United States Patent [19]

Brandenberg

[11] **3,732,934**

[45] **May 15, 1973**

[54] **FLUID-DRIVEN TOOL WITH BUILT-IN WORK CONTROL MECHANISM**

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[22] Filed: **Mar. 29, 1971**

[21] Appl. No.: **128,899**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 853,632, Aug. 28, 1969, Pat. No. 3,580,285.

[52] **U.S. Cl.**.....**173/12,** 415/51

[51] **Int. Cl.**.....**B25b 23/14**

[58] **Field of Search**.....173/12; 415/51; 137/624.2; 91/35; 60/57

[56] **References Cited**

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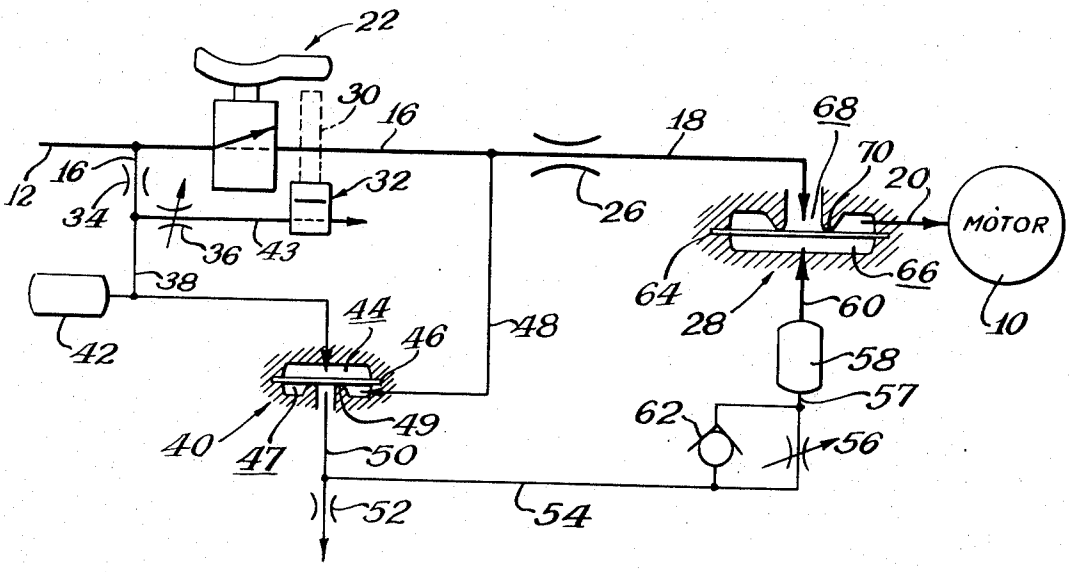
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[57] **ABSTRACT**

A work control mechanism for a pneumatically driven tool such as an impact wrench is incorporated as part of the tool. The motor for the tool commences operation upon movement of a manual trigger mechanism on the tool. As the motor meets increased resistance in its operation, the back pressure in the main fluid supply line to the motor increases. This increase in pressure is sensed and subsequent to the sensing of this increase, a time delayed signal operates a control valve in the main fluid flow line. Operation of this control valve opens the fluid flow circuit to the motor, thereby terminating operation of the motor even though the manual trigger for the tool remains depressed.

24 Claims, 6 Drawing Figures



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SHEET 1 OF 2

FIG. 1.

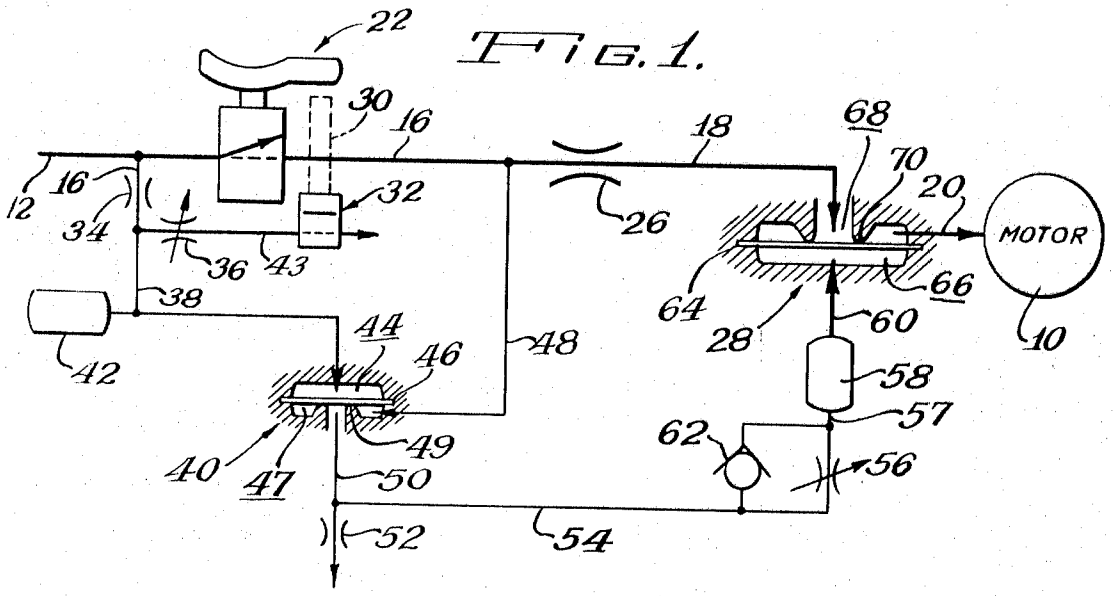


FIG. 3.

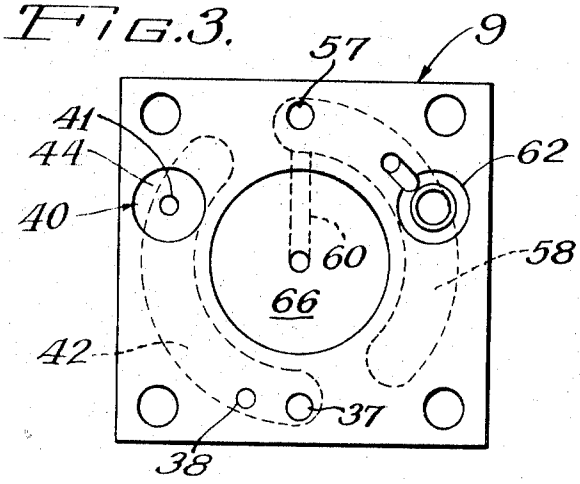


FIG. 5.

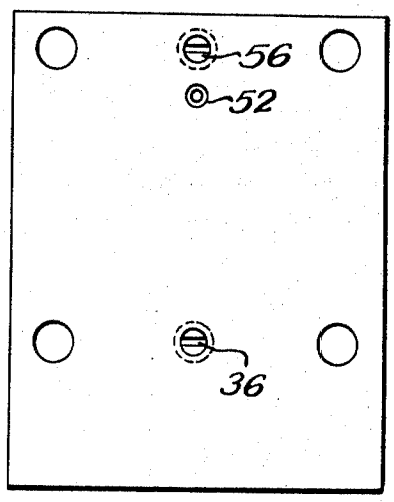
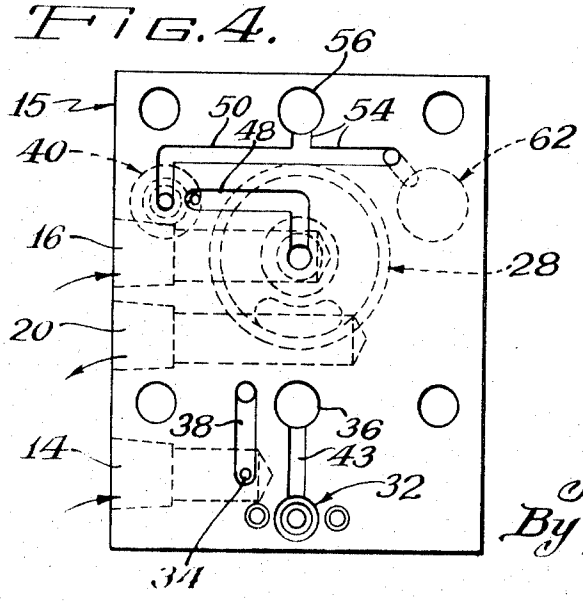


FIG. 4.



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FIG. 2.

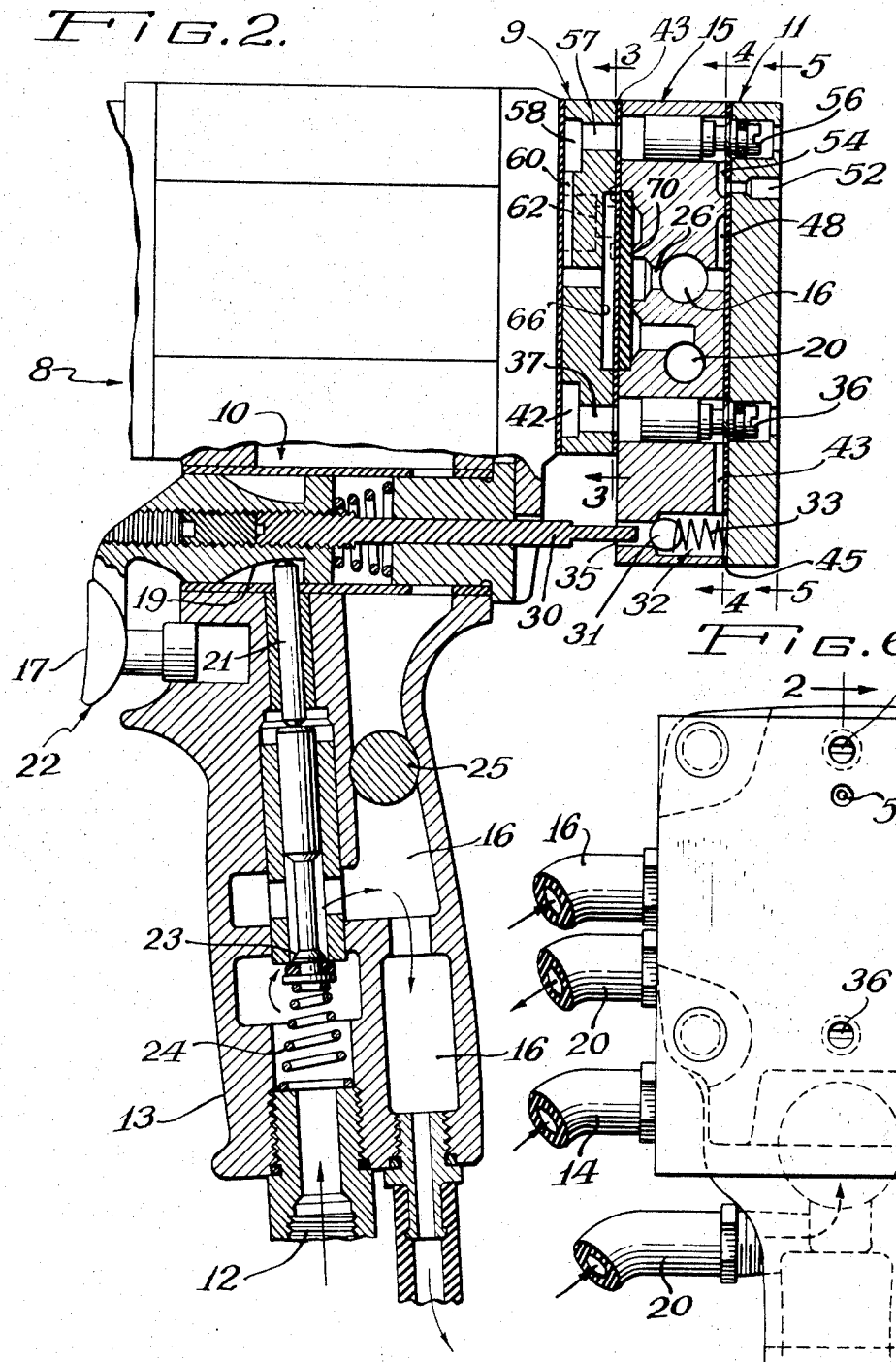


FIG. 6.

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FLUID-DRIVEN TOOL WITH BUILT-IN WORK CONTROL MECHANISM

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my co-pending application Ser. No. 853,632 filed Aug. 28, 1969 and now U.S. Pat. No. 3,580,285 for a Work Control Device for Fluid Driven Apparatus. This application is also related by virtue of the common assignee and of the subject matter to the application of German and Short for a Work Control System, Ser. No. 766,202 filed Oct. 9, 1968 now U.S. Pat. No. 3,590,582 issued July 6, 1971.

BACKGROUND OF THE INVENTION

In the above-referenced related applications, a theory and some specific examples of pneumatic work control systems are set forth. In these systems, a work control device separate from the fluid driven apparatus or tool is connected in the fluid flow line which connects a fluid flow source to the tool. The work control devices disclosed sense the pressure in the line to the tool. The operation of the tool is then correlated with the feed-back pressures in the line to the tool by means of various logic devices. The present application is directed to yet a further improvement and aspect of these previous inventions. In particular, the present invention relates to the incorporation of a work control device as part of the working tool itself.

SUMMARY OF THE INVENTION

In a principal aspect then, the present invention comprises a work control device for fluid driven apparatus wherein the work control device is advantageously incorporated as part of the fluid driven apparatus. A motor is associated with the fluid driven apparatus. The motor is connected by means of a fluid flow line with a fluid input source. A fluid flow control valve is provided in this line. Additionally, means for sensing the back pressure upstream the fluid flow control valve are provided. Initiation of the sequence of events which control the work output of the fluid driven apparatus is provided by the trigger mechanism which operates the fluid driven apparatus.

When the sensing means senses increased resistance to the operation of the fluid driven apparatus, a fluid output signal is provided to a timing means. The timing means after a predetermined increment of delay provides a further signal to the fluid control valve means in the main fluid flow line. This signal acts to open the valve means and terminate operation of the motor. Since the motor has been operating for a predetermined increment of time against the resistance offered to operation of the fluid driven apparatus, a known amount of work has been imparted by operation of the fluid driven apparatus.

Thus, it is an object of the present invention to provide an improved work control apparatus.

It is a further object of the present invention to provide an improved work control apparatus which may be incorporated as a part of the working tool which is being controlled.

Still another object of the present invention is to provide a work control apparatus wherein the control sequence is initiated by operation of the means for commencing operation of the fluid driven apparatus.

One further object of the present invention is to provide a work control apparatus which can be economically and effectively incorporated with fluid driven tools and apparatus.

Still another object of the present invention is to provide a work control device which can be incorporated with existing types of fluid driven tools and apparatus without major modifications of such apparatus.

One further object of the present invention is to provide a work control device which may be incorporated as part of a fluid driven tool wherein the control device does not include external fluid power sources or monitoring means.

These and other objects, advantages and features of the present invention will be set forth in greater detail in the description which follows.

BRIEF DESCRIPTION OF THE DRAWING

In the detailed description which follows, reference will be made to the drawing comprised of the following FIGURES:

FIG. **1** is a schematic circuit diagram of the work control device of the present invention as utilized in combination with fluid driven apparatus;

FIG. **2** is a partial cross-sectional view taken substantially along the line **2—2** in FIG. **6** illustrating a typical impact wrench which has been modified to include a prototype work control device of the present invention;

FIG. **3** is a cross-sectional view of the prototype control device taken substantially along the line **3—3** in FIG. **2**;

FIG. **4** is a second cross section of the work control device taken substantially along the line **4—4** in FIG. **2**;

FIG. **5** is an end view of the work control device taken substantially along the line **5—5** in FIG. **2**; and

FIG. **6** is an end view of the work control device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the detailed description which follows, the work control device of the present invention will be described functionally and operationally by reference to FIG. **1**. FIG. **1** is a schematic representation of the work control device as incorporated in a fluid driven apparatus. Reference will also be directed to FIGS. **2** through **6** wherein there is illustrated a prototype embodiment of the work control device as incorporated with fluid driven apparatus.

It is understood that this prototype device includes some conduits interconnecting various portions of the fluid driven apparatus-work control device combination. However, it is contemplated that production models of the device would not include external conduit connections and would instead provide for such connections by means of internal passageways within the fluid driven apparatus which passageways would be cast into or otherwise provided in the fluid driven apparatus. Thus, the specific embodiment shown is illustrative of the inventive concept of the present invention. Additionally the embodiment illustrates a typical manner for modification of an existing type of fluid driven apparatus to thereby incorporate the invention. Thus, FIGS. **2** through **6** are included to demonstrate the utility, practicality and means known to the inventor of practicing the invention, particularly by modification of an existing fluid driven apparatus.

Referring first to FIG. 1 and noting that in FIG. 1 labeled schematic components of the apparatus have their corresponding physical components identically labeled in FIGS. 2 through 6, reference is directed to a fluid driven motor 10. The motor 10 is included as part of a fluid driven apparatus such as an impact wrench or the like and is operated by means of pressurized fluid provided to the motor 10. Fluid for operation of the motor 10 is introduced through an input segment 12 of a fluid flow line having segments labeled respectively 16, 18 and 20. As illustrated in FIG. 2, input segment 12 provides fluid flow into the tool through a handle 13. A first conduit 14 in FIGS. 1 and 4 connects from segment 12 to a middle logic block 15 illustrated in FIGS. 2 and 4.

A trigger mechanism 22 illustrated in FIGS. 1 and 2 is comprised of a trigger 17 which may be manually displaced to drive a cam surface 19 against a rod 21. The rod 21, in turn, actuates a valve 23 to close a fluid flow path from input 12 to fluid flow line segment 16. Note that a plug 25 in handle 13 seals the flow line segment 16 from the segment 20. Prior to modification of the air tool, the plug 25 did not exist, and fluid flow went directly to the motor 10.

Thus, interposed between fluid flow line segments 14 and 16 and included as part of the fluid flow line is a manually operable trigger mechanism 22. This mechanism 22 and more particularly the valve 23 serves as a restrictor in the fluid flow line whereby the pressure on the downstream side of valve 23 is lower than on the upstream side. The valve 23 is normally biased by spring means 24 so that the mechanism 22 is maintained in an open position as illustrated in FIGS. 1 and 2. By manually depressing the trigger 17, the fluid flow line between segments 12 and 16 will be positioned to a closed position and will permit fluid flow from the input 12 through manual restrictor valve 23, through segment 16, through a restrictor 26, through segment 18, through a first fluid valve means 28 and thence through a final fluid flow line segment 20 to the motor 10. In this manner, pressurized fluid is supplied directly to the motor 10 to operate that motor 10.

Mechanically coupled with the trigger mechanism 22 by means of a rod 30 is an exhaust valve 32. That is, when the trigger mechanism 22 is depressed, the exhaust valve 32 which is otherwise open is moved to the closed position to permit exhausting therethrough to the atmosphere. Thus, in FIG. 2, rod 30 moves a ball 31 against spring 33 to permit exhaust from opening 35 in block 15.

The exhaust valve 32 connects the fluid flow input segment 12 via conduit 14, a fixed restrictor 34 (FIGS. 1 and 4) and an adjustable restrictor 36 to the atmosphere. Exhaust valve 32 permits exhaust therethrough via a conduit 38 which is a continuation of first conduit 14. Together, conduits 14 and 38 connect input 12 with an upper chamber 44 of a second valve means 40.

Also connected with the conduit 38 is a volume or reservoir 42. When the exhaust valve 32 is in the open position, the reservoir 42 and the chamber 44 become pressurized at the line pressure of the segment 12. Upon closing the exhaust valve 32, a regulated amount of fluid flows through the variable restrictor 36 to the atmosphere thereby lowering the pressure in the conduit 38 and thus lowering the force (which is a function of the product of pressure and area) against a diaphragm 46 in the second valve means 40. This has significance as will be explained in greater detail below.

The fluid flow line segment 16 downstream the trigger mechanism 22 and upstream the restrictor 26 is also connected with the second valve means 40 via a conduit 48. The connection provides a force signal dependent upon the pressure in the conduit 48 and the surface area against which that pressure is exerted on the lower side of the diaphragm 46 via chamber 47.

As illustrated schematically in FIG. 1, the area against which the pressure from conduit 48 is exerted against diaphragm 46 is less than the area of the pressure signal exerted against the opposite side of the diaphragm 46 via conduit 38. Also, the manual restrictor valve 23 causes pressure in conduit 48 to be less than pressure in conduit 14, although restrictor 34 causes pressure to be effectively reduced in conduit 38. Normally, upon initial actuation of trigger mechanism 22, force via chamber 44 exceeds force via chamber 47. When the force against the lower side of the diaphragm 46 exceeds the force against the upper side of that diaphragm 46, a change in the sign of the algebraic sum of the signals or forces in the second valve means occurs. Then, the second valve means 40 will switch. Fluid will then flow through the conduit 48 past a seat 49 and then through output conduit 50 of the second valve means 40.

The conduit 50 is bifurcated and a portion of fluid flow passes through a restrictor 52 to the atmosphere. A second portion passes through conduit 54 to a timing mechanism.

The timing mechanism includes a variable restrictor 56 in series via conduit 57 with a reservoir 58 from which there in an output 60 to the first valve means 28. A check valve 62 is interposed about the restrictor 56 and is parallel therewith to permit reverse flow from the reservoir 58 and ultimately out the restrictor 52 to the atmosphere. The check valve 62 thus serves as a means for exhausting the reservoir 58 and conduit 60 in a rapid fashion not possible through the restrictor 56.

The signal relationship at valve 28 due to pressure signals is similar to that described for the signal relationship for the second valve means 40. That is, the signals or forces which are the product of pressure and area acting on a diaphragm 64 are effectively summed algebraically. The force acting through conduit 60 via a chamber 66 is the product of the pressure in that conduit and the surface area of the diaphragm 64 exposed in chamber 66. The force through segment 18 of the fluid flow line acting against diaphragm 64 via chamber 68 is determined by the pressure in the segment 18 and the area of the diaphragm surface 64 in the chamber 68. When the force effected through chamber 66 exceeds that effected through chamber 68, the diaphragm 64 closes the first valve means 28 by engaging a seat 70. This turns off the fluid supply to the motor 10 (opens the circuit) and thus effectively stops operation of the motor 10.

It should also be noted that the trigger mechanism 22 constitutes a restriction in the same manner as the restriction 26. Thus, pressure on the downstream side of the trigger mechanism 22 will be less than the pressure at the input side of the trigger mechanism 22. It is this feature as well as the sizing of the chamber 44 and 45 that maintains the second valve means 40 in the closed position as shown until the sensing is initiated.

It is also important to realize that the restrictor 26 is required for a similar reason. That is, pressure on the

downstream side of the restrictor **26** will be less than on the upstream side of the restrictor. In this manner, pressure through the conduits **48, 50** and **54** acting against the first valve **28** can effect a switching operation through the first valve **28.**

In FIG. **1,** the device is schematically illustrated. In FIGS. **2–6,** the device is illustrated as including a typical fluid driven tool **8** modified by the addition of three control blocks **9, 15** and **11,** separated by diaphragm seals **43** and **45.** The blocks **9, 15** and **11** and seals **43, 45** are fixed to the housing of the tool as depicted in FIG. **1.** Diaphragm seal **43** corresponds to diaphragms **46** and **64.** The blocks **9, 15** and **11** as well as diaphragms **43** and **45** constitute the major modification portions of a typical fluid driven tool converted to work control capability.

OPERATION OF THE CONTROL DEVICE

Initially, the trigger mechanism **22** is in the off or open circuit position. Upon initial depression of the trigger mechanism, fluid flow will be effected in the main fluid flow line from the segment **12** to the motor **10** via the valve **23,** restrictor **26** and through the first control valve **28.** At this initial time, there is no force effective through chamber **66** since the second valve means **40** prohibits fluid flow from conduit **48** through the conduits **50** and **54** and also since the reservoir **58** and conduit **60** are exhausted through restrictor **52.** Note that prior to depressing the trigger mechanism **22,** chamber **44** was pressurized and that initial opening of valve **32** does not depressurize chamber **44,** not is the pressure in chamber **44** reduced to effect a switching of valve **40** until "increased resistance" is sensed as described below. Initially then, when the motor **10** and the operation of the fluid driven apparatus driven by the motor **10** meet no resistance, there will be no change in the circuitry from that just described.

However, when the motor **10** meets what is defined as "increased resistance", certain sensing and switching operations take place. The term "increased resistance" means that the motor encounters resistance or is, in other words, doing work to overcome the resistance of some operation provided by the fluid driven apparatus which includes the motor **10.** This increased resistance is manifested by increased back pressure in the fluid flow line made of segments **16, 18** and **20.** This phenomena was discussed in detail in the parent application as well as the other related application cited above.

When the trigger mechanism **22** is in the closed position and valve **32** is also in the closed position, and following an increase in back pressure in the system, increased pressure in line **48** effects switching of valve **40.** Variable restrictor **36** permits adjustment of the sensitivity level for effecting the switching operation and sensing through the second valve means **40.** The reservoir **42** provides a damping or time delay effect in the sensing of the increased back pressure, but only during the start period immediately after the trigger mechanism **22** has been actuated.

Therefore, subsequent to the increase in back pressure, fluid flow through the conduit **48** provides a signal which overcomes the signal through the line **38,** thus permitting fluid flow into the conduit **50.** Conduit **50** then provides fluid flow to the timing elements comprised of the adjustable restrictor **56** and reservoir **58.** Accumulation of the appropriate amount of fluid pressure in the reservoir **58** and the conduit **60** will, after a predetermined time increment, cause movement of the diaphragm **64** and thus close the first valve **28.**

Therefore, subsequent to sensing the increased resistance to operation of the motor **10,** a timing sequence is initiated. This timing sequence permits flow of fluid to the motor **10** for a predetermined increment of time. Since fluid flow is provided to the motor for a predetermined increment of time, the motor will do a fixed or ascertainable amount of work during that time. Note that the time increment is adjustable by virtue of the adjustability of the restrictor **56.** Thus, the control device described controls the work output of the motor **10** and the fluid driven apparatus associated with the motor **10.**

Note that release of the trigger mechanism **22** resets the circuit. That is, release of the trigger mechanism **22** causes the valve **32** to open. The main line is also opened at this time. The upper chamber **44** of the second valve means **40** thus becomes pressurized causing the diaphragm **46** to seat. Simultaneously, fluid in the reservoir **58** is exhausted through check valve **62** and restrictor **52.** In this manner, the mechanism is reset.

In the above-identified description, there has been set forth a functional and operation dissertation for the present invention. It is to be realized that the size of the restrictors, reservoirs and the relative areas of the opposite sides of the diaphragms as well as the sizes of the conduits may all have an effect on the particular desired operation of the device comprising the invention. In fact, in some instances such components may physically be omitted, although in concept and function they are included within the embodiment by virtue of component selection, size and desired sensitivity of operation.

What is claimed is:

1. In a fluid driven apparatus of the type having a fluid input and a fluid driven motor in communication with said input, improved means for controlling fluid flow from said input to said motor to control the work output of said motor, comprising, in combination:

a fluid flow line from said input to said motor; first fluid valve means in said line upstream from said motor, said first fluid valve means having a normally open position to prevent fluid flow to said motor and an actuable closed position to permit fluid flow to said motor, timing means, and fluid pressure sensing means upstream from said first fluid valve means for sensing increased back pressure in said fluid flow line after said first fluid valve means is closed and said motor encounters increased resistance to fluid driven operation, said sensing means operating to then provide a fluid signal to said timing means which, in turn, after a predetermined increment of time, provides a fluid signal to open said first fluid valve means and discontinue operation of said motor.

2. The improvement of claim **1** wherein said timing means is adjustable to provide for adjustment of said predetermined time increment.

3. The improvement of claim **1** including restrictor means between said fluid pressure sensing means and said first fluid valve means.

4. The improvement of claim **1** including manual valve means for opening and closing said fluid flow line to said motor through said first fluid valve means, said manual means in said fluid flow line upstream said first

fluid valve means and comprising a portion of said fluid pressure sensing means.

5. The improvement of claim **1** wherein said first fluid valve means includes a first fluid valve for receiving a fluid flow line signal and a timing means fluid signal, said signals being algebraically summed by said first fluid valve to control fluid flow to said motor.

6. The improvement of claim **1** wherein said timing means includes a timing restrictor.

7. The improvement of claim **1** including exhaust means for exhausting said timing means whenever said motor does not receive fluid flow.

8. The improvement of claim **1** wherein said fluid pressure sensing means includes fluid restrictor means in said fluid flow line upstream said first fluid valve means, means for providing a first fluid pressure signal, said first signal being initially indicative of the line pressure in said fluid flow line when said first fluid valve means is open, means for providing a second fluid pressure signal indicative of the line pressure in said fluid flow line downstream said restrictor means when said first fluid valve means is closed, means for algebraically summing said first signal with said second signal, the algebraic sum of said signals providing an output signal to said timing means whenever the algebraic sum of said first and second signals changes from a first sign to a second sign.

9. The improvement of claim **8** wherein said means for providing a first signal includes a first conduit from said fluid flow line to said second valve means, and a restrictor intermediate said second valve means and connection of said first conduit to said fluid flow line.

10. The improvement of claim **8** wherein said means for providing a first signal includes exhaust means for diminishing said first signal whenever fluid flows through said restrictor means.

11. The improvement of claim **10** wherein said exhaust means includes means for controlling the rate of exhaust.

12. The improvement of claim **11** wherein said means for controlling the rate of exhaust is adjustable.

13. The improvement of claim **8** wherein said means for providing a first signal includes means for delaying any change in said first signal.

14. The improvement of claim **13** wherein said means for delaying change in said first signal includes reservoir means.

15. The improvement of claim **8** wherein said second valve means includes a pressure responsive diaphragm, one portion of said diaphragm being responsive to said first signal and another portion of said diaphragm being responsive to said second signal, said diaphragm being movable to effect switching whenever the algebraic sum of said signals sensed by said diaphragm changes from a first sign to a second sign.

16. The improvement of claim **1** wherein said timing means includes timing reservoir means for receiving fluid, the increment of time being a function of the volume of said timing reservoir means.

17. The improvement of claim **16** wherein said timing restrictor is adjustable.

18. The improvement of claim **16** wherein said timing means includes timing reservoir means and said timing restrictor is upstream said timing reservoir means.

19. The improvement of claim **18** wherein said time increment is adjustable.

20. The improvement of claim **18** wherein said fluid pressure sensing means is adjustable to sense a desired back pressure before effecting closure of said first fluid valve means.

21. The improvement of claim **18** wherein said fluid pressure sensing means includes a first fluid conduit from the upstream side of said manual valve means in said fluid flow line connected to said second fluid valve means, said conduit carrying a fluid pressure signal, said signal being initially indicative of said line pressure in said fluid flow line when said manually operable valve is open, said signal being algebraically summed with a second fluid pressure signal indicative of the line pressure in said fluid flow line downstream of said manually operable valve to thereby operate said second valve means whenever the algebraic sum of said signals changes sign.

22. In a fluid driven apparatus of the type having a fluid input and a fluid driven motor in communication with said input, the improvement comprising, in combination:

improved means for controlling fluid flow from said input to said motor to thereby control the work output of said motor comprising, in combination:

a fluid flow line from said input to said motor,

first fluid valve means in said line upstream from said motor, said first fluid valve means having a closed position to permit fluid flow to said motor,

a manually operable valve in said line upstream from said first fluid valve means, said manual valve having a closed position to permit fluid flow to said motor,

restrictor means in said fluid flow line interposed between said first valve means and said manually operable valve means, and

fluid pressure sensing means for sensing the back pressure in said fluid flow line upon increased resistance to fluid driven operation of said motor, said fluid pressure sensing means including second fluid valve means connected with said fluid flow line upstream said restrictor, said second fluid valve means also connected with said first fluid valve means and operable to provide fluid flow to and thereby position said first fluid valve means in open position subsequent to a time increment following sensing of said back pressure.

23. In a fluid driven apparatus of the type having a fluid inlet and a fluid driven motor in communication with said inlet, improved means for controlling fluid flow from said inlet to said motor to control the work output of said motor comprising, in combination:

a fluid flow line from said inlet to said motor; first fluid valve means in said line upstream from said motor, said first fluid valve means having a normally open position to prevent fluid flow to said motor and an actuable closed position to permit fluid flow to said motor; timing means; a manually operable valve in said line upstream from said first fluid valve means, said manual valve having a closed position to permit fluid flow to said motor; and fluid pressure sensing means upstream from said first fluid valve means and downstream from said manually operable valve, said fluid pressure sensing means operable for sensing increased back pressure in said fluid flow line after said first fluid valve means is closed and said manual valve is closed and said motor encounters increased resis-

tance to a fluid driven operation, said sensing means operating to then provide a fluid signal to said timing means which, in turn, after a predetermined increment of time provides a fluid signal to open said first fluid valve means and discontinue operation of said motor.

24. In a fluid driven apparatus of the type having a fluid input and a fluid driven motor in communication with said input, improved means for controlling fluid flow from said input to said motor to control the work output of said motor, comprising in combination:

a fluid flow line from said input to said motor; first fluid flow valve means in said line upstream from said motor, said first fluid valve means having a normally open position to prevent fluid flow to said motor and an actuable closed position to permit fluid flow to said motor; timing means; and fluid pressure sensing means upstream from said first fluid valve means, said fluid pressuring sensing means including fluid restrictor means in said fluid flow line upstream from said first fluid valve means, means for providing a first fluid pressure signal, said first signal being initially indicative of the line pressure in said fluid flow line when said first fluid valve means is open, means for providing a second fluid pressure signal indicative of the line pressure in said fluid flow line downstream from said restrictor means when said first fluid valve means is closed, means for algebraically summing said first signal with said second signal, the algebraic sum of said signals providing an output signal to said timing means whenever the algebraic sum of said first and second signals changes from a first sign to a second sign.

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