United States Patent

[11] 3,530,767

[72] Inventor **William M. Shook**
New Philadelphia, Ohio

[21] Appl. No. **818,037**
[22] Filed **April 21, 1969**
Continuation-in-part of Ser. No. 703,123, Feb. 5, 1969, Pat. No. 3,481,251
[45] Patented **Sept. 29, 1970**

[73] Assignee **The Warner & Swasey Company**
Cleveland, Ohio
a corporation of Ohio

[54] **MACHINE WITH HYDRAULIC BOOM**
3 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **91/411,** 214/138, 60/97
[51] **Int. Cl.** **F15b 11/16,** B66f 9/00
[50] **Field of Search** 91/411; 60/97H; 214/138

[56] **References Cited**

UNITED STATES PATENTS

2,869,327	1/1959	Symmank	91/412
2,916,205	12/1959	Litz	60/97X
2,935,852	5/1960	Russell	91/172
3,018,010	1/1962	Przybylski	214/138
3,170,379	2/1965	Dempster	60/97X
3,388,819	6/1968	Przybylski	214/138

Primary Examiner—Edgar W. Geoghegan
Attorney—Yount, Flynn and Tarolli

ABSTRACT: An improved machine includes a load carrying member which is moved by a piston and cylinder assembly against the influence of variable loads. Controls for the piston and cylinder assembly include a first valve which is manually operable between a neutral condition and either one of two operated conditions. In the neutral condition the first valve blocks fluid flow to and from the piston and cylinder assembly to retain the member in a selected position. The first valve is operable from the neutral condition to enable fluid to flow to and from the piston and cylinder assembly in such a manner as to move the member either inwardly or outwardly. A second control valve is manually operable between first and second operating conditions to selectively communicate an operating area of the piston and cylinder assembly directly to drain or to a source of fluid under pressure through the first valve when it is in one of the operated conditions. Communicating the operating area with the source of fluid under pressure by operation of the second valve decreases the speed and increases the power with which the member is moved.

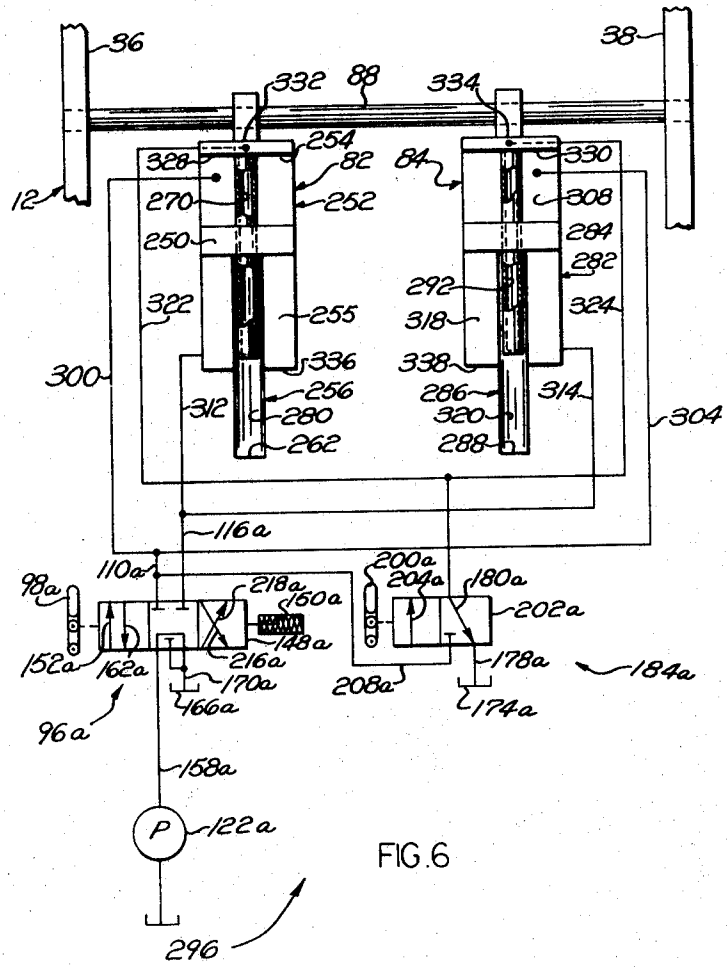


FIG. 6

Patented Sept. 29, 1970 3,530,767

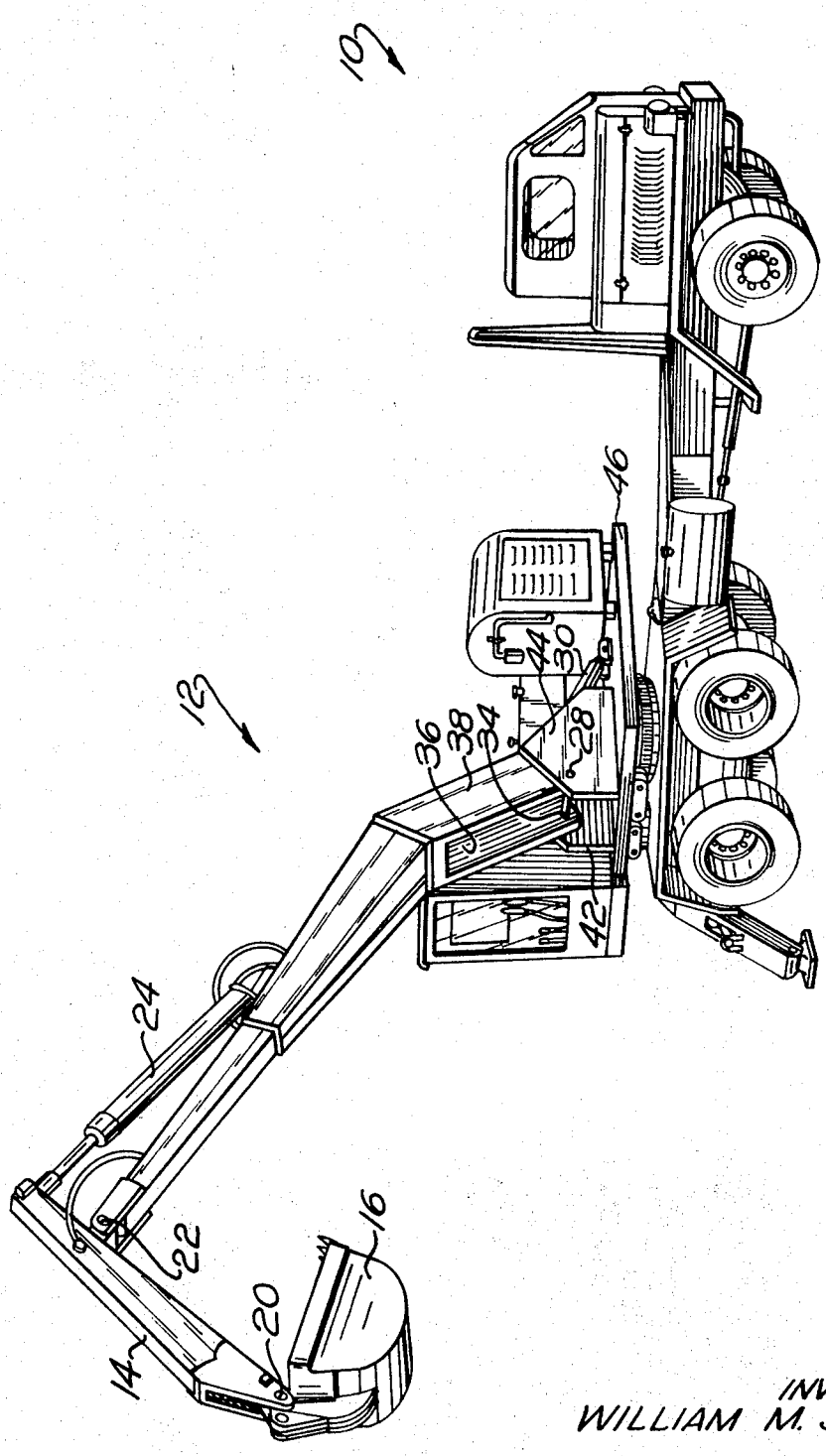


FIG. 1

INVENTOR
WILLIAM M. SHOOK

BY Yount, Flynn & Tarolli
ATTORNEYS

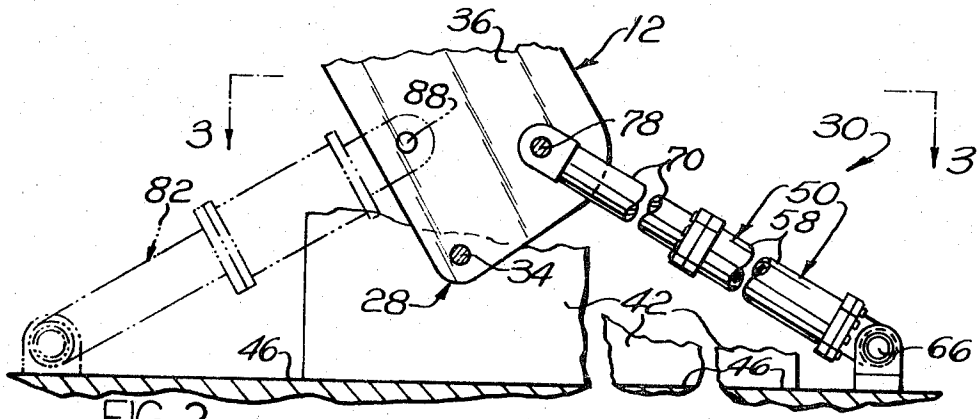


FIG. 2

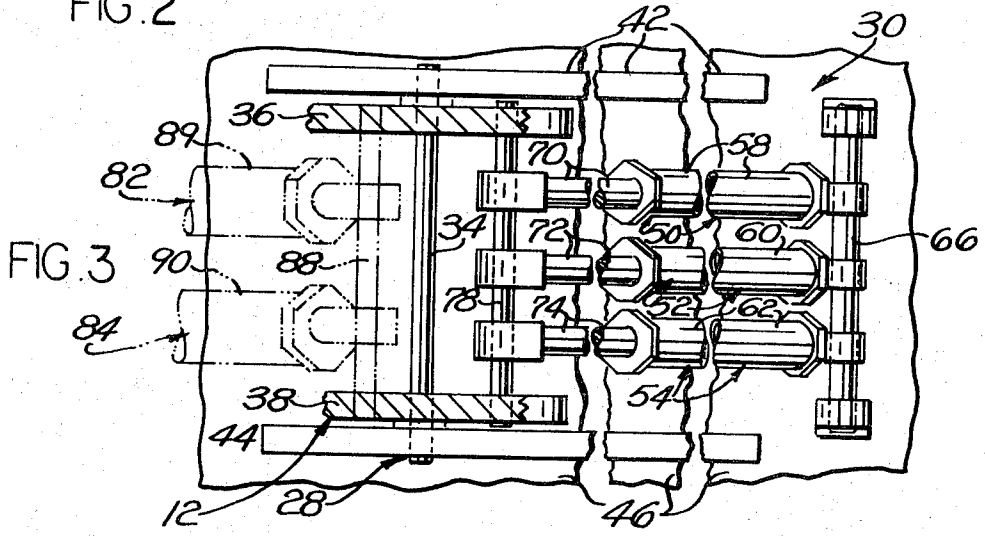


FIG. 3

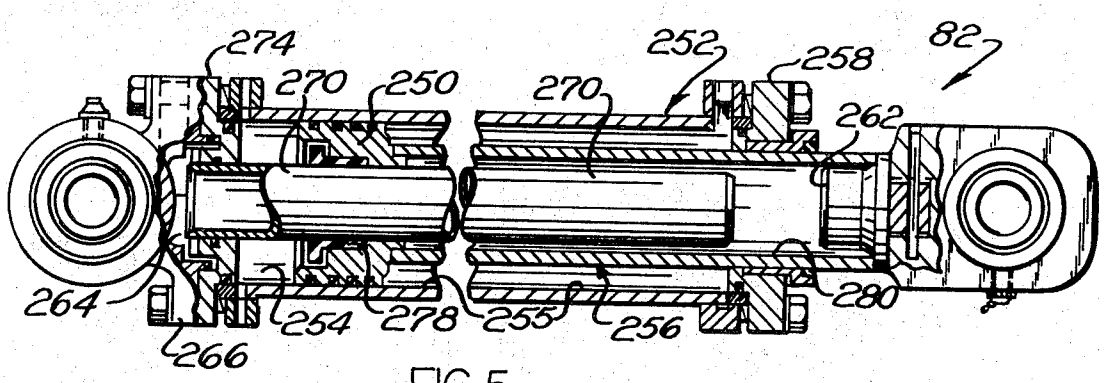


FIG. 5

INVENTOR
WILLIAM M. SHOOK

BY Yount, Flynn & Tarolli
ATTORNEYS

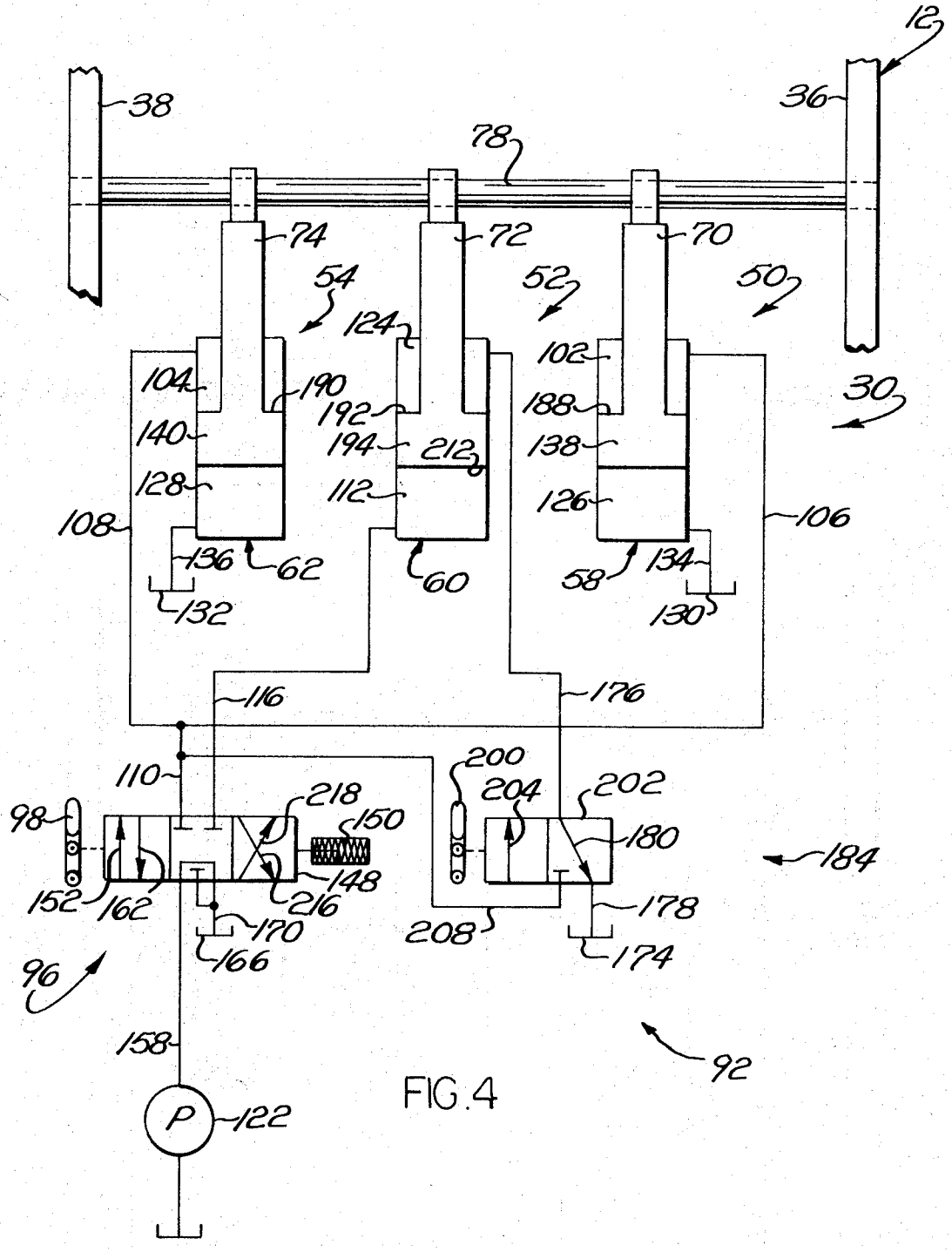


FIG. 4

INVENTOR
WILLIAM M. SHOOK

BY Yount, Flynn & Tarolli
ATTORNEYS

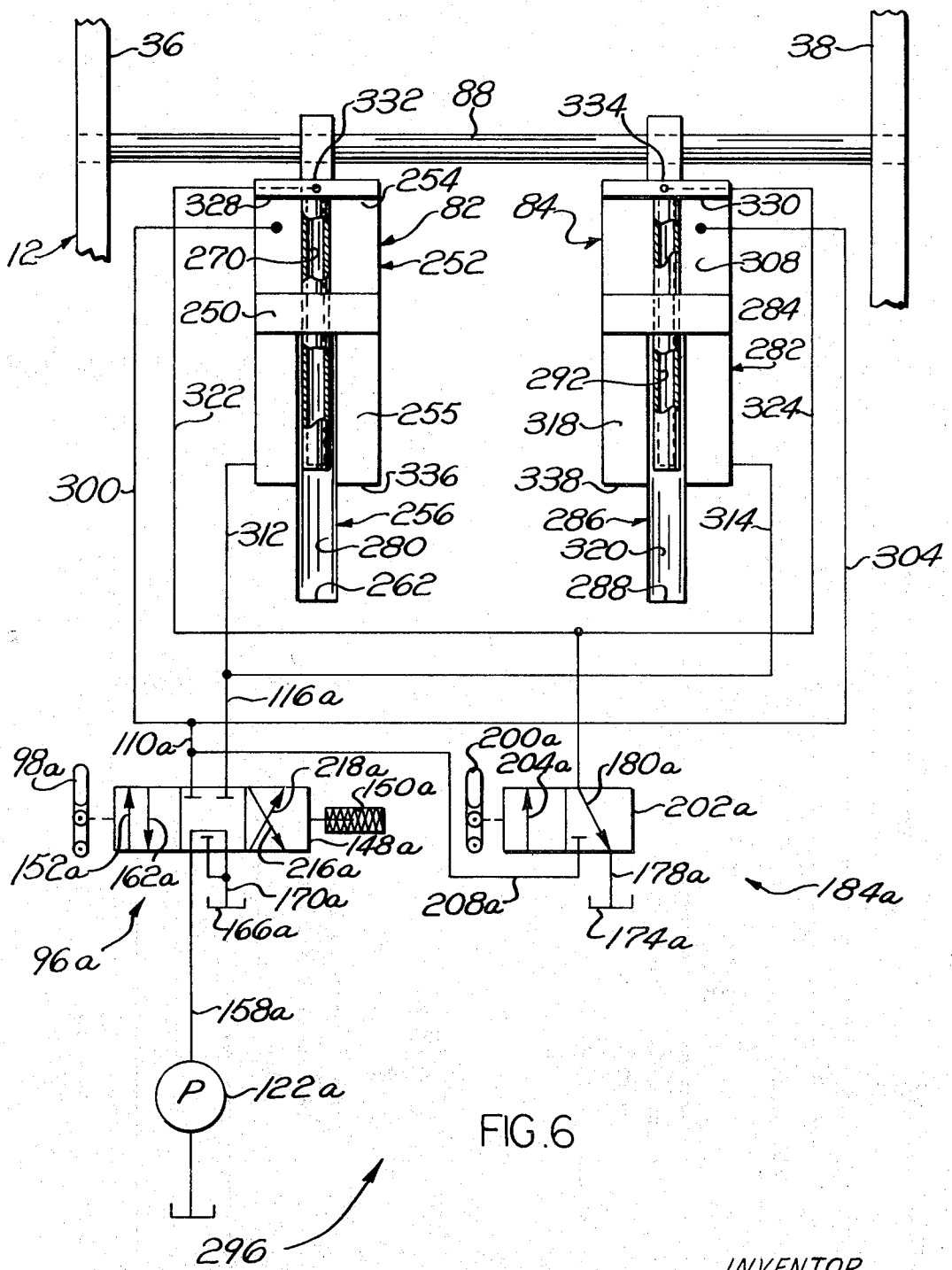


FIG. 6

INVENTOR
WILLIAM M. SHOOK
BY Yount, Tilghman & Tarolli
ATTORNEYS

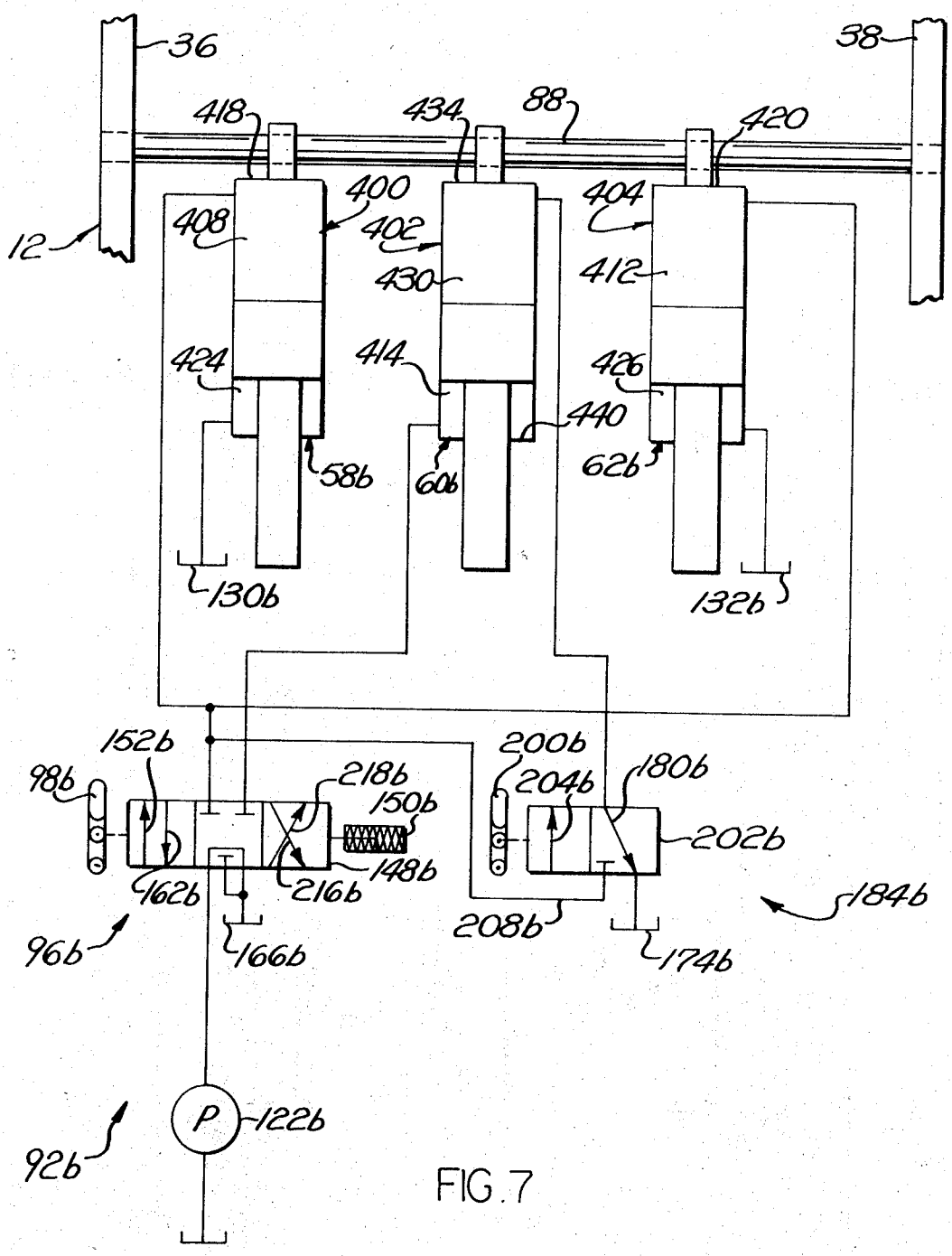


FIG. 7

INVENTOR
WILLIAM M. SHOOK

BY Yount, Flynn & Tarolli
ATTORNEYS

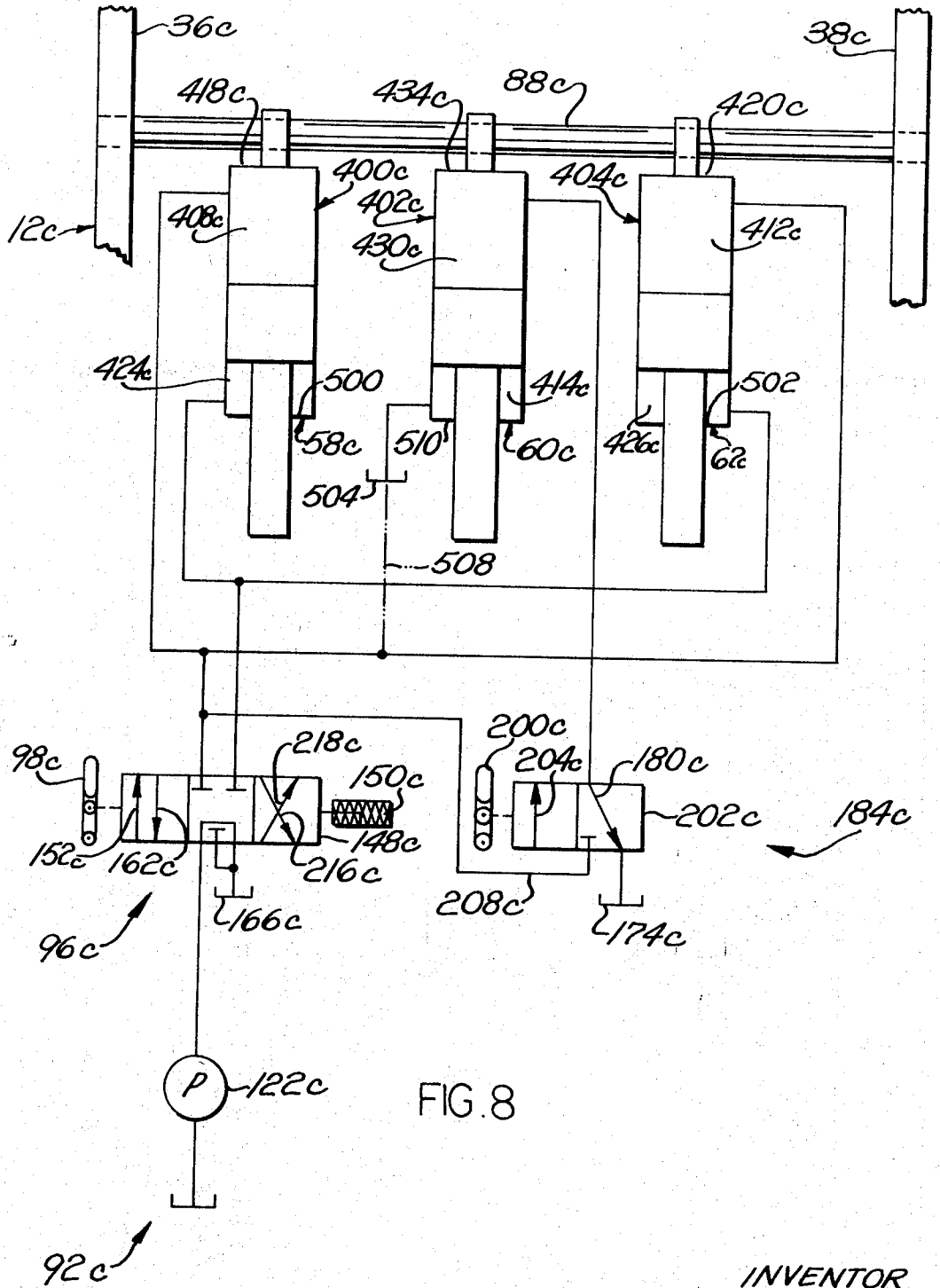


FIG. 8

INVENTOR
WILLIAM M. SHOOK

BY Young, Flynn & Tarolli
ATTORNEYS

MACHINE WITH HYDRAULIC BOOM

This application is a continuation-in-part of my copending application Ser. No. 703,123, filed Feb. 5, 1969, now U.S. Pat. No. 3,481,251.

This invention relates to construction and material handling machines having a hydraulically operated boom or other member which can be selectively operated through either a power stroke or a speed stroke.

Material handling and construction machines with booms or other working members are sometimes used to transfer or handle relatively light loads but at other times are required to transfer or handle relatively heavy loads. Under certain operating conditions the magnitude of the load to which such a machine is subjected may vary while the loads are being handled or transferred. Efficient handling of these different loads requires different speed and power characteristics.

If the boom or other working members of the machine is being positioned relative to a load or being subjected to a relatively light load, efficient handling of the load frequently requires that the machine have relatively high speed and low power operating characteristics. Conversely, when the boom or other working member is being subjected to a relatively heavy load, efficient handling of the load frequently requires that the machine have low speed and high power operating characteristics. Smooth or uniform handling of a load which tends to vary in magnitude requires that the machine maintain low speed and high power operating characteristics without shifting or oscillating between high and low speed operation. In addition, a material handling or construction machine should have an actuating mechanism which is compact and easily positioned relative to other components of the machine while being reliable in operation under many different conditions.

An important object of the present invention is to provide a new and improved machine having a hydraulically actuated working member and wherein an operator can vary the piston area of a hydraulic actuating means to which fluid pressure is applied to move the working member to provide for power or speed in handling a load, as desired.

A further object of the present invention is to provide hydraulic power means for moving a working member wherein the hydraulic power means has a first piston area to which pressure is selectively applied when it is desired to move the working member with a relatively high speed and a larger piston area to which pressure is applied when power is required.

Another object of this invention is to provide a new and improved machine having a working member which may be subjected to a load which varies in magnitude and wherein the machine includes actuating means which is selectively operable to provide and maintain either high speed-low power machine operating characteristics or low speed-high power machine operating characteristics independently of the magnitude of the load to which the working member is subjected at any given instant to thereby enable the load to be handled or moved in a smooth, uniform manner.

Another object of this invention is to provide a new and improved machine having a piston and cylinder assembly for moving a load carrying member to be subjected to different loads and first and second valves for controlling operation of the piston and cylinder assembly wherein the first valve is operable between a neutral condition in which it blocks fluid flow to and from the piston and cylinder assembly to retain the load carrying member in a selected position and either one of two operated conditions to enable fluid to flow to the piston and cylinder assembly to move the load carrying member, the second valve being manually operable between a first condition in which the load carrying member is moveable at a high speed upon operation of the first valve and an operating area of the piston and cylinder assembly communicates directly to drain through the second valve and a second condition in which the load carrying member is moved at a relatively low speed upon operation of the first valve and the operating area communicates through the first valve with a source of fluid under pressure.

A further object of the present invention is to provide a new and improved excavating machine, such as a backhoe, in which a plurality of hydraulic piston-cylinder actuators are utilized to move the boom when power is required and only part of the piston and cylinder actuators utilized to move the boom when a light load is being handled.

While the present invention is susceptible of various modifications and constructions and of use in various machines employing fluid pressure means for operating a boom or other working members, it is particularly useful in construction and material handling machines and is herein shown as incorporated in a backhoe.

Further objects and advantages of the present invention will be apparent from the following detailed description of the preferred embodiment of the present invention in which:

FIG. 1 is a perspective view of a material handling or construction machine embodying the present invention;

FIG. 2 is an enlarged fragmentary view illustrating the relationship of a boom of the machine of FIG. 1 to piston and cylinder means for moving the boom, a pull type piston and cylinder arrangement being shown in solid lines and a push type piston and cylinder arrangement being shown in dashed lines;

FIG. 3 is a plan view, taken approximately along the line 3–3 of FIG. 2, further illustrating the relationship of the piston and cylinder means of FIG. 2 to the boom;

FIG. 4 is a hydraulic circuit diagram schematically illustrating one embodiment of the invention wherein a pull type piston and cylinder arrangement is utilized to move the boom;

FIG. 5 is an enlarged sectional view of a relatively compact piston and cylinder assembly of the inside-outside cylinder type for moving the boom of the machine of FIG. 1;

FIG. 6 is a hydraulic circuit diagram schematically illustrating an embodiment of the invention wherein piston and cylinder assemblies of the type illustrated in FIG. 5 are utilized to move the boom;

FIG. 7 is a hydraulic circuit diagram schematically illustrating an embodiment of the invention wherein a push type piston and cylinder arrangement is used to move the boom; and

FIG. 8 is a hydraulic circuit diagram schematically illustrating another embodiment of the invention wherein a push type piston and cylinder arrangement is used to move the boom.

The present invention provides a machine having a load carrying member which is moved by operation of piston and cylinder means. Operation of the piston and cylinder means is controlled by a main control valve and a speed-power control valve. The main control valve is selectively operable from a neutral condition in which the load carrying member is held in a selected position to either one of two operating conditions to effect a movement of the load carrying member in either of two directions. The second or speed-power control valve is selectively operable between a high speed-low power condition and a low speed-high power conditon to effect either high or low speed movement of the load carrying member when the main valve is in one of its operating conditions. The speed-power control valve is manually actuated between its operating conditions to allow the valve to be maintained in a selected operating condition. This enables the load carrying member to be moved in a smooth and uniform manner while being subjected to a load which varies in magnitude.

Although the present invention can be utilized in many different types of machines, it is illustrated in FIG. 1 in association with a material handling machine **10** which is commonly called a backhoe. The backhoe **10** has a plurality of pivotally mounted load carrying members including a boom **12**, dipper stick **14** and bucket or tool **16**. The boom **12**, dipper stick **14** and bucket or tool **16** can be moved relative to each other by associated hydraulic piston and cylinder means to enable material to be moved or otherwise operated on by the bucket. Accordingly, a suitable piston and cylinder means (not

shown) is mounted on the dipper stick **14** for pivoting the bucket **16** or other tool about a connection **20** between the dipper stick and bucket. The dipper stick **14** and bucket **16** can both be pivoted relative to the boom **12** about a connection **22** upon operation of a piston and cylinder means **24**. Similarly, the boom **12**, dipper stick **14** and bucket **16** are all pivotal about a connection **28** under the influence of a piston and cylinder means **30**. The pivot connection **28** is formed by a shaft **34** which extends through opposite sides **36** and **38** of the boom **12** (see FIGS. **2** and **3**) into engagement with support plates **42** and **44** which project upwardly from a rotatable platform **46**.

The piston and cylinder means **30** for moving the boom **12** can include either push and/or pull type piston and cylinder arrangements. Thus, pull type piston and cylinder assemblies **50**, **52** and **54** are illustrated in solid lines in FIGS. **2** and **3** as having cylinders **58**, **60** and **62** pivotally connected to a rod **66** mounted on the platform **46**. Piston rods **70**, **72** and **74** of the piston and cylinder assemblies **50**, **52** and **54** are pivotally connected to shaft **78** extending between the opposite sides **36** and **38** of the boom **12**. Suitable pistons on inner ends of the piston rods **70** through **74**, cooperate with the cylinders **58** through **62** to form working chambers into which fluid is conducted under pressure to effect an expansion or contraction of the piston and cylinder assemblies in a known manner. The piston and cylinder assemblies **50**, **52** and **54** are contracted to pivot the boom **12** inwardly or upwardly in a clockwise direction as viewed in FIG. **2** and are expanded to pivot the boom **12** outwardly or downwardly in a counterclockwise direction as viewed in FIG. **2**.

Piston and cylinder assemblies **82** and **84** can be pivotally connected to the boom **12** at their cylinder ends by a shaft **88** in the push type arrangement illustrated in dashed lines in FIGS. **2** and **3**. The push type piston and cylinder assemblies **82** and **84** also include piston elements which cooperate with cylinders **89** and **90** to form working chambers into which fluid is conducted under pressure to effect an expansion or contraction of the piston and cylinder assemblies in a known manner. Of course, the boom **12** is pivoted inwardly or upwardly (see FIG. **2**) by expanding the push type cylinder assemblies **82** and **84** and is pivoted outwardly or downwardly by contracting the push type piston and cylinder assemblies. Although both push and pull type cylinder assemblies have been illustrated in FIGS. **2** and **3** in association with the boom **12**, it is contemplated that only one type of piston and cylinder assembly, that is either the push or the pull type, may be used for moving the boom **12** relative to the platform **46**.

The efficient handling of materials by the backhoe **10** requires that the bucket **16** or other tool be moved quickly with the expenditure of relatively little power to position the bucket adjacent to a load and to move or transport relatively light loads. Conversely, when the bucket **16** engages a relatively heavy load, it is frequently desirable to move the bucket at a slower speed with greater power. When the bucket **16** or other tool is operating on a load which varies, for example the bucket is being used to dig through materials of varying densities, the load to which the bucket, dipper stick **14** and boom **12** are subjected to varies in magnitude. In order to provide for a smooth or uniform operation of the backhoe **10**, the bucket **16** or other tool should be moved at a relatively slow speed so that the requisite power is available to enable the bucket to operate or dig smoothly and continuously upon the materials of varying densities.

To provide these operational characteristics, the piston and cylinder means **30** is selectively operable by a control assembly **92** (see FIG. **4**) to move the boom **12** with either high speed-low power operating characteristics or low speed-high power operating characteristics. The high speed operating characteristics are obtained by flowing fluid at a relatively high rate into only some of the working chambers formed in the piston and cylinder assemblies to thereby apply fluid pressure to a relatively small operating area of the piston and cylinder assemblies. The boom **12** is moved at a somewhat slower speed by actuation of the control assembly **92** to apply fluid pressure to a larger operating area by a somewhat slower rate of fluid flow into a greater number of working chambers of the piston and cylinder assemblies.

The control assembly **92** (FIG. **4**) includes a first or main valve **96** which is manually actuatable by operation of a lever **98** from a neutral condition to either one of two operating conditions to activate the piston and cylinder means **30** to move the boom **12** either inwardly or outwardly. When the main valve **96** is in the neutral condition illustrated in FIG. **4**, the boom **12** is retained or held in a position to which it had been previously moved by operation of the piston and cylinder means **30**. The boom **12** is held against movement by blocking fluid flow to and from working chambers or end portions of the cylinders **58**, **60** and **62**. Thus, fluid flow to and from the working chambers or rod end portions **102** and **104** through the conduits **106**, **108** and **110** is blocked by the main valve **96**. Fluid flow from the head end portion or working chamber **112** of the cylinder **60** through the conduit **116** is also blocked by the main valve **96**. Since fluid flow from the rod end working chambers **102** and **104** of the cylinders **58** and **62** is blocked and fluid flow from the head end working chamber **112** of the cylinder **60** is blocked, the shaft **78** and boom **12** are securely retained against pivoting movement relative to the platform **46**.

When the boom is being used to handle relatively light loads where maximum power is not required, the boom **12** is moved inwardly or upwardly at a high speed by communicating the rod end working chambers **102** and **104** of the piston and cylinder assemblies **50** and **54** with a source of fluid under pressure, *i.e.* a pump **122**, through the main control valve **96**. Since maximum power is not required, rod and head end working chambers **124** and **112** of the piston and cylinder assembly **60** are exhausted to drain or reservoirs so that the piston and cylinder assembly **52** is not operated to effect movement of the boom **12**. This results in high speed operation of the piston and cylinder assemblies **50** and **54** since the entire output of the pump **122** flows at a relatively high rate into only the two rod end working chambers **102** and **104**. It should be noted that head end working chambers **126** and **128** of the piston and cylinder assemblies **50** and **54** are continuously in fluid communication with drain or fluid reservoir **130** and **132** through conduits **134** and **136** to enable pistons **138** and **140** to move in the cylinders **58** and **62** upon the application of fluid pressure to the rod end working chambers **102** and **104**.

To initiate relatively high speed inward or upward pivoting movement of the boom **12**, the lever **98** is manually operated to move a valve spool **148** of the main valve assembly **96** to the right as viewed in FIG. **4** against the influence of a spring assembly **150**. This movement of the valve spool **148** aligns the passage **152** in the valve spool with the conduit **110** to thereby connect the rod end working chambers **102** and **104** of the cylinders **58** and **62** in fluid communication with the pump **122** through the passage **152** and the conduits **106**, **108**, **110** and **158**. Similarly, a second passage **162** in the valve spool **148** is aligned with conduit **116** to connect the head end working chamber **112** of the cylinder **60** in fluid communication with a reservoir or drain **166** through conduits **116** and **170**. The rod end working chamber **124** of the cylinder **60** is connected to a drain or fluid reservoir **174** through conduits **176** and **178** and a passage **180** in a second or speed-power control valve **184**. Therefore, fluid pressure against operating areas **188** and **190** formed on the rod ends of the pistons **138** and **140** forces the pistons inwardly of the cylinders **58** and **62** to contract the piston and cylinder assemblies **50** and **54** and move the boom **12** upwardly or inwardly. Since fluid under pressure is being conducted from the pump **122** to only the piston and cylinder assemblies **50** and **54**, there is a relatively high rate of fluid flow to each of these piston and cylinder assemblies to pivot the boom **12** at a relatively high speed.

If power operation is required, fluid is also conducted to the working chamber **124** to apply pressure to an operating area

192 on a piston 194 of the piston and cylinder assembly 52. Of course, this increases the available force or power for moving the boom 12 inwardly or upwardly. However, since fluid must now be pumped into the rod end working chambers 102, 124 and 104 of the piston and cylinder assemblies 50, 52 and 54, the rate of fluid flow into each of the working chambers is lower than when fluid was being pumped into only the working chambers 102 and 104 of the piston and cylinder assemblies 50 and 54. Therefore, the piston and cylinder assemblies 50, 52 and 54 are contracted at a relatively slow speed and the boom 12 is moved at a relatively slow speed relative to the platform 46.

Fluid pressure is applied against the operating area 192 of the piston 194 by actuating the speed-power control valve 184 to connect the rod end working chamber 124 of the cylinder 60 in fluid communication with the pump 122 through the main control valve 96. Thus, upon manual actuation of a control lever 200, a valve spool 202 of the speed-power control valve 184 is moved toward the right as viewed in FIG. 4 to connect the rod end working chamber 124 of the cylinder 60 in fluid communication with the pump 122 through the conduit 176, a passage 204 formed in the valve spool 202, a conduit 208, the passage 152 formed in the now actuated main control valve 96, and the fluid conduit 158. If desired, a suitable detent can be associated with the valve spool 202 to retain the speed-power control valve 184 in the actuated condition.

The boom 12 is moved downwardly or outwardly by exhausting the rod end working chambers 102, 144 and 104 of the piston and cylinder assemblies 50, 52 and 54 to drain and conducting fluid under pressure to the head end working chamber 112 of the piston and cylinder assembly 52. Fluid pressure is then applied against an operating surface 212 on the piston 194 to extend the piston and cylinder assembly 52 and the piston and cylinder assemblies 50 and 54 which are interconnected by the shaft 78. Since only the piston and cylinder assembly 52 is operated to pivot the boom 12 outwardly or downwardly, the head end working chamber 112 is quickly filled with fluid to effect high speed movement of the boom 12.

Outward or downward movement of the boom 12 is initiated by moving the actuating lever 98 of the main valve 96 toward the left, as viewed in FIG. 4, to connect the conduit 110 in communication with the drain 166 through a passage 216 formed in the spool 148. This exhausts the rod end working chambers 102 and 104 of the piston and cylinder assemblies 50 and 54 to the drain 166 through conduits 106, 108, 110, and 170. In addition, the pump 122 is connected in fluid communication with the head end working chamber 112 of the cylinder 60 through a passage 218 formed in the valve spool 148 and the fluid conduits 158 and 116. If the speed-power control valve 184 is in the high speed operating condition shown in FIG. 4, the rod end working chamber 124 of the cylinder 60 is connected to the drain 174 through the passage 180 in the valve spool 202 independently of the main control valve 96. However, if the speed-power control valve 184 is in the low speed operating condition, the rod end working chamber 124 of the cylinder 60 is connected to the drain or fluid reservoir 166 through the passage 204 in the valve spool 202, the conduit 208, the passage 216 formed in the valve spool 148 of the main control valve 96, and the conduit 170. Therefore, upon operation of the main control valve to the second operated condition, *i.e.* toward the left as viewed in FIG. 4, the rod end working chambers 102, 124 and 104 of the piston and cylinder assemblies 50, 52 and 54 are all exhausted to drain to enable fluid pressure against the operating surface or area 212 of the piston 194 to move the boom 12 outwardly.

From the foregoing description it can be seen that the control assembly 92 is selectively operable to apply fluid pressure against the operating areas or surfaces 188 and 190 to effect a relatively high speed-low power inward pivoting movement of the boom 12. By actuating the speed-power control valve 184, the operating surface or area 192 is connected in fluid communication with the pump 122 through the control valves 184 and 96. While this results in a decrease in the speed at which the boom 12 is moved by the piston and cylinder assemblies 50, 52, and 54, the potential power available for moving the boom is increased due to the application of fluid pressure against the operating area 192. If the boom 12 is subjected to varying loads, that is loads that vary substantially in magnitude, the speed-power control valve 184 can be operated to the actuated condition to provide for a uniform, though slow, movement of the boom 12 even though the load to which it is subjected varies during this pivoting movement.

The piston and cylinder assembly 82 (FIG. 5) is of the inside-outside cylinder type. This type of piston and cylinder assembly may well be preferred to the piston and cylinder assemblies 50 through 54 since the piston and cylinder assembly 82 is relatively compact and, for certain purposes at least, has been found to have superior control characteristics. The piston and cylinder assembly 82 includes an annular piston 250 which is slidably positioned in a cylinder 252 to form head and rod end working chambers 254 and 255. A hollow piston rod 256 is fixedly secured to the piston 250 and projects outwardly from a rod end portion 258 of the cylinder 252. The hollow piston rod 256 has a piston area 262 formed on the outward end portion thereof. This piston area is connected in fluid communication with an end chamber 264 at the head end 266 of the cylinder 252 by a central tube 270. The tube 270 is fixedly secured to an end plate 274 and slidably engaged by the piston 250. A seal 278 on the piston 250 prevents fluid communication between the head end working chamber 254 and a working chamber 280 which includes the chamber 264 and the interior of the hollow piston rod 256.

The piston and cylinder assembly 84 (FIG. 6) is identical in construction with the piston cylinder assembly 82 and includes a cylinder 282 in which a piston 284 is slidably mounted. A hollow piston rod 286 is fixedly connected to the piston 284 and has a piston area 288 which is exposed to fluid conducted through a tube 292 fixedly secured to the head end of the cylinder 282 and extending through the piston 284.

The piston and cylinder assemblies 82 and 84 are selectively operable to move the boom 12 in much the same manner as was previously explained in connection with the piston and cylinder assemblies 50, 52 and 54. Thus, the piston and cylinder assemblies 82 and 84 can be operated to move the boom 12 inwardly or upwardly with either a high speed-low power stroke or a low speed-high power stroke. The piston and cylinder assemblies 82 and 84 can also be operated to move the boom 12 outwardly. In addition, the piston and cylinder assemblies 82 and 84 function to retain the boom 12 in a selected operated position.

The operation of the piston and cylinder assemblies 82 and 84 is selectively controlled by an assembly 296 which is substantially identical to the control assembly 92 of FIG. 4. To avoid prolixity of description, elements of the control assembly 296 which are the same as elements of the control assembly 92 will be designated with similar numerals, the suffix letter *a* being added to the numerals used to designate the elements of the control assembly 296 to avoid confusion.

The control assembly 296 includes a first or main control valve 96*a* which is selectively actuatable by a manual lever 98*a* to move a valve spool 148*a* from the illustrated neutral position to either one of two operating conditions to move the boom 12 either inwardly or outwardly. When the main control valve 96*a* is in the neutral position the boom 12 is retained against pivoting movement by the piston and cylinder assemblies 82 and 84. The main control valve 96*a* is actuatable to a first operated condition by manually moving the lever 98*a* toward the right, as viewed in FIG. 6, to initiate inward or upward movement of the boom 12. Similarly, the main control valve 96*a* is actuatable to a second operated condition by manually moving the lever 98*a* toward the left, as viewed in FIG. 6, to initiate outward or downward movement of the boom 12. A second or speed-power control valve 184*a* is selectively operable by a manual control lever 200*a* from a high speed-low power operating condition (illustrated in FIG. 6) to a low speed-high power operating condition.

When the main control valve 96*a* is in the neutral position illustrated in FIG. 6, the main control valve blocks fluid flow through conduit 300 extending from the head end working chamber 254 of the cylinder 252 and through the conduit 304 connected to the head end working chamber 308 of the cylinder 282. Similarly, the main control valve also blocks fluid flow through the conduits 312, 314 from the rod end working chambers 255 and 318 of the piston and cylinder assemblies 82 and 84. Since fluid flow is blocked from both rod end and head end working chambers 254, 308, 255 and 318 of the piston and cylinder assemblies 82 and 84, the boom 12 is retained against movement by the piston and cylinder assemblies 82 and 84. It should be noted that working chambers 280 and 320 within the piston rods 256 and 286 are connected in fluid communication with reservoir 174*a* through conduits 322, 324 and a passage 180*a* of the speed-power control valve 184*a* when the control valve 184*a* is in the high speed-low power operated condition of FIG. 6.

To initiate relatively high speed inward or upward pivoting movement of the boom 12, the lever 98*a* is manually operated to move a valve spool 148*a* of the main valve assembly 96*a* to the right as viewed in FIG. 6 against the influence of a spring assembly 150*a*. This movement of the valve spool 148*a* aligns a passage 152*a* in the valve spool with the conduit 110*a* to thereby connect the head end working chambers 254 and 308 of the cylinders 252 and 282 in fluid communication with pump 122*a* through passage 152*a* and the conduits 300, 304, 110*a* and 158*a*. Similarly, a second passage 162*a* in the spool 148*a* is aligned with conduit 116*a* to connect the rod end working chambers 255 and 318 of the cylinders 252 and 282 in fluid communication with a reservoir or drain 166*a* through the conduits 312, 314 and 170*a*. The working chambers 280 and 320 within the piston rods 256 and 286 are connected to a drain or fluid reservoir 174*a* through the conduits 322, 324 and 178*a* and a passage 180*a* in the unactuated second or speed-power control valve 184*a*. Therefore, fluid pressure against operating areas 328 and 330 formed on the head ends of the cylinders 252 and 282 forces the cylinders outwardly from pistons 250 and 284 to expand the piston and cylinder assemblies 82 and 84 and move the boom 12 upwardly or inwardly. Since fluid under pressure is being conducted from the pump 122 to only the working chambers 254 and 308 of piston and cylinder assemblies 82 and 84, there is a relatively high rate of fluid flow to each of these piston and cylinder assemblies to pivot the boom 12 at a relatively high speed.

If power operation is required, fluid is also conducted to the working chambers 280 and 320 to apply pressure to operating areas 332 and 334 on the cylinders 252 and 282 and piston areas 262 and 288 on the piston rods 262 and 288. Of course, this increases the available force or power for moving the boom 12 inwardly or upwardly. However, since fluid must now be pumped into the working chambers 280 and 320 of the piston and cylinder assemblies 82 and 84 as well as into the working chambers 254 and 308, the rate of fluid flow into each of the working chambers is lower than when fluid was being pumped into only the working chambers 254 and 308 of the piston and cylinder assemblies 82 and 84. Therefore, the piston and cylinder assemblies 82 and 84 are expanded at a relatively slow speed and the boom 12 is moved at a relatively slow speed relative to the platform 46.

Fluid pressure is applied against the operating areas 332 and 334 of the cylinders 252 and 282 by actuating the speed-power control valve 184*a* to connect the working chambers 280 and 320 in fluid communication with the pump 122*a* through the main control valve 96*a*. Thus, upon manual actuation of the control lever 200*a*, a valve spool 202*a* of the speed-power control valve 184*a* is moved toward the right as viewed in FIG. 6 to connect the working chambers 280 and 320 of the piston and cylinder assemblies 82 and 84 in fluid communication with the pump 122*a* through the conduits 322 and 324, a passage 204*a* formed in the valve spool 202*a*, a conduit 208*a*, the passage 162*a* formed in the now actuated main control valve 96*a*, and the fluid conduit 158*a*. If desired, a suitable detent can be associated with the valve spool 202*a* to retain the speed-power control valve 184*a* in the actuated condition.

The boom 12 is moved downwardly or outwardly by exhausting the working chambers 254, 308, 280, and 320 of the piston and cylinder assemblies 82 and 84 to drain and conducting fluid under pressure to the rod end working chambers 255 and 318 of the piston and cylinder assemblies 82 and 84. Fluid pressure is then applied against operating surfaces 336 and 338 on the cylinders 252 and 282 to contract the piston and cylinder assemblies 82 and 84 which are interconnected by the shaft 88. Since only the working chambers 255 and 318 of the piston and cylinder assemblies 82 and 84 are utilized to pivot the boom 12 outwardly or downwardly, the working chambers are quickly filled with fluid to effect high speed movement of the boom 12.

Outward or downward movement of the boom 12 is initiated by moving the actuating lever 98*a* of the main valve 96*a* toward the left, as viewed in FIG. 6, to connect the conduit 110*a* in communication with the drain 166*a* through a passage 216*a* formed in the spool 148*a*. This exhausts the head end working chambers 254 and 308 of the piston and cylinder assemblies 80 and 82 to the drain 166*a* through conduits 300, 304, 110*a* and 170*a*. In addition, the pump 122*a* is connected in fluid communication with the rod end working chambers 255 and 318 of the cylinders 252 and 282 through a passage 218*a* formed in the valve spool 148*a* and the fluid conduits 312, 314 and 116*a*. If the speed-power control valve 184*a* is in the high speed operating condition shown in FIG. 6, the working chambers 280 and 320 of the cylinders 252 and 282 are connected to the drain 174*a* through the passage 180*a* in the valve spool 202*a* independently of the main control valve 96*a*. However, if the speed-power control valve 184*a* is in the low speed operating condition, the working chambers 280 and 320 of the cylinders 252 and 282 are connected to the drain or fluid reservoir 166*a* through the passage 204*a* in the valve spool 202*a* the conduit 208*a*, the passage 216*a* formed in the valve spool 148*a* of the main control valve 96*a* and the conduit 170*a*. Therefore, upon operation of the main control valve to the second operated condition, *i.e.* toward the left as viewed in FIG. 6, the working chambers 254, 308, 280 and 320 of the piston and cylinder assemblies 82 and 84 are all exhausted to drain to enable fluid pressure against the operating surfaces or areas 336 and 338 of the cylinders 252 and 282 to move the boom 12 outwardly.

From the foregoing description it can be seen that the control assembly 296 is selectively operable to apply fluid pressure against the operating areas or surfaces 328 and 330 to effect a relatively high speed-low power inward pivoting movement of the boom 12. By actuating the speed-power control valve 184*a*, the operating surfaces or areas 332 and 334 are connected in fluid communication with the pump 122*a* through the control valves 184*a* and 96*a*. While this results in a decrease in the speed at which the boom 12 is moved by the piston and cylinder assemblies 82 and 84, the potential power available for moving the boom is increased due to the application of fluid pressure against the operating areas 332 and 334. If the boom 12 is subjected to varying loads, that is loads that vary substantially in magnitude, the speed-power control valve 184*a* can be operated to the actuated condition to provide for a uniform, though slow, movement of the boom 12 even though the load to which it is subjected varies during this pivoting movement.

From the foregoing description of the piston and cylinder assemblies 82 and 84 it can be seen that each of the piston and cylinder assemblies includes three operating areas, *i.e.* the operating areas 328, 336 and 332 for the piston cylinder assembly 82 and the operating areas 330, 338 and 334 for the piston cylinder assembly 84. These areas correspond to operating areas provided by either one of the two piston and cylinder assemblies 50 and 54 and the piston and cylinder assembly 52. Thus, the operating areas 328 and 330 of the piston and cylinder assemblies 82 and 84 correspond to the operating areas 188 and 190 of the piston and cylinder assemblies 50 and 54 of FIG. 4. The operating areas 336 and 338 of the piston and cylinder assemblies 82 and 84 correspond to the operating area 212 of the piston and cylinder assembly 52.

Finally, the operating areas **332** and **334** of the piston and cylinder assemblies **82** and **84** correspond to the operating area **192** of the piston and cylinder assembly **52** of FIG. **4**. Although the piston and cylinder assemblies **82** and **84** have been described herein as being of the push type with the operating areas **328** and **330** formed on the cylinders **252** and **282**, the positions of the piston and cylinder assemblies **82** and **84** could be reversed so that the piston rods **256** and **286** are connected to the shaft **88** and moved outwardly relative to the cylinders **252** and **282** rather than the cylinders being moved relative to the pistons and piston rods in the manner previously described. The operating areas **328** and **330** will then be formed on the head sides of the pistons **250** and **284**. The operating areas **336** and **338** would be formed on the rod sides of the pistons **250** and **284**. The operating areas **332** and **334** would be formed by the piston areas **262** and **288** on the hollow piston rods **256** and **286**. Of course, the piston and cylinder assemblies **82** and **84** could be mounted in such a manner as to function as pull type assemblies.

In the embodiment of the invention illustrated in FIG. **7**, push type piston and cylinder assemblies **400**, **402** and **404** are shown connected to the shaft **88** extending between the sides **36** and **38** of the boom **12**. The piston and cylinder assemblies **400**, **402** and **404** are of the same construction as the piston and cylinder assemblies **50**, **52** and **54** of FIG. **4**. Therefore, to avoid needless prolixity of description elements of the embodiment of FIG. **7** which are similar to the elements of the embodiment of FIG. **4** will be designated with similar numerals, the suffix letter *b* being added to the numerals to avoid confusion.

The operation of the piston and cylinder assemblies **400** through **402** is regulated by a control assembly **92***b* which includes a first or main control valve **96***b* and a second or speed-power control valve **184***b*. When the main control valve **96***b* is in the neutral condition of FIG. **7** fluid flow to and from head end working chambers **408** and **412** in the cylinders **400** and **404** is blocked by valve spool **148***b*. Similarly, the valve spool **148***b* blocks fluid flow to and from the rod end working chamber **414** of the cylinder **402** to hold or retain the boom **12** in a selected operating position.

Upon operation of the main control valve **96***b* to an inward or upward operated condition by pivoting control lever **98***b* toward the right as viewed in FIG. **7**, the head end working chambers **408** and **412** of the cylinders **58***b*, **60***b* and **62***b* are connected in fluid communication with pump **122***b* through passage **152***b* in the valve spool **148***b* to apply pressure to operating areas **418** and **420** of the cylinders **58***b* and **62***b*. Rod end working chambers **424** and **426** of the cylinders **58***b* and **62***b* are connected in continuous fluid communication with drains **130***b* and **132***b*. Rod end working chamber **414** of the cylinder **60***b* is connected in fluid communication with the drain **166***b* through passage **162***b* formed in the valve spool **148***b*. If the boom is to be moved inwardly with a high speed-low power stroke, head end working chamber **430** of the cylinder **60***b* is connected in fluid communication with drain **174***b* through passage **180***b* in valve spool **202***b* of the speed-power control valve **184***b* independently of the main control valve **96***b*. However, if a low speed-high power movement of the boom **12** is desired, the speed-power control valve **184***b* is operated to an actuated condition by manual pivoting movement of a control lever **200***b* to communicate an operating area **434** on the cylinder **60***b* with the pump **122***b* through a passage **204***b* in the spool **202***b*, conduit **208***b* and passage **152***b* in the spool **148***b* of the main control valve **96***b*.

The direction of movement of the boom **12** can be reversed to move the boom outwardly by actuating the manual control lever **98***b* toward the left as viewed in FIG. **7**. This exhausts the head end working chambers **408** and **412** of the cylinders **58***b* and **62***b* to the drain **166***b* through the passage **216***b* in the valve spool **148***b*. The head end working chamber **430** of the cylinder **60***b* is exhausted through the passage **180***b* to the drain **174***b* when the speed-power control valve **184***b* is in the high speed operated position of FIG. **7**. If the control valve **184***b* is operated to the high power condition, the working chamber **430** of the cylinder **60***b* is exhausted to the drain **166***b* through the passage **204***b* of the control valve **184***b* and the passage **216***b* of the control valve **96***b*. An operating surface **440** on the cylinder **60***b* is connected in fluid communication with the pump **122***b* through passage **218***b* in the valve spool **148***b* to positively retract the piston and cylinder assembly **402** and move the boom **12** downwardly or outwardly.

The embodiment of the invention illustrated in FIG. **8** is generally similar to the embodiment illustrated in FIG. **7**. Therefore, similar components have been designated with similar numerals, the suffix letter *c* being added to the numerals associated with the components of the embodiment illustrated in FIG. **8** to avoid confusion.

The embodiment of the invention illustrated in FIG. **8**, includes cylinder assemblies **400***c* and **404***c* which are both activated to move the boom **12** either inwardly or outwardly. Thus, when the control lever **98***c* is moved to the left as viewed in FIG. **8**, pump **122***c* is connected in fluid communication with rod end working chambers **424***c* and **426***c* of cylinders **58***c* and **62***c*. This results in fluid pressure being applied against operating areas **500** and **502** of the cylinders **58***c* and **62***c* to positively move the boom **12** outwardly or downwardly. It is believed that it will be apparent that the operating areas **500** and **502** correspond to the operating area **440** in the embodiment of FIG. **7**. However, the combined operating areas **500** and **502** are substantially larger than the operating area **440** to thereby provide for greater power on the outward stroke or movement of the boom **12**. The working chambers **424***c* and **426***c* of the cylinders **58***c* and **62***c* are exhausted through passage **162***c* to the drain **166***c* upon operation of the main control valve to move the boom **12** inwardly.

Although the rod end working chamber **414***c* of the cylinder **60***c* has been illustrated in FIG. **8** as being continuously connected to a drain **504**, it is contemplated that the rod end working chamber **414***c* of the cylinder **60***c* could be connected through a suitable conduit, illustrated in dashed lines at **508** in FIG. **8**, with the main control valve **96***c* to enable fluid pressure to be applied against the operating area **510** of the cylinder **60***c* during the outward stroke of the boom **12**. Of course, the rod end working chamber **414***c* of the cylinder **60***c* would then be exhausted to the drain **166***c* upon operation of the main control valve **96***c* to allow the boom **12** to pivot inwardly.

In view of the foregoing description it can be seen that the boom **12** or other working member can be moved with either high speed-low power characteristics or low speed-high power characteristics by selectively actuating the speed-power control valve **184** when the main control valve **96** has been actuated to its first operating condition. To accomplish this, the control valves **96** and **184** are selectively actuatable to connect a relatively small operating area in fluid communication with the pump **122**. The associated piston and cylinder assemblies are then quickly operated upon an application of fluid pressure to the relatively small operating area. When increased power is desired, the operating area to which fluid pressure is applied is increased by actuating the speed-power control valve **184**. An additional operating area is then communicated with the pump **122** to increase the power which is available to move the boom **12** against a load to which it may be subjected.

The speed-power control valve **184** is manually actuatable to enable it to be maintained in either one of two operating conditions independently of the load to which the boom **12** is subjected at any given instant. This enables the boom **12** to be moved with a smooth uniform motion when it is being subjected to a load which varies in magnitude. It should be noted that the speed-power control valve **184** is operable to connect at least one working chamber of at least one of the piston and cylinder assemblies directly to drain independently of the main control valve **96**. This enables the speed-power control valve **184** to be actuated to increase the available power for moving the boom **12** by connecting the previously exhausted working chamber in fluid communication with the pump **122**.

I claim:

1. In a machine, a movable load carrying member to be subjected to different loads, fluid pressure actuating means for moving said load carrying member, and control means for selectively controlling the operation of said fluid pressure actuating means, said fluid pressure actuating means including piston and cylinder means having a plurality of operating areas against which fluid may act, said piston and cylinder means including a cylinder, a piston slidably mounted within said cylinder to form a first fluid chamber between one end portion of said cylinder and said piston and a second fluid chamber between another end portion of said cylinder and said piston, said first fluid chamber being at least partially defined by a first operating area, said second fluid chamber being at least partially defined by a second operating area, a hollow piston rod connected to said piston and extending outwardly of said cylinder, tube means fixedly connected to said one end portion of said cylinder and extending through said piston into said hollow piston rod to form a third fluid chamber located at least partially within said hollow piston rod, said third fluid chamber being at least partially defined by a third operating area, said control means including first and second valve means selectively operable between a plurality of operating conditions, said first valve means having a first operating condition blocking fluid flow toward and from said first and second operating areas of said piston and cylinder means, said second valve means having a first operating condition communicating said third operating area of said piston and cylinder means with drain when said first valve means is in its first operating condition, said first valve means having a second operating condition communicating said first operating area with a source of fluid under pressure and said second operating area to drain when said second valve means is in its first operating condition to thereby activate said piston and cylinder means to move said member in a first direction with a first speed, said second valve means being actuatable to a second operating condition to communicate said third operating area with said source of fluid under pressure when said first valve means is in its second operating condition to thereby activate said piston and cylinder means to move said member in the first direction with a second speed which is slower than said first speed.

2. In a machine as set forth in claim 1 wherein said one end portion of said cylinder is connected to said load carrying member and said third operating area is at least partially formed by said one end portion of said cylinder.

3. In a machine, a movable load carrying member to be subjected to different loads, piston and cylinder means for effecting movement of said member, said piston and cylinder means including at least one cylinder operatively connected with said member and a piston assembly located at least partially within said cylinder and including a plurality of interconnected operating areas mounted for simultaneous movement relative to said one cylinder to thereby move said member, said piston and cylinder means including a cylinder, said piston assembly forming a first fluid chamber between one end portion of said cylinder and said piston assembly and a second fluid chamber between another end portion of said cylinder and said piston assembly, said first fluid chamber being at least partially defined by a first operating area, said second fluid chamber being at least partially defined by a second operating area, said piston assembly including a piston and a hollow piston rod connected to said piston and extending outwardly of said cylinder, tube means fixedly connected to said one end portion of said cylinder and extending through said piston into said hollow piston rod to form a third fluid chamber which is at least partially defined by said hollow piston rod and a third operating area, and control means for selectively controlling the speed of relative movement between said piston assembly and cylinder to thereby control the rate of movement of said member, said control means including first and second valve means selectively operable between a plurality of operating conditions, said first valve means having a first operating condition blocking fluid flow toward and from said first and second operating areas which are located on opposite sides of said piston assembly to thereby retard relative movement between said piston assembly and cylinder and to retain said member in a selected operated condition, said second valve means having a first operating condition communicating said third operating area of said piston assembly with drain, said first valve means having a second operating condition communicating said first operating area with a source of fluid under pressure and said second operating area to drain when said second valve means is in its first operating condition to thereby provide for relative movement between said piston assembly and cylinder to move said member in a first direction with a first speed, said second valve means being manually actuatable to a second operating condition independently of the fluid pressure communicated to said first operating area to communicate said third operating area with said source of fluid under pressure when said first valve means is in its second operating condition to thereby provide for relative movement between said piston assembly and cylinder to move said member in the first direction with a second speed which is slower than the first speed.