Dec. 16, 1958 E. DAWSON 2,864,313

HYDRAULIC INTENSIFIER

Filed April 24, 1957 3 Sheets-Sheet 1

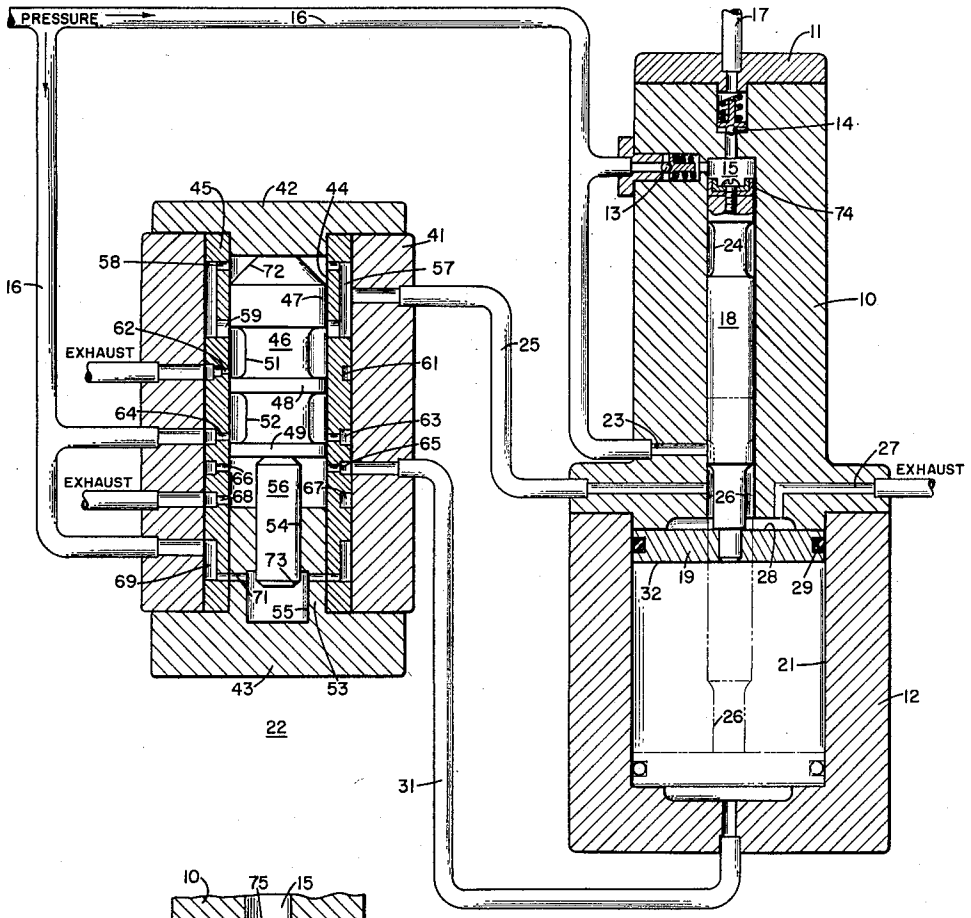


FIG. 1

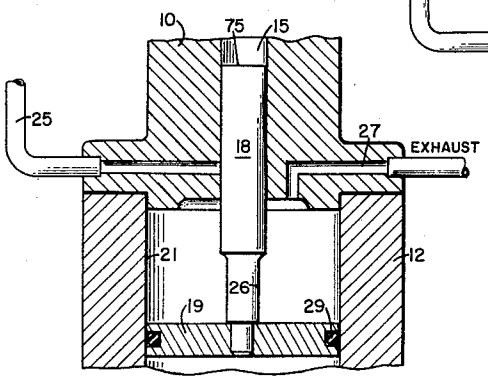


FIG. 2

EDWARD DAWSON

INVENTOR.

BY

G. D. O'Brien

V. C. Muller

ATTORNEYS

Dec. 16, 1958 E. DAWSON 2,864,313

HYDRAULIC INTENSIFIER

Filed April 24, 1957 3 Sheets-Sheet 2

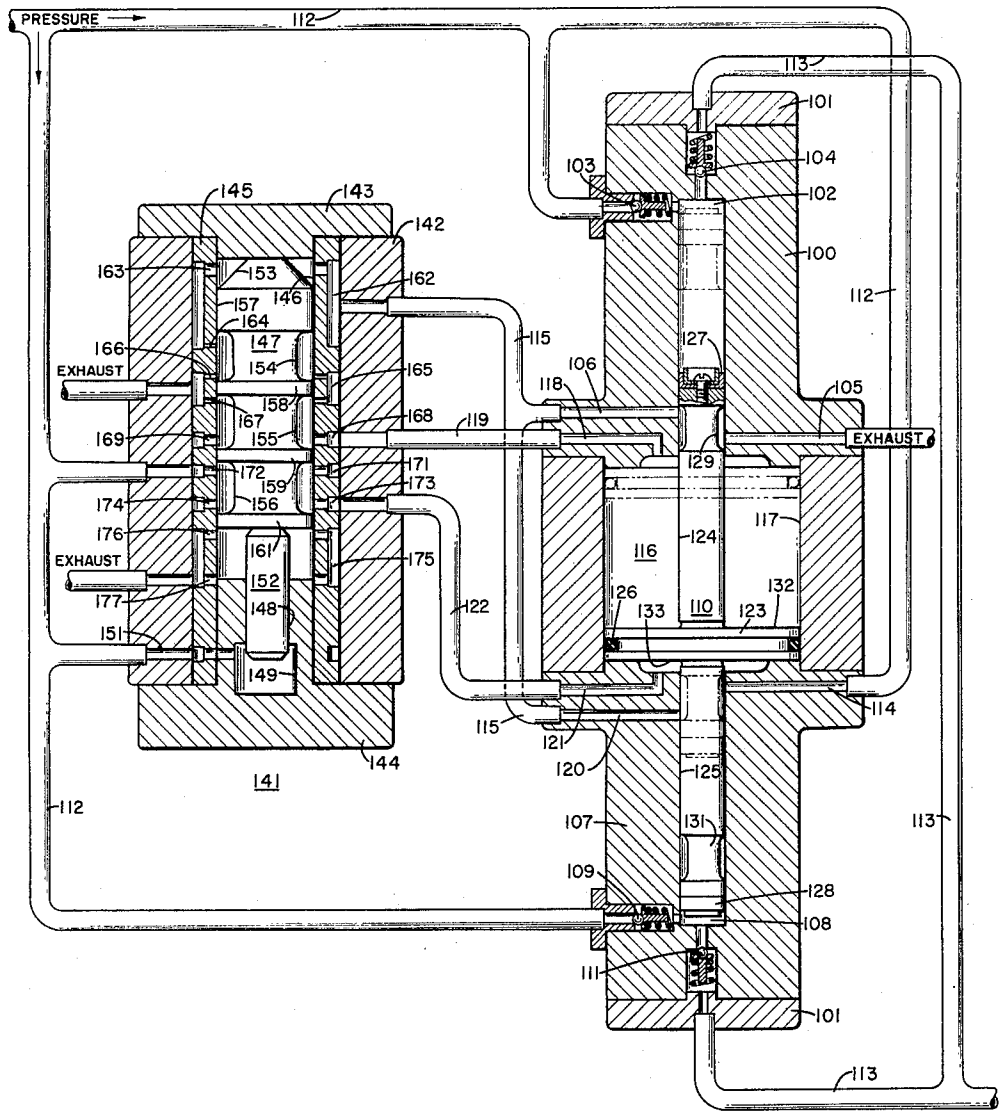


FIG. 3

EDWARD DAWSON

INVENTOR.

BY

ATTORNEYS

Dec. 16, 1958 E. DAWSON 2,864,313

HYDRAULIC INTENSIFIER

Filed April 24, 1957 3 Sheets-Sheet 3

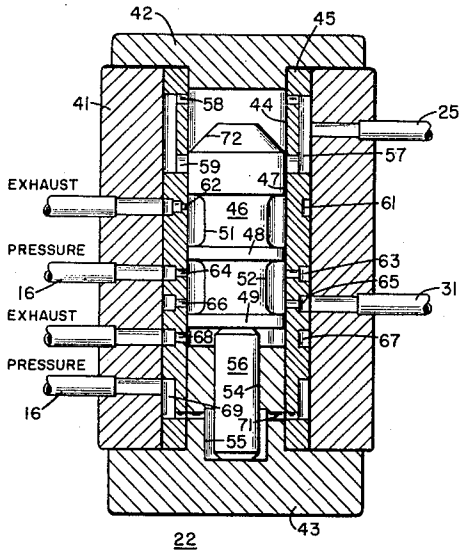


FIG. 4

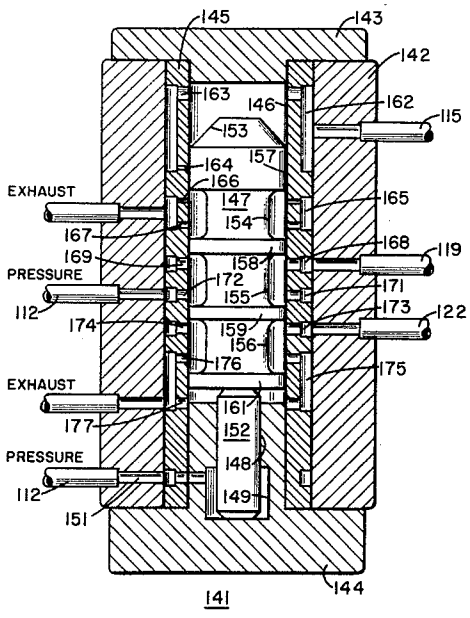


FIG. 5

EDWARD DAWSON

INVENTOR.

BY

ATTORNEYS

United States Patent Office 2,864,313 Patented Dec. 16, 1958

2,864,313

HYDRAULIC INTENSIFIER

Edward Dawson, State College, Pa., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Application April 24, 1957, Serial No. 654,977

13 Claims. (Cl. 103—51)

This invention relates to fluid pressure intensifying means and more particularly to hydraulic intensifiers for creating an elevated fluid pressure wherein the hydraulic intensifier is controlled by a single hydraulically operated control valve.

Prior art pressure intensifying means generally utilize more complex and expensive means to control the action of one or more pistons adapted to produce elevated fluid pressure.

The present invention is useful in substantially any application where elevated fluid pressures are desired, such as for example, to operate presses, rams and the like and the invention provides a highly dependable hydraulic intensifier that is simple in operation and economical to manufacture. The present invention may be mounted in any position and may be maintained in service for long periods of time without the necessity of adjustments or maintenance. The new and novel manner in which the hydraulic intensifier cooperates with the control piston provides a high degree of positive control and dependability and utilizes a lesser number of moving parts than heretofore. In addition, the new and novel manner of cooperation of the various components result in a hydraulic intensifier that cannot reach an undesirable point of equilibrium resulting in failure of the device to operate satisfactorily.

An object of the invention is to provide a new and improved hydraulic intensifier.

Another object of the invention is to provide an improved hydraulic intensifier and control means therefor.

It is another object of the invention to provide a new and improved hydraulic intensifier that is dependable in operation, that contains a minimum number of moving parts and that may be easily and economically manufactured.

A still further object of the invention is the provision of a hydraulic intensifier and control means therefor wherein the control means cooperates with the hydraulic intensifier in a new and novel manner to provide a simple and dependable control of the hydraulic intensifier that is rapid and positive in operation and that cannot reach an undesirable point of equilibrium.

Another object resides in the provision of a hydraulic intensifier that may be mounted in any position, that needs no adjustments and that may be used over long periods without attention.

These and other features of the invention together with their incident advantages, will be more readily understood and appreciated from the following detailed description of the preferred embodiments thereof selected for the purposes of illustration and shown in the accompanying drawings in which:

Figure 1 is a longitudinal section of the invention as applied to a single acting hydraulic intensifier showing the intensifier piston in solid lines in one extreme position and in phantom in its extreme opposite position and showing the hydraulic control device enlarged for purposes of illustration.

Figure 2 is a fragmentary sectional view of a modification of the high pressure cylinder and piston shown in Figure 1 for relatively low pressure applications.

Figure 3 is a longitudinal section of the invention as applied to a double acting hydraulic intensifier showing the intensifier piston in solid lines in one extreme position and in phantom in its extreme opposite position and showing the hydraulic control device enlarged for purposes of illustration.

Figure 4 is a fragmentary sectional view through the hydraulic control device of Figure 1 showing the control piston in its opposite extreme position.

Figure 5 is a fragmentary sectional view through the hydraulic control device of Figure 3 showing the control piston in its opposite extreme position.

In the embodiment of the invention illustrated in Figure 1 there is shown a high pressure cylinder 10 closed at one end by a wall 11 and integral at its opposite end with a low pressure cylinder 12 having an internal diameter greater than the internal diameter of the high pressure cylinder 10. A ball-check inlet valve 13 and a ball-check outlet valve 14 are provided in the upper portion of the high pressure cylinder and operatively associated with the bore 15 of the high pressure cylinder 10 to provide communication respectively between the bore 15 of the high pressure cylinder and the low pressure fluid conduit 16 and a high pressure fluid conduit 17. A high pressure piston 18 integral with a low pressure piston 19 are reciprocally disposed respectively in bores 15—21 and are operationally associated with a hydraulic control device 22 hereinafter described. A low pressure inlet passage 23 in communication with the low pressure fluid conduit 16 is provided in the lower portion of the high pressure cylinder 10 and operatively associated with a circumferential groove 24 provided on the upper portion of the high pressure piston 18 such that when the high pressure piston approaches its maximum downward position the low pressure inlet passage 23 will be placed exclusively in communication with a conduit 25 connecting the high pressure cylinder bore 15 and the hydraulic control device 22. A circumferential groove 26 is also provided on the lower portion of the high pressure piston 18 whereby conduit 25 will be placed in communication with an exhaust outlet 27 to drain or a sump (not shown) as the high pressure piston 18 approaches its maximum upward position. As shown in Figure 1, the circumferential groove 26 places conduit 25 in communication with the exhaust outlet 27 through the upper portion of the low pressure cylinder bore 21, but it is to be understood that such need not necessarily be the case. For example, a separate and different exhaust port may be provided for connecting conduit 25 to drain and exhaust port 27 may be retained to permanently connect the upper surface 28 of the low pressure piston 19 to drain whereby any fluid contained thereinabove may be exhausted. The inlet passage 23, conduit 25 and grooves 24—26 preferably should be arranged and formed such that groove 24 will connect the inlet passage 23 solely to conduit 25 and groove 26 will connect the conduit 25 solely to drain as the high pressure piston 18 just approaches its respective maximum downward and upward position. Low pressure piston 19 is preferably provided with an O ring 29 to prevent fluid seepage around the low pressure piston 19. Conduit 31 provides fluid communication between the low pressure piston lower surface 32 and the hydraulic control device 22 for the purposes hereinafter described.

The hydraulic control device 22 as shown in Figure 1 is comprised of a cylindrical casing 41 closed at both ends by walls 42—43 and is provided with an axially extending bore 44. A distributing sleeve 45 is secured within the cylindrical casing 41 and is provided with a

plurality of circumferentially extending grooves having ports therein which communicate between the respective grooves and the bore 44. A control piston 46 which is reciprocally mounted in bore 44 is provided with a plurality of axially spaced lands 47, 48, 49 which are adapted to form grooves 51—52.

A sleeve element 53 is secured in the lower portion of the distributing sleeve 45 and is provided with an axial passage 54 communicating with the bore 44 and a second bore 55. A thrust piston 56 is reciprocally disposed in passage 54 and is of such length and configuration as to engage the control piston 46 for upward movement in a manner hereinafter described. A first distributing sleeve groove 57 is connected through the conduit 25 with the lower portion of the high pressure cylinder 10 and through a plurality of ports 58—59 with the bore 44, ports 58 being disposed such that they are permanently in communication with bore 44 and ports 59 being disposed such that when the control piston is in its maximum upward position as shown in Figure 1 they are at least partially open to bore 44 and when the control piston 46 is approaching its maximum downward position as shown in Figure 4 they are closed by land 47. A second groove 61 is connected to exhaust and to the bore 44 through at least one port 62 disposed such that it is permanently in communication with the control piston groove 51 irrespective of the position of the control piston. A third groove 63 is connected to the source of fluid pressure through conduit 16 and to bore 44 through a plurality of ports 64. A fourth groove 65 is connected through conduit 31 to the low pressure cylinder bore 21 and through a plurality of ports 66 to the bore 44. A fifth groove 67 is connected to exhaust and to bore 44 through at least one port 68 and is disposed such that it is never closed irrespective of the position of the control piston 46. Groove 65 is disposed below groove 63 and groove 67 is disposed below groove 65 such that when the control piston 46 is approaching its maximum upward position as shown in Figure 1 conduit 31 is connected to exhaust via groove 65, ports 66, bore 44, port 68 and groove 67; and when the control piston 46 is approaching its maximum downward position as shown in Figure 4 conduit 31 is connected to the source of fluid pressure via conduit 16, groove 63, ports 64, groove 52, ports 66 and groove 65. A sixth groove 69 provides communication between the source of fluid pressure via conduit 16 and the lower portion of the thrust piston 56 through a plurality of ports 71 such that at least a transverse portion of the thrust piston 56 is continually exposed to the source of fluid pressure.

In the description following hereinbelow of the operation of the embodiment shown in Figure 1 it is initially assumed that the device is in normal operation and that the high pressure piston 18 is approaching its maximum downward position (shown in phantom) and that the control piston 46 is in its maximum upward position as shown in Figure 1. As will become more apparent hereinafter, when the high pressure piston 18 is moving downwardly the control piston 46 will always be in its up position as shown in Figure 1 and when the high pressure piston 18 is moving upwardly the control piston 46 will always be in its down position as shown in Figure 4. As the high pressure piston approaches its maximum downward position groove 24 will place conduit 25 in communication with conduit 16 thereby supplying low pressure fluid to the space between the frusto-conical surface 72 and the adjacent wall 42. When the pressure on the frusto-conical surface 72 of the control piston reaches a predetermined value the control piston 46 will begin to move in a downward direction. It will be noted that as the control piston 46 begins to move in a downward direction fluid is supplied to the bore 44 above and below land 47 and also exhausted in both instances through ports 59 and exhaust port 62. As the control piston begins to move downwardly land 47 progressively reduces

the exposed area of ports 59 thus causing the pressure on the frusto-conical surface 72 to increase rapidly. When ports 59 are substantially closed the pressure on surface 72 will build up rapidly and cause the control piston 46 to snap downwardly to its maximum down position as shown in Figure 4. If the exhaust port 62 has a diameter less than that of conduit 25, when groove 24 has opened conduit 25 to such an extent that the pressure at both points is such that the pressure exerted downwardly on surface 72 is just greater than the pressure exerted upwardly on the thrust piston 56, the control piston will begin to move downwardly and begin closing ports 59 as previously stated. Low pressure fluid is continuously supplied to at least one surface 73 of the lower portion of the thrust piston, hence the critical pressure at which the control piston will begin movement will depend upon the ratio of the exposed area of the top of the control piston to the exposed area of the bottom of the thrust piston. A 2:1 ratio will be found to be satisfactory for most applications and although the ratio may be varied to secure a desired sensitivity a ratio of 1:1 is not recommended. When the control piston approaches its maximum down position fluid will be trapped above surface 72 and the pressure exerted thereby will maintain the control piston in its maximum down position until relieved. As the control piston approaches its maximum down position the lower surface 32 of the low pressure piston 19 will be placed in communication with the low pressure fluid through conduit 31, groove 65, ports 66, groove 52, ports 64 and groove 63. The application of low pressure fluid to the lower surface 32 of the low pressure piston 19, due to increased area, will cause the high pressure piston 18 to move upwardly thereby closing conduit 25 and entraping the fluid and consequent pressure above surface 72. Ball-check valve 13 prevents the high pressure fluid from entering the low pressure line 16 and the ball-check valve 14 allows the high pressure fluid to enter the high pressure line 17. As may now be obvious the high pressure piston 18 will move upwardly until such time as groove 26 begins to open conduit 25. As the high pressure piston approaches its maximum upward position, groove 26 will begin to open conduit 25 thus allowing the fluid above surface 72 to be partially exhausted through conduit 25, groove 26 and exhaust outlet 27 and thence to a vented storage tank or sump, not shown in the drawing. When the pressure on surface 72 decreases to the critical pressure referred to hereinabove the control piston will begin to move in an upwardly direction due to the fluid pressure on surface 73 of the thrust piston 56. As the control piston moves upwardly it will begin to open ports 59 thus providing an additional passage for the fluid above surface 72 to be exhausted through exhaust port 62 to drain. When a sufficient area of ports 59 are exposed the control piston will snap to its maximum up position thereby connecting the fluid in contact with the lower surface 32 of the low pressure piston to exhaust through conduit 31, groove 65, ports 66, ports 68 and groove 67. It may now be obvious that once the pressure previously exerted on the lower surface 32 of the low pressure piston is removed the high fluid pressure entrapped in bore 15 will cause the high pressure piston to begin moving in a downwardly direction. The high pressure piston will now move downwardly due to the aforementioned high fluid pressure and will continue moving downwardly until such time as it reaches the fluid pressure in conduit 16. Thereafter, the fluid pressure in conduit 16, through ball-check valve 13, will continue forcing the high pressure piston to its maximum downward position. As the high pressure piston approaches its maximum downward position groove 24 will place conduits 16—25 in communication thereby causing the control piston to snap to its down position and the cycle to be repeated as described hereinabove.

The fluid pressure intensifying means as described here-

inabove is self-acting and will begin operation no matter where the high pressure piston or the control piston should stop or be located. Should the high pressure line be closed the control piston will not reach an undesirable point of equilibrium. If there is no leakage around the control piston, the entire system will remain in equilibrium until such time as the high pressure line is opened, at which time operation will immediately commence Should there be slight leakage of fluid from above surface **72** such as for example, through ports **59**, the control piston **46** will slowly begin to creep upwardly. When the control piston is substantially in its mid position ports **66** and hence conduit **31** is closed thus entrapping the fluid present below the lower surface **32** of the low pressure piston. If the fluid above surface **72** continues to leak out the control piston will continue to move upwardly thus beginning to open ports **59**. When a sufficient area of ports **59** have been exposed the control piston will snap to its upward position as previously described hereinabove thus causing the high pressure piston to move to its maximum downward position and thereby begin a new compression stroke. With properly fitting parts the time necessary to complete the above operation will be on the order of hours with no consequent loss in high pressure or detrimental effects. Although the operation of the control piston has been discussed as possessing two distinct steps it is to be understood that should they exist separately they will occur so close together in point of time that the control piston will immediately snap to its appropriate position as the high pressure piston approaches an extreme end position.

For the simplest and most economical construction for relatively low pressure applications the high pressure cylinder **10** and the high pressure piston **18** may be modified as shown in Figure 3 wherein the pressure seal **74** and groove **24** are eliminated thereby providing a substantially flat upper surface **75** on the high pressure piston **18** which performs the same function as groove **24**, the necessary fluid being supplied to conduit **25** through conduit **16**, ball-check valve **13** and bore **15**. In order that surface **75** may properly place conduit **25** in communication with bore **15** it may be obvious that the length of bores **15—21** and the high pressure piston **18** must be such that when the high pressure piston **18** approaches its maximum downward position surface **75** will be positioned below conduit **25** and above bore **21** thereby permitting the passage of fluid solely to conduit **25**.

There is shown in Figure 3 an embodiment of the invention as applied to a double acting hydraulic intensifier. As shown in Figure 3 the hydraulic intensifier comprises a first high pressure cylinder **100** closed at one end by a wall **101** and provided with an axial bore **102** and a ball-check inlet valve **103** and a ball-check outlet valve **104** in operational communication with the upper portion of the bore **102**. In the inner portion of the high pressure cylinder **100** there is provided a passage **105** connected to exhaust and connectable to passage **106** longitudinally offset from the exhaust passage **105** as hereinafter described. A second high pressure cylinder **107** substantially identical with the first high pressure cylinder **100** is oppositely disposed to and away from the said first high pressure cylinder whereby its bore **108** is in axial alignment with bore **102**. Ball-check inlet and outlet valves **109—111** are similarly provided in communication with bore **108**, the ball-check inlet valves **103—109** being connected to a source of fluid pressure (not shown) by a conduit **112** and the ball-check outlet valves **104—111** are connected by a conduit **113**. Passages **114—120** are similarly provided in the inner portion of the high pressure cylinder **107**, passage **114** being connected by conduit **112** to the source of fluid pressure and passage **120** being connected to passage **106** by means of conduit **115**. Integral with and axially disposed between the high pressure cylinders **100—107** is a low pressure cylinder **116** provided with a bore **117** having a diameter greater than the bores **102—108** of the high pressure cylinders, a passage **118** connecting the upper portion of the low pressure cylinder bore **117** to conduit **119** and a passage **121** connecting the lower portion of the low pressure cylinder bore **117** to conduit **122**.

A double acting piston **110** comprised of a low pressure piston **123** reciprocally mounted in bore **117** and integral with substantially identical high pressure pistons **124—125** reciprocally mounted respectively in bores **102—108** provide the means for supplying fluid at an elevated pressure to conduit **113**. An O ring **126** is provided on the low pressure piston **123** to provide a fluid seal between passages **118—121** and pressure seals **127—128** are provided on the outer end portions of high pressure pistons **124—125** to provide a seal at the high pressure pistons for the high pressure fluid. Although sealing means have been shown and described for the high pressure and low pressure pistons it is to be understood that such sealing means may well be modified or eliminated as the type of use and preference may dictate. A circumferential groove **129** is provided on the outer portion of the high pressure piston **124** and a substantially identical groove **131** is provided on the outer portion of the high pressure piston **128**. As shown in Figure 3 grooves **129—131** are so disposed and arranged that as the double acting piston approaches its maximum down position groove **129** will place passage **106** exclusively in communication with exhaust through passage **105** and as the double acting piston **110** approaches its maximum up position (shown in phantom) groove **131** will place passage **120** exclusively in communication with the source of fluid pressure through passage **114**.

The hydraulic control device **141** for the double acting piston **110** as shown in Figure 3 is similar in appearance to the hydraulic control device **22** as shown in Figure 1 in the provision and association of a cylindrical casing **142** closed at both ends by walls **143—144**, a distributing sleeve **145** secured within the cylindrical casing **142** and having an axial bore **146**, a control piston **147** reciprocally mounted in the distributing sleeve bore **146**, a passage **148** connecting bore **146**, and an enclosed space **149**, said space being in communication with the source of fluid pressure, a passage **151** and conduit **112**, and a thrust piston **152** reciprocally mounted in said passage **148** and adapted to operate in a manner substantially identical to that described for thrust piston **56**. As noted in connection with the description of the single acting hydraulic intensifier the thrust piston **152** has a diameter less than the maximum diameter of the control piston **147** and is formed such that when it is in either its up or down position there is exposed to the low pressure fluid a more or less transverse surface having an area less than the area of the control piston frusto-conical surface **153**.

The control piston **147** is provided with a frusto-conical upper surface **153**, circumferential grooves **154—155—156** formed by lands **157**, **158**, **159**, **161**, said grooves and land being disposed and formed to operate in the manner hereinafter described. The distributing sleeve **145** is provided with a first circumferential groove **162** in communication with conduit **115** and with bore **146** through ports **163** and at least one port **164**. Ports **163** provide continuous communication between groove **162** and bore **146**, while port **164** is disposed such that it is open when the control piston **147** approaches its maximum up position as shown in Figure 3 and it is closed when the control piston **147** approaches its maximum down position as shown in Figure 5. A second groove **165** connected to drain is provided with two sets of ports **166—167** communicating with bore **146**. Ports **166** and ports **167** are located such that when the control piston **147** is in its maximum up position ports **166** are in communication with the control piston groove **154** and ports **167** are in communication with the control piston groove **155** and when the control piston **147** is approaching its

maximum down position both sets of ports 166—167 are in communication with the control piston groove 154. A third groove 168 is provided with a plurality of ports 169 in communication with bore 146 and is also connected to conduit 119. A fourth groove 171 similarly provided with a plurality of ports 172 in communication with bore 146 and is connected to the source of fluid pressure by conduit 112. The above described third and fourth grooves 168—171 and their respective ports are located and formed such that when the control piston is approaching its maximum up position (Figure 3) the third groove 168 is placed in communication with exhaust through ports 169, control piston groove 155, ports 167 and groove 165, and when the control piston is approaching its maximum down position (Figure 5) the third groove 168 is placed in communication with the source of low pressure fluid via ports 169, control piston groove 155, ports 172 and groove 171. A fifth groove 173 is provided with ports 174 in communication with bore 146 and is connected to conduit 122. A sixth groove 175 is connected to exhaust and is provided with two sets of ports 176—177 in communication with bore 146. The ports 174 in communication with the fifth groove 173, the ports 176 in communication with the sixth groove 175, and the ports 172 in communication with the fourth groove 171 are located such that when the control piston is approaching its maximum up position the source of low pressure fluid is placed in communication with conduit 122 via groove 171, ports 172, control piston groove 156, ports 174 and groove 173, and when the control piston is approaching its maximum down position conduit 122 is placed in communication with exhaust via groove 173, ports 174, control piston groove 156, ports 176 and groove 175. The remaining ports 177 associated with the sixth groove 175 are provided to prevent the entrapment of fluid below the control piston.

To facilitate the explanation of the operation of the embodiment shown in Figure 3 it is assumed that the double acting piston 110 is just finishing its down stroke and that the fluid previously trapped above the frusto-conical surface 153 of the control piston as explained herein later has been partially exhausted to drain through groove 162, conduit 115, passage 106, groove 129 and passage 105. When the fluid pressure of surface 153 becomes less than the pressure exerted by the thrust piston 152 on the thrust piston due to the leakage of fluid to drain as previously explained, the control piston 147 will begin to move in an upwardly direction. When land 157 begins to uncover port 164 an additional path to drain will be opened thereby allowing the control piston to snap to its maximum up position. As the control piston approaches its maximum up position as shown in Figure 3 conduit 119 will be placed in communication with drain via the third groove 168, ports 169, control piston groove 155, ports 167 and the second groove 165 as previously explained thereby placing the fluid entrapped above the upper surface 132 of the low pressure piston 123 in communication with drain or exhaust. Simultaneously, the lower surface 133 of the low pressure piston 123 will be placed in communication with the source of fluid pressure via conduit 122, the fifth groove 173, ports 174, control piston groove 156, ports 172, the fourth groove 171 and conduit 112 thereby causing the double acting piston 110 to begin moving in an upwardly direction. As the high pressure piston 124 moves in an upwardly direction the high pressure fluid trapped in bore 102 will maintain ball-check inlet valve 103 closed and will cause ball-check outlet valve 104 to open thereby admitting the high pressure fluid into conduit 113 and as the high pressure piston 125 moves upwardly the decreased pressure in bore 108 will cause the ball-check outlet valve 111 to close and allow the ball-check inlet value 109 to open and admit low pressure fluid to bore 108 thereby filling bore 108 with fluid and providing a second force adapted to urge the double acting piston 110 in an upwardly direction. The double acting piston 110 will now continue moving in an upward direction until groove 131 on the high pressure piston 125 places the frusto-conical surface 153 of the control piston in communication with the source of fluid pressure through passage 114, groove 131, passage 120, conduit 115, groove 162 and ports 163.

Due to the preferably relatively small size of port 164 as compared to the area of passage 120 the pressure on the frusto-conical surface 153 of the control piston will increase rapidly until the force thereon overcomes the upwardly directed force on the thrust piston 152 and the control piston will therefore begin to move in a downwardly direction. When land 157 substantially closes port 164 the control piston will snap to its maximum down position as shown in Figure 5; as this occurs the upper surface 132 of the low pressure piston will be placed in communication with the source of fluid pressure through conduit 119, the third groove 168, ports 169, control piston groove 155, ports 172 and groove 171 as previously explained. The lower surface 133 of the low pressure piston will be simultaneously placed in communication with drain through conduit 122, the fifth groove 173, ports 174, control piston groove 156, ports 176 and the sixth groove 175 as previously explained. It may now be obvious that the fluid entrapped below the lower surface 133 of the low pressure piston is now connected to drain and that the source of fluid pressure is now in communication with the upper surface 132 of the low pressure piston, hence the double acting piston 110 will now begin moving in a downwardly direction, thereby entrapping fluid above the control piston surface 153 and forcing the high pressure fluid in bore 108 into conduit 113. As the high pressure piston 124 moves downwardly fluid through ball-check inlet valve 103 will fill bore 102 thereby supplying an additional downwardly directed force on the top of the high pressure piston 124. The double acting piston will continue moving in a downwardly direction until groove 129 places passages 106—105 in communication consequently allowing the control piston to begin moving in an upwardly direction as previously described and repeat the cycle.

It is to be noted that with regard to the above described operation of the double acting piston 110, the operation of the control piston 147 is very fast and will occur before the double acting piston 110 actually reaches an extreme end position thereby resulting in a substantially constant supply of high pressure fluid to conduit 113. Further, in view of the above discussion, it may now be readily observed that the present invention provides a new and novel arrangement for supplying fluid at elevated pressures that contains a minimum number of moving parts, that is inexpensive to manufacture and that is highly dependable and inexpensive to maintain. Still further, there is provided a unitary device for complete control of the operation of the double acting piston that operates in a new and novel manner to prevent either the double acting piston or the control device from reaching an undesirable point of equilibrium under normal or even extreme operating conditions.

While I have shown particular embodiments of my invention, I am aware that many minor changes therein will readily suggest themselves to others skilled in the art without departing from the spirit and scope of the invention. It is to be understood, therefore, that I do not wish to be limited to the particular showings made, but wish to be limited by the scope of the claims hereto appended.

What is claimed is:

1. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having a first portion, a second portion and a plurality of circumferential grooves, said control piston having a first position and a second position; a high pressure piston having a first portion and a second portion; a low pressure piston integral with said high pressure piston, said

high pressure piston and said low pressure piston being adapted to be moveable from a first position to a second position; a fluid supply inlet; a drain outlet; first conduit means connecting said distributing sleeve and said high pressure piston first portion to said fluid supply inlet and connecting said control piston first portion and said high pressure piston second portion whereby fluid may be supplied to said high pressure piston first portion and said control piston first portion, said high pressure piston first portion being adapted to act as a valve for the supply of fluid to said control piston first portion; second conduit means connecting said distributing sleeve and said low pressure piston and operatively associated with said first conduit means and said control piston whereby said low pressure piston may be connected to said fluid supply inlet when said high pressure piston approaches said first position and connected to drain when said high pressure piston approaches said second position; means for exhausting fluid supplied to said control piston first portion, said means comprising third conduit means associated with said distributing sleeve and connecting said control piston first portion and one of said control piston circumferential grooves to drain when said control piston is approaching its said first position and fourth conduit means operable to connect said control piston first portion to drain when said high pressure piston is approaching its second position; and a thrust piston adapted to constantly urge said control piston towards its said first position.

2. A fluid pressure intensifying device comprising: a high pressure cylinder having a closed end portion and an open end portion; an inlet valve and an outlet valve operationally associated with said closed end; a low pressure cylinder rigidly connected to said high pressure cylinder and having an open end portion and a closed end portion, said low pressure cylinder open end portion being fixedly connected to said high pressure cylinder open portion; a first piston reciprocally mounted in said low pressure cylinder; a second piston fixedly connected to said first piston and having a first portion and a second portion and reciprocally mounted in said high pressure cylinder, said high pressure piston second portion being adapted to provide a passage between said high pressure cylinder open end portion and said low pressure cylinder open end portion; a distributing sleeve closed at both ends and having a first cylinder portion and a second portion, said first cylinder portion and said second portion being connected by a passage; a control piston reciprocally mounted in said first cylinder portion and having first and second circumferential grooves; a thrust piston reciprocally mounted in said passage; first conduit means adapted for connection to a source of fluid pressure and connecting said inlet valve, said distributing sleeve first cylinder portion and said second portion; second conduit means connecting said distributing sleeve cylinder portion to said low pressure cylinder closed end portion and said high pressure cylinder open end portion; first and second exhaust outlets connecting said distributing sleeve first cylinder portion to drain; and a third exhaust outlet connecting said low pressure cylinder open end portion to drain whereby when said low pressure piston and said high pressure piston are moving upwardly said control piston remains in a maximum end position thereby connecting the source of fluid pressure to said low pressure cylinder closed end portion and trapping fluid above said control piston and when said high pressure piston and said low pressure piston are moving in the opposite direction said control piston remains in its maximum opposite end position thereby connecting said trapped fluid to said first exhaust outlet and connecting said low pressure cylinder closed end portion to said second exhaust outlet.

3. The combination as described in claim 2 wherein said control piston additionally comprises a head portion and an end portion; said second exhaust outlet is disposed below said control piston end portion and said conduit means connecting said source of fluid pressure to said distributing sleeve cylinder portion is disposed in operational relationship with said second groove whereby when said control piston head portion is disposed away from its respective distributing sleeve closed end portion said source of fluid pressure is connected to said low pressure cylinder closed end portion and when said control piston approaches its maximum opposite end position said low pressure cylinder closed end portion is connected to drain.

4. The combination as described in claim 3 wherein said first exhaust outlet is operationally associated with said first groove; said control piston head portion is constructed and adapted to provide a continuously exposed surface; and said second conduit means connecting said distributing sleeve cylinder portion and said high pressure cylinder open end portion comprises a first passage in communication with said control piston exposed surface and a second passage disposed below said first passage and in communication therewith and said high pressure cylinder open end portion whereby when said control piston head portion is disposed away from its respective distributing sleeve closed end portion fluid is trapped above said control piston and when said control piston is in its maximum opposite end position said second passage is in communication with said first exhaust outlet.

5. The combination as described in claim 4 wherein said first conduit means is additionally adapted to provide a source of fluid pressure to the open end portion of said high pressure cylinder and the first portion of said high pressure piston is provided with fluid conducting means whereby when said low pressure piston is approaching said low pressure cylinder closed end portion said source of fluid pressure is in communication with said first passage and when said low pressure piston is approaching its maximum opposite end position said first passage is connected to said third exhaust outlet.

6. In a fluid pressure intensifying device the combination comprising: a first high pressure cylinder having a closed end portion and an open end portion; a second high pressure cylinder oppositely disposed to said first high pressure cylinder and having a closed end portion and an open end portion; a low pressure cylinder having a first end portion and a second end portion and connecting said high pressure cylinder open end portions; first and second outlet valves respectively in communication with said high pressure cylinder closed end portions; first and second inlet valves respectively in communication with said high pressure cylinder closed end portions, a reciprocable intensifier piston having a first side and a second side, said first side being divided into a first high pressure fluid contact surface disposed in said first high pressure cylinder and a first low pressure fluid contact surface dispsoed in said low pressure cylinder, said second side being divided into a second high pressure fluid contact surface disposed in said second high pressure cylinder and a second low pressure fluid contact surface disposed in said low pressure cylinder; fluid conducting means provided respectively intermediate said first high pressure surface and said first low pressure surface and said second high pressure surface and said second low pressure surface, said fluid conducting means being located respectively adjacent said first and second high pressure surfaces; a fluid supply inlet; a control piston having a first, second, third circumferential grooves and a first end portion and a second end portion and a first end position and a second end position; a distributing sleeve closed at both ends and having a first portion and a second cylinder portion adapted to reciprocally receive said control piston, said first portion and said second cylinder portion being connected by a passage; a thrust piston reciprocally mounted in said passage and adapted to urge said control piston toward its said first end position; a first exhaust outlet connecting said control piston second end portion to drain; control piston reversing means comprising second conduit means operationally associated with said fluid conducting means for supplying a source of fluid pressure

to said control piston first end portion when said intensifier piston approaches a maximum end position and connecting said control piston first end portion to drain when said intensifier piston approaches its maximum opposite end position, said distributing sleeve having a passageway connecting said second conduit means and said control piston first groove, and a second exhaust outlet associated with said control piston first groove and said passageway whereby when said control piston is in a maximum end position said second conduit means is connected to drain and when said control piston is in its maximum opposite end position said connection is closed; and third conduit means connecting said low pressure cylinder first and second end portions and said control piston second and third grooves whereby when said control piston is in a maximum end position fluid pressure is supplied to said first low pressure fluid contact surface and said second low pressure contact surface is connected to drain and when said control piston is in its maximum opposite position said first low pressure fluid contact surface is connected to drain and fluid pressure is supplied to said second low pressure fluid contact surface, said second conduit means and said second exhaust outlet being so apportioned and located whereby when said intensifier piston approaches a maximum end position said control piston will be caused to move to a maximum end position.

7. The combination as described in claim 6 wherein said fluid conducting means comprises a first circumferential groove having a first portion and a second portion on said intensifier piston adjacent said first high pressure surface; a second circumferential groove having a first portion and a second portion on said intensifier piston and adjacent said second high pressure surface; a first passage in communication with said first groove first portion; a second passage in communication with said first groove second portion; a second passage in communication with said second groove first portion; and a third passage in communication with said second groove second portion.

8. The combination as described in claim 6 wherein said third conduit means comprises a fourth conduit permanently in communication with said first low pressure fluid surface and said second control piston groove, a fifth conduit permanently in communication with said second low pressure fluid contact surface and said third control piston groove, an inlet passage disposed in said distributing sleeve whereby it is in communication with said control piston second groove when said control piston approaches a maximum end position and it is in communication with said control piston third groove when said control piston approaches its said other maximum end position; said passage connecting said conduit means and said control piston first groove has an area less than the smallest area of said second conduit means; and said control piston first portion is provided with a permanently exposed surface having an area greater than the transverse area of said thrust piston.

9. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having circumferential grooves disposed between a head portion and an end portion; a thrust piston for constantly urging said control piston in one direction; pressure intensifying means including a reciprocable high pressure piston and a low pressure piston integral therewith; a fluid supply inlet; a drain outlet; first conduit means establishing communication between said distributing sleeve and said fluid supply inlet and for supplying fluid to said control piston head portion through said pressure intensifying means, said high pressure piston acting as a valve whereby when said high pressure piston is in one position fluid is supplied to said control piston head portion and when said high pressure piston is in its opposite position said control piston head portion is connected to drain; second conduit means establishing communication between said distributing sleeve and said low pressure piston whereby said low pressure piston is alternately placed in communication with said fluid supply when said control piston is in one position and in communication with drain when said control piston is in its opposite position; and third conduit means establishing communication between said control piston head portion and an adjacent circumferential groove and drain when said control piston is approaching one position whereby when fluid is supplied to said control piston head portion said control piston snaps to its opposite position and when said head portion is connected to drain said control piston snaps to its opposite position to alternately reverse said high pressure piston.

10. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having circumferential grooves disposed between a head portion and an end portion; a thrust piston in abutting engagement with said control piston end portion for constantly urging said control piston in one direction; pressure intensifying means including a reciprocable high pressure piston and a low pressure piston integral therewith; a fluid supply inlet; a drain outlet; first conduit means establishing communication between said distributing sleeve and said fluid supply inlet and for supplying fluid to said control piston head portion through said pressure intensifying means, said high pressure piston acting as a valve whereby when said high pressure piston is in one position fluid is supplied to said control piston head portion and when said high pressure piston is in its opposite position said control piston head portion is connected to drain; second conduit means establishing communication between said distributing sleeve and said low pressure piston whereby said low pressure piston is alternately connected to said fluid supply when said control piston is in one position and to drain when said control piston is in its opposite position; and third conduit means establishing communication between said control piston head portion and an adjacent circumferential groove and drain when said control piston is approaching one position, said control piston head portion being formed such that only a portion of said control piston is exposed when in one extreme position whereby when fluid is supplied to said control piston head portion said control piston snaps to its opposite position and when said head portion is connected to drain said control piston snaps to its opposite position to alternately reverse said high pressure piston.

11. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having circumferential grooves disposed between a head portion and an end portion; a thrust piston in abutting engagement with said control piston end portion for constantly urging said control piston in one direction; pressure intensifying means including a reciprocable high pressure piston and a low pressure piston integral therewith; a fluid supply inlet; a drain outlet; first conduit means establishing communication between said distributing sleeve and said fluid supply inlet and for supplying fluid to said control piston head portion through said pressure intensifying means, said high pressure piston acting as a valve whereby when said high pressure piston is in one position fluid is supplied to said control piston head portion and thereafter trapped to cause said control piston to move to and remain in its opposite position until said high pressure piston substantially reaches its opposite position whereupon said trapped fluid is connected to drain thereby allowing said thrust piston to cause said control piston to return to its original position; second conduit means establishing communication between said distributing sleeve and said low pressure piston whereby said low pressure piston is alternately

connected to said fluid supply when said control piston is in one position and to drain when said control piston is in its opposite position; and third conduit means establishing communication between said control piston head portion and an adjacent circumferential groove and drain when said control piston is approaching one position, said control piston head portion being formed such that a lesser area is exposed when said control piston head portion is connected to drain whereby when fluid is supplied to said control piston head portion said control piston snaps to its opposite position and when said head portion is connected to drain said control piston snaps to its opposite position to alternately reverse said high pressure pistons.

12. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having circumferential grooves disposed between a head portion and an end portion; a thrust piston in abutting engagement with said control piston end portion for constantly urging said control piston in one direction; pressure intensifying means including a low pressure piston disposed between and integral with first and second reciprocable high pressure pistons; a fluid supply inlet; a drain outlet; first conduit means establishing communication between said distributing sleeve and said fluid supply inlet and for supplying fluid to said control piston head portion through said pressure intensifying means, said high pressure pistons acting as a valve whereby when one of said high pressure pistons is in one position fluid is supplied to said control piston head portion and thereafter trapped to cause said control piston to move to and remain in its opposite position and when said other high pressure piston substantially reaches its opposite position said trapped fluid is connected to drain thereby allowing said thrust piston to cause said control piston to return to its original position; second conduit means establishing communication between said distributing sleeve and said low pressure piston whereby each exposed surface of said low pressure piston is alternately connected to said fluid supply when said control piston is in one position and to drain when said control piston is in its opposite position; and third conduit means establishing communication between said control piston head portion and the adjacent circumferential groove and drain when said control piston is approaching one position, said control piston head portion being formed such that a lesser area is exposed when said control piston head portion is connected to drain whereby when fluid is supplied to said control piston head portion said control piston snaps to its opposite position and when said head portion is connected to drain said control piston snaps to its opposite position to alternately reverse said high pressure pistons.

13. In a fluid pressure intensifying device the combination comprising: a distributing sleeve closed at both ends; a control piston reciprocally mounted in said sleeve and having circumferential grooves disposed between a head portion and an end portion; a thrust piston in abutting engagement with said control piston end portion for constantly urging said control piston in one direction; pressure intensifying means including first and second reciprocable high pressure pistons and a low pressure piston having exposed surfaces and disposed between said first and second high pressure pistons and integral therewith; a fluid supply inlet; a drain outlet; first conduit means establishing communication between said distributing sleeve and said fluid supply inlet and for supplying fluid to said control piston head portion through said pressure intensifying means, said first high pressure piston acting as an inlet valve whereby when it is in one position fluid is supplied to said control piston head portion and thereafter trapped to cause said control piston to move to and remain in its opposite position, said second high pressure piston acting as an outlet valve whereby when it substantially reaches its opposite position said trapped fluid is connected to drain thereby allowing said thrust piston to cause said control piston to return to its original position; second conduit means establishing communication between said distributing sleeve and said low pressure piston whereby each exposed surface of said low pressure piston is alternately connected to said fluid supply when said control piston is in one position and to drain when said control piston is in its opposite position; and third conduit means establishing communication between said control piston head portion and the adjacent circumferential groove and drain when said control piston is approaching one position and being closed when said control piston is in its opposite position, said control piston head portion being formed such that a lesser area is exposed when said control piston head portion is connected to drain whereby when fluid is supplied to said control piston head portion said control piston snaps to its opposite position and when said head portion is connected to drain said control piston snaps to its opposite position to alternately reverse said high pressure pistons.

References Cited in the file of this patent

UNITED STATES PATENTS

2,296,647	McCormick	Sept. 22, 1942
2,413,029	McFarland	Dec. 24, 1946
2,416,317	Hoffar	Feb. 25, 1947
2,484,884	Hanna	Oct. 18, 1949