mechanism to said actuators, shiftable mechanism driven by one of said actuators, means on said shiftable mechanism for timingly controlling the actuation of said valve mechanism, a second valve mechanism for independently controlling the fluid in connection with one of said actuators, and means on said shiftable mechanism

for timingly actuating said second valve mechanism.

70. In a hydraulic system for controlling a plurality of fluid operated actuators, a fluid pump mechanism for propelling one of said actuators at a feeding rate, a second fluid mechanism for propelling another of said actuators at a feeding rate, a third fluid pumping mechanism for propelling said actuators at rapid traverse speed, a valve mechanism for selectively controlling the delivery of fluid from said pumping mechanism to said actuators, a shiftable mechanism driven by one of said actuators, means on said shiftable mechanism for timingly controlling the actuation of said valve mechanism, a rotary valve mechanism for independently controlling the fluid in connection with one of said actuators, and means on said shiftable mechanism for timingly actuating said second rotary mechanism.

71. In a hydraulic actuator system, a plurality of fluid operated actuators for propelling supporting members, means for supplying fluid under pressure to one of said actuators for imparting movement thereto, means for connecting said last mentioned actuator with a second actuator whereby said first actuator serves to volumetrically control the delivery of fluid to said second actuator and thereby effect simultaneous action and synchronized speed of said actuators, and control mechanism adapted for automatic operation in response to an impulse from one of said supporting members to timingly govern the direction and extent of movement of said actuators.

72. In a hydraulic actuator system, a plurality of fluid operated actuators for propelling supporting members, means for supplying fluid under pressure to one of said actuators for imparting movement thereto, means for connecting said last mentioned actuator with a second actuator whereby said first actuator serves to volumetrically control the delivery of fluid to said second actuator and thereby effect simultaneous action and synchronized speed of said actuators, and shiftable control mechanism for timingly governing the direction and extent of movement of said actuators, said control mechanism being automatically shiftable to a reverse position in response to fluid pressure.

73. In a hydraulic actuator system, a plurality of fluid operated actuators for propelling supporting members, means for supplying fluid under pressure to one of said actuators for imparting movement thereto, means for connecting said last mentioned actuator with a second actuator whereby said first actuator serves to volumetrically control the delivery of fluid to said second actuator and thereby effect simultaneous action and synchronized speed of said actuators, and shiftable control mechanism for timingly governing the direction and extent of movement of said actuators and adapted to circulate fluid, the pressure of said circulating fluid serving to maintain said control mechanism normally in balance and also serving to shift said valve mechanism to a reverse position.

74. In a hydraulic actuator system, a plurality of fluid operated actuators for propelling supporting members and the like, means for supplying fluid under pressure to one of said actuators for imparting movement thereto, means connecting said last mentioned actuator with another actuator whereby fluid in the return side of said first actuator will exert a pressure sufficient to propel said second actuator, and whereby said fluid serves as a volumetric control means for governing the relative speed and starting of said second actuator synchronously with said first actuator, and control means for automatically governing the synchronized movement of said actuators.

75. In a hydraulic actuator system, a plurality of fluid operated actuators, each of said actuators including a reciprocable cylinder and piston construction adapted to propel supporting members in accordance with the resistance experienced by said members, means for supplying fluid under pressure to one of said actuators for effecting the shifting thereof, a duct connecting said last mentioned actuator with a second actuator whereby fluid forced from said first actuator volumetrically controls the extent and speed of travel of said second actuator synchronously with the first actuator, and control means for receiving fluid from said fluid supplying means and for directing said fluid to at least one of said actuators in accordance with the desired direction of movement.

76. In combination with a plurality of shiftable machine elements, a fluid operated actuator for each element including a relatively shiftable piston and cylinder construction, means for supplying fluid under a given pressure to one side of the piston in one of said actuators to effect the movement thereof in a given direction, a duct for directing fluid under a lower pressure from the advancing side of said piston to the cylinder of a second actuator, and means for directing fluid under another pressure for said second actuator, whereby the degree and rate of movement of the second actuator will be controlled in conformity with the volumetric displacement resulting from the travel of the first mentioned actuator, and automatically operable control mechanism for timingly governing the direction and extent of movement of said actuators.

77. In combination with a plurality of shiftable machine elements, a fluid operated actuator for each element including a relatively shiftable cylinder and piston construction, plunger pump for supplying fluid under pressure to one side of said actuators to effect the movement thereof in a given direction, a duct for directing fluid from the advancing side of said first actuator to the cylinder of a second actuator, whereby the degree and rate of movement of said second actuator will be controlled in conformity with the degree and rate of movement experienced by the first actuator, means for directing fluid from the advancing side of the second actuator to the intake side of the plunger pump for charging said plunger pump, and control mechanism for timingly governing the direction and extent of movement of said actuators.

78. In a machine tool transmission, a single power supplying means, a plurality of shiftable supporting elements, an actuator for each of said supporting elements whereby said supporting elements are adapted to be propelled synchronously and individually, control means connectable with said single power supplying means and said actuators in a manner to effect simultaneous movement of said supporting elements and adapted to render said single power means functionally ineffective when desired, and a plurality of variable power supplying means arranged to impart movement to said supporting elements when said single power means is rendered ineffective by said control means.

79. In a machine tool transmission, a single

power supplying means, a plurality of shiftable supporting elements, an actuator for each of said supporting elements whereby said supporting elements are adapted to be propelled synchronously and individually, control means connectable with said single power supplying means and said actuators in a manner to effect simultaneous movement of said supporting elements and adapted to render said single power means functionally ineffective when desired, a plurality of variable power supplying means arranged to impart movement to said supporting elements when said single power means is rendered ineffective by said control means, and a third actuator adapted to intercept the propelling power of one of said actuators when said actuator has traveled a preselected distance.

80. In a machine tool transmission, a single power supplying means, a plurality of shiftable supporting elements, an actuator for each of said supporting elements whereby said supporting elements are adapted to be propelled synchronously and individually, control means connectable with said single power supplying means and said actuators in a manner to effect simultaneous movement of said supporting elements and adapted to render said single power means functionally ineffective when desired, a plurality of variable power supplying means arranged to impart movement to said supporting elements when said single power means is rendered ineffective by said control means, and unitary power means for starting and stopping said plurality of power supplying means in response to the actuation of said control means.

81. In a machine tool transmission, a single power supplying means, a plurality of shiftable supporting elements, an actuator for each of said supporting elements whereby said supporting elements are adapted to be propelled synchronously and individually, control means connectable with said single power supplying means and said actuators in a manner to effect simultaneous movement of said supporting elements and adapted to render said single power means functionally ineffective when desired, a plurality of variable power supplying means arranged to impart movement to said supporting elements when said single power means is rendered ineffective by said control means, and unitary power means including a clutch mechanism for starting and stopping said plurality of power supplying means in response to the actuation of said control means.

82. In a hydraulic system of control, a pump, a shiftable valve having a plurality of inlet and outlet ports, a plurality of fluid operated actuators, ducts connecting said shiftable valve with said actuators, said valve being adapted in one shifted position to receive fluid from said pump and direct said fluid to one of said actuators and to receive fluid from a second of said actuators, and a duct connecting said first actuator with said second actuator, whereby said first actuator is adapted to hydraulically propel said second actuator in accordance with the fluid displaced by the first actuator whereby the speed of said actuators is synchronized with the displacement of said pump.

83. In material working apparatus of the class described, a plurality of shiftable supporting elements, a fluid operated actuator connected with each element, a constantly driven large displacement pumping mechanism for supplying fluid under pressure for propelling said actuators, a valve mechanism for dispatching fluid from said constantly driven mechanism to one of said actuators, a duct connecting said last mentioned actuator with a second actuator, whereby the second actuator is driven by said first actuator in accordance with the volumetric delivery of fluid from said pump to said first actuator, and a high pressure fluid propelling means connectable with at least one of said actuators for propelling said actuator at a slower speed when the large displacement pumping mechanism is rendered ineffective.

84. In a hydraulic actuator system, a plurality of fluid operated actuators, fluid pressure generating means for supplying fluid under pressure to one of said actuators, means for conducting fluid from said last mentioned actuator to a second actuator, whereby the movement of the first actuator will effect the actuation of the second actuator and whereby the speed and starting of said second actuator is accurately governed by fluid displaced from the advancing side of the first actuator, a second fluid pressure generating means, means responsive to the flow of fluid from said first actuator for causing said second fluid pressure generating means to be rendered functionally operable, means for controlling the connection of the first fluid pressure generating means with said first actuator, and means operatively coupling said control means with one of said actuators, whereby said control means is governed in response to the actuation of one of said actuators.

85. In a hydraulic actuator system, a plurality of fluid operated actuators, fluid propelling means for supplying fluid under pressure to one of said actuators, means for conducting fluid from said last mentioned actuator to a second actuator, whereby the movement of the first actuator will effect the actuation of the second actuator, a shiftable valve mechanism for controlling the connection of the fluid propelling means with said first actuator, means for operatively connecting said valve mechanism with one of said actuators, whereby said valve mechanism is shiftable in response to the actuation of one of said actuators, a second fluid propelling means, and means operable as an incident to the flow of fluid from said first to said second actuator for causing said second fluid propelling means to be rendered functionally operable.

86. In combination with a plurality of relatively shiftable supporting members, a fluid operated actuator associated with each of said supporting members, means for delivering fluid under pressure to the actuator associated with one of said supporting members, a duct connecting said last mentioned actuator with the actuator of a second supporting member, whereby the speed of travel of said second supporting member is controlled in accordance with the displacement of fluid from the advancing side of the actuator associated with the first supporting member to thereby accurately govern the degree of movement of said second actuator, control means associated with one of said actuators whereby to initiate a change in the rate of fluid delivery after a predetermined amount of fluid has been displaced from the advancing side of the first actuator, a second means for delivering fluid under pressure, and means responsive to the delivery of fluid through said duct for causing said second fluid pressure delivering means to be rendered functionally operable.

87. In a hydraulic system of control, a pump, a shiftable valve means including a plurality

of valve plungers within a housing having a plurality of inlet and outlet ports, a plurality of fluid operated actuators, ducts connecting said shiftable valve means with said actuators, said valve means being adapted in one shifted position to receive fluid from said pump, direct said fluid to one of said actuators, and to receive fluid from a second of said actuators, said valve means being shiftable in timed relation with the movement of one of said fluid operated actuators, means for hydraulically shifting said valve means to at least one of said positions, and a duct connecting said first actuator with said second actuator, whereby said first actuator is adapted to hydraulically control said second actuator.

88. In a hydraulic system of control, a plurality of fluid operated actuators, means for supplying fluid under pressure, a valve connected with said fluid supplying means, said valve being shiftable to at least three positions and having a plurality of outlet and inlet ports, ducts connecting said valve with said actuators, said valve in one position interrupting communication between the supplying means and said actuators, and in a second shiftable position adapted to supply fluid to one of said actuators and receive fluid from another of said actuators, a duct connecting said first actuator and said second actuator, whereby movement of said second actuator is occasioned in response to movement of said first actuator, said valve in a third shifted position being adapted to deliver and receive fluid from a plurality of said actuators, a second fluid supplying means, and means operable in response to the shifting of said valve to a predetermined position for controlling the operativeness of said last mentioned fluid supplying means.

89. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, means for supplying fluid under pressure, and a reservoir, a valve mechanism including a valve member shiftable to at least two positions, a port in said valve mechanism which is adapted, when the valve member is shifted to one position, to direct fluid under pressure to one of said actuators, a second port for contemporaneously receiving fluid from another of said actuators and for directing said fluid to said reservoir, said valve being adapted in another shifted position to direct fluid under pressure to a plurality of said actuators and to receive fluid from said actuators, a second fluid supplying means, and means operable in response to the flow of fluid when said valve mechanism occupies a predetermined position for controlling the operativeness of said second fluid supplying means.

90. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, a pumping means, and a fluid reservoir, a valve mechanism having a valve member shiftable to various positions and having a plurality of inlet and outlet ports connectable with said actuators, said valve in one shifted position being adapted to receive fluid from said pump and dispatch said fluid to the reservoir, and in a second position to dispatch fluid under pressure to a single actuator and receive fluid from another single actuator, and in a third position to dispatch fluid to a plurality of actuators and receive fluid from a plurality of actuators, and fluid power means for shifting said valve member to at least one of said positions.

91. In combination with a hydraulic actuator system, including a plurality of fluid operated actuators, a pump for supplying fluid under pressure, and a reservoir, a valve mechanism including a plurality of valve members shiftable within a casing, said mechanism being connectable with the pump and said actuators, one of said valve members being adapted in one shifted position to direct fluid under pressure to a single actuator, and the other valve member being adapted the same instant to receive fluid from another actuator, said valve members in a second shifted position being adapted to dispatch fluid under pressure to a plurality of said actuators, a plurality of pumps for supplying fluid under pressure to said actuators at a rate differing from the rate at which the first mentioned pump supplies fluid thereto, and means operable in response to the flow of fluid initiated by the shifting of said valve mechanism for controlling the operativeness of said last mentioned pumps.

92. In combination with a rotatable supporting member, a supporting member cooperatively associated therewith, said members being relatively movable axially and transversely with respect to the axis of said rotary supporting member, fluid operated actuators associated with said supporting members for imparting said relative movement thereto, a pump for supplying fluid under pressure, a valve for controlling the delivery of fluid under pressure to one of said actuators, fluid conducting means for effecting the starting and speed of a second of said actuators in response to the actuation of said first mentioned actuator, and means operable in response to the actuation of one of said supporting members for controlling the actuation of said valve.

93. In combination with a plurality of shiftable supporting carriages, a fluid operated actuator connected with each supporting carriage, a single source of fluid supply connectable with one of said actuators, a second of said actuators being connected with and operated by said last mentioned actuator, a third actuator shiftable in response to the movement of one of the aforementioned actuators, a second source of fluid supply adapted to be rendered operable in response to the movement of said third actuator, and means operated by said second actuator for controlling the delivery of fluid from said single source of supply to the other actuator.

94. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto, whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, and fluid power control mechanism including a plurality of shiftable fluid directing plungers adapted in one shifted position to render said actuators operable in said series circuit and in another shifted position to render said actuators operable in parallel, whereby to enable an independent effective fluid flow to and from each actuator.

95. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto, whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, fluid power control

mechanism including a plurality of shiftable fluid directing plungers adapted in one shifted position to render said actuators operable in said series circuit and in another shifted position to render said actuators operable in parallel, whereby to enable an independent effective fluid flow to and from each actuator, and automatically shiftable abutment means for positioning said fluid control mechanism in various shifted positions in timed relation with the effective fluid flow in said circuit arrangement.

96. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid to said actuators for causing a fluid flow when said actuators are connected in series whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, fluid power control mechanism including a shiftable plunger adapted in one shifted position to render said actuators operable in said series circuit and in another position to render said actuators operable in parallel, and a second fluid power generating means companion to each of said actuators for propelling said actuators at a feeding rate when said actuators are connected in parallel.

97. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid to said actuators for causing a fluid flow when said actuators are connected in series whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, fluid power control mechanism including a shiftable plunger adapted in one shifted position to render said actuators operable in said series circuit and in another position to render said actuators operable in parallel, a second fluid power generating means companion to each of said actuators for propelling said actuators at a feeding rate when said actuators are connected in parallel, and automatically shiftable abutment means for positioning said fluid control mechnism in various shifted control positions in timed relation with the effective fluid flow in said circuit arrangement.

98. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid to said actuators for causing a fluid flow when said actuators are connected in series whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, fluid power control mechanism including a shiftable plunger adapted in one shifted position to render said actuators operable in said series circuit and in another position to render said actuators operable in parallel, a second fluid power generating means companion to each of said actuators for propelling said actuators at a feeding rate when said actuators are connected in parallel, automatically shiftable abutment means for positioning said fluid control mechanism in various shifted control positions in timed relation with the fluid flow in said circuit arrangement, and fluid power control means including channels within said fluid power control mechanism responsive to said abutment means for shiftably positioning said fluid power control plunger to at least one shifted position.

99. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto, whereby one actuator serves to volumetrically control delivery of fluid to the actuator connected in series therewith, control mechanism including a shiftable valve plunger within a housing for controlling the dispatchment of fluid from said fluid power generating means to said actuators connected in series, a fluid receiving chamber within said housing operatively associated with said valve plunger, whereby fluid may be dispatched in various directions from the chamber by shifting the valve plunger, fluid conducting means between said fluid power generating means and said chamber, and restricted orifice means cooperatively arranged with respect to said chamber, whereby to maintain fluid under a predetermined pressure for control purposes.

100. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto, whereby one actuator serves to volumetrically control delivery of fluid to the actuator connected in series therewith, control mechanism including a shiftable valve plunger within a housing for controlling the dispatchment of fluid from said fluid power generating means to said actuators connected in series, a fluid receiving chamber within said housing operatively associated with said valve plunger, whereby fluid may be dispatched in various directions from the chamber by shifting the valve plunger, fluid conducting means between said fluid power generating means and said chamber, restricted orifice means cooperatively arranged with respect to said chamber, whereby to maintain fluid under a predetermined pressure for control purposes, shiftable abutment means movable as an incident to the shifting of one of said actuators, and a control plunger shiftable within said housing for directing said control fluid to shift said valve plunger, said control plunger being shiftable in response to said abutment means.

101. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, a variable delivery fluid power generating means associated with each actuator for imparting feeding movement thereto when said actuators are connected in parallel, a control mechanism including a plurality of shiftable valve plungers adapted in one position to render said actuators operable in said series circuit and in another position to render said actuators operable in parallel, said first mentioned fluid power generating means being hydraulically connectable with said valve plungers, and shiftable means for controlling said valve plungers including abutment means shiftable as an incident to the flow in said circuit arrangement for causing the shifting of said valve plungers.

102. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series and parallel, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto whereby one actuator serves to volumetrically control the delivery of fluid to the actuator connected in series therewith, a variable delivery fluid power generating means associated with each actuator for imparting feeding movement thereto when said actuators are connected in parallel, a control mechanism including a plurality of valve plungers adapted in one position to render said actuators operable in said series circuit and in another position to render said actuators operable in parallel, said first mentioned fluid power generating means being hydraulically connectable with said valve plungers, shiftable means for controlling said valve plungers including abutment means shiftable as an incident to the flow in said circuit arrangement for causing the shifting of said valve plungers, and means for manually shifting said valve plungers in unison or independently.

103. In a hydraulic actuator system, a fluid circuit arrangement including a plurality of fluid operated actuators adapted to be connected in series, fluid power generating means for supplying fluid under pressure to one of said actuators for imparting movement thereto, whereby one actuator serves to volumetrically control delivery of fluid to the actuator connected in series therewith, fluid power generating means companion to each actuator and adapted to move fluid as a unit with said actuator, automatic control mechanism including a plurality of fluid directing plungers within a housing, each of said plungers being companion to one of said fluid operated actuators, and fluid power control means within said housing for causing the hydraulic shifting of said plungers in at least one direction.

104. In a hydraulic actuator system, a plurality of hydraulic actuators adapted to be connected in series and parallel, a circuit including fluid power generating means for imparting feeding movement when said actuators are connected in parallel, a second circuit including fluid power generating means for imparting rapid traverse movement when said actuators are connected in series, a fluid reservoir providing a source of fluid supply, and restricted orifice means associated with said second circuit to enable the fluid flow in said circuit to be maintained at a predetermined pressure for control purposes.

105. In a fluid transmission system and control mechanism therefor, a first fluid circuit including fluid pressure generating means therefor, a second fluid circuit including a second fluid pressure generating means adapted to move fluid as a unit in said second circuit, a plurality of hydraulic actuators connectable within said circuits, control mechanism including a plurality of shiftable plungers within a housing companion to said actuators for determining the starting and stopping of fluid flow in said circuits, and means responsive to the flow of fluid in at least one of the circuits for variously and automatically positioning said control mechanism.

106. In a fluid transmission system for machine tools and the like, a plurality of shiftable hydraulic actuators adapted to be connected in series, a first fluid power circuit including fluid pressure generating means therefor, driving means for said fluid pressure generating means, control mechanism for said circuit including a shiftable plunger within a housing for determining the starting and stopping of fluid flow in said circuit, a second fluid pressure generating means, driving means for said second fluid pressure generating means independent of the first mentioned driving means, and means automatically actuated by said first circuit for starting and stopping of fluid flow in said second circuit in timed relation with the fluid flow in said second circuit.

107. In a fluid transmission system for machine tools and the like, a first fluid circuit including rapid traverse fluid pressure generating means, a plurality of shiftable hydraulic actuators adapted to be hydraulically connected in series within said first circuit, a second fluid circuit including slow traverse fluid pressure generating means which is adapted to be functionally operable independently of said rapid traverse fluid pressure generating means, and means operable as an incident to the fluid flow in said first fluid circuit to cause said slow traverse fluid pressure generating means to be rendered functionally ineffective.

108. A fluid transmission system for machine tools and the like, a plurality of hydraulic actuator members, two sources of fluid supply, means for conducting fluid from one of said sources to said actuators in series and parallel for propelling purposes, and control means operable for enabling the fluid from both of said sources to simultaneously act upon said actuator member during a predetermined movement of said actuator member and including means operable in response to the shifting of said actuator member by the action of fluid from both of said sources to enable the positive continued movement of said actuator member under the influence of fluid from only one of said sources.

ERNEST J. SVENSON.