

[54] **MULTIPLE FULCRUM VALVE
OPERATING LEVER**

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[73] Assignee: **Bucyrus-Erie Company, South Milwaukee, Wis.**

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[52] U.S. Cl.74/522, 74/491, 74/518,
251/233

[51] **Int. Cl.** **G05g 1/04**

[58] **Field of Search**.....74/522, 523, 491, 516, 518,
74/105; 251/233

[56] **References Cited**

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Adams Thierry

[57] **ABSTRACT**

A pivotal control lever for a valve stem has two different spaced fulcrum connections with a base, one through a pin and slot connection and the other through a floating abutment which is held in a normal position by opposite springs. Initial pivotal movement of the lever is about the abutment, but when the limit of movement of the pin-slot connection is reached the lever begins to pivot about that connection, overriding the springs. In one form, deadband reduction is achieved by having the abutment radially further from the connection between the lever and stem than the pin and slot. A second form has the abutment closer to enhance initial control. A modification of the second form has a lost motion connection between the lever and the abutment and a torsion spring between the lever and stem which provides, in effect, an infinite lever to reduce deadband. Another form simply uses the torsion spring with a lost motion connection to reduce deadband.

6 Claims, 12 Drawing Figures

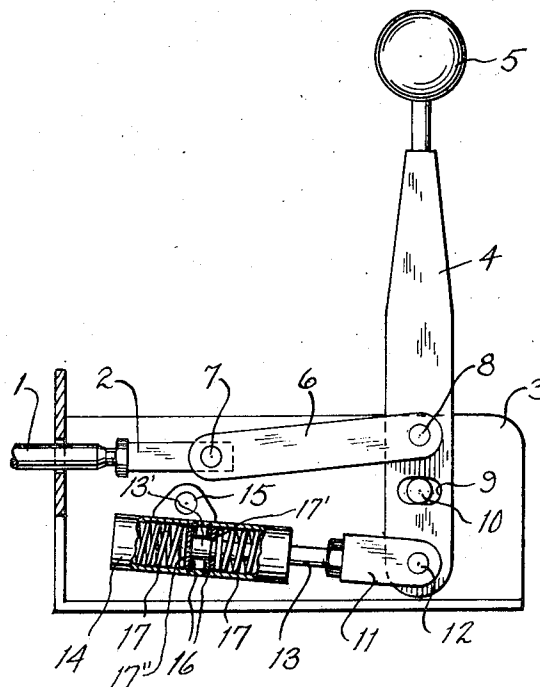


Fig. 1

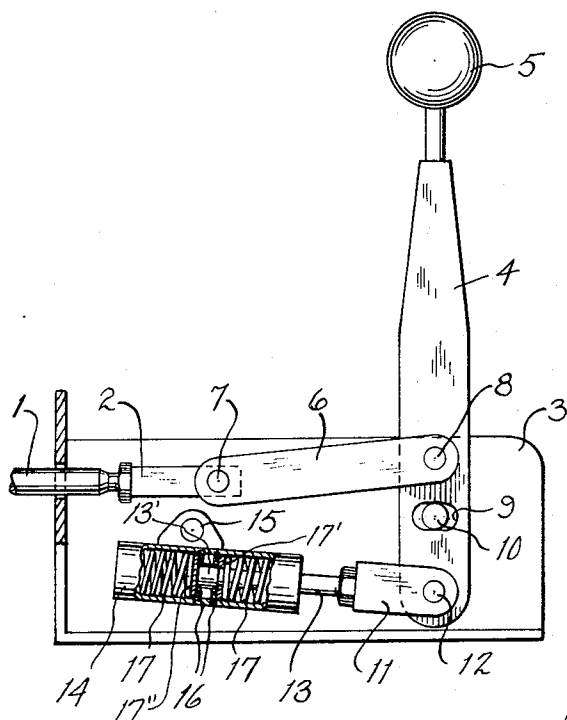


Fig. 1a

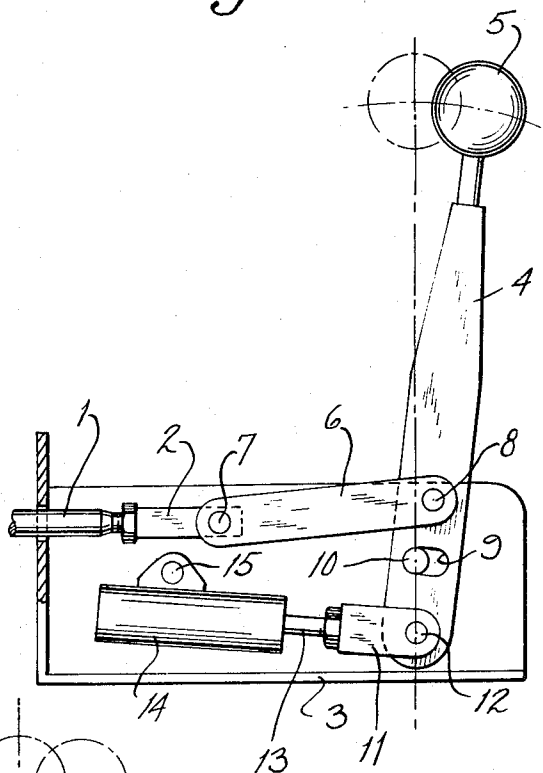
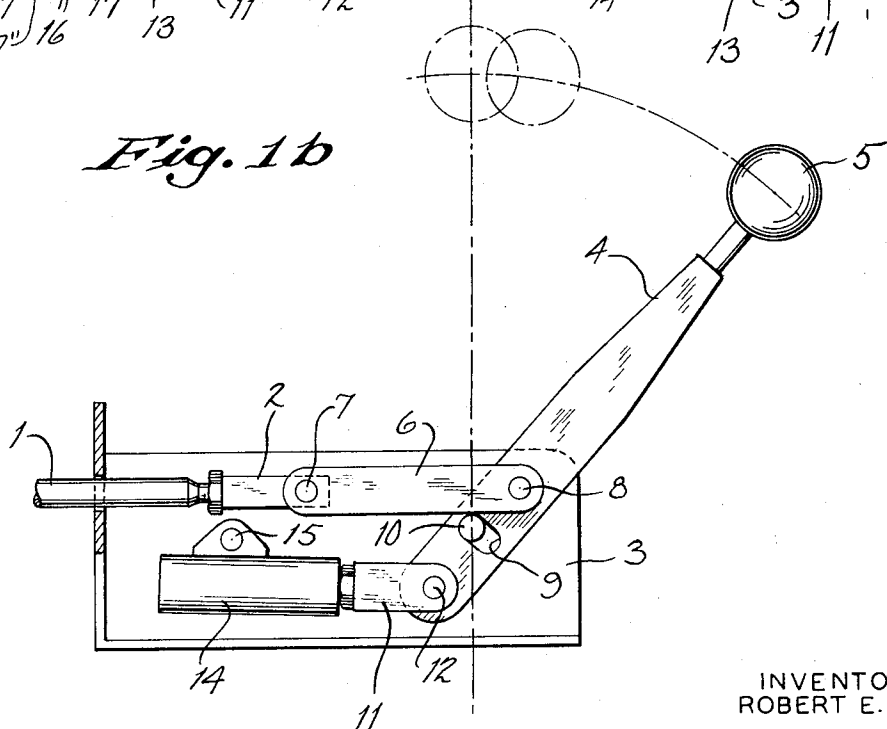


Fig. 1b



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Fig. 2

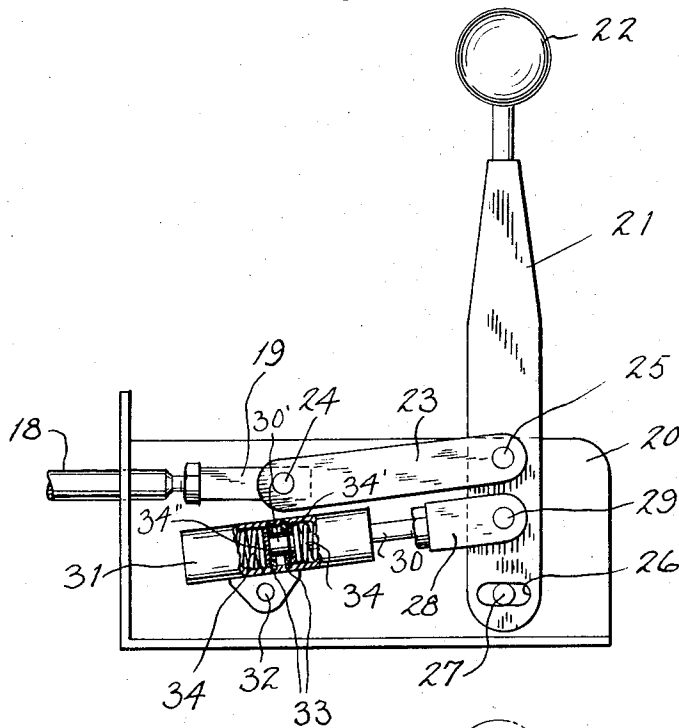
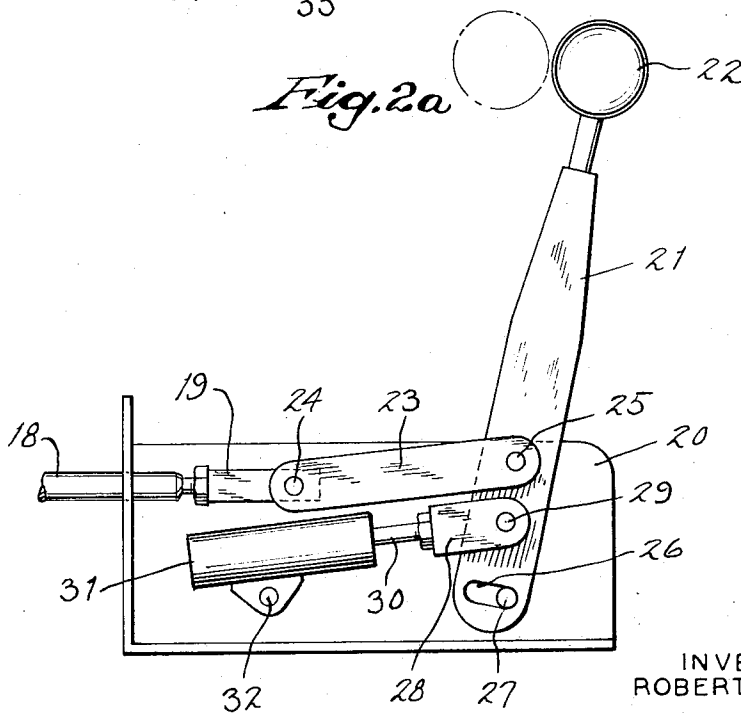


Fig. 2a



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Fig. 3

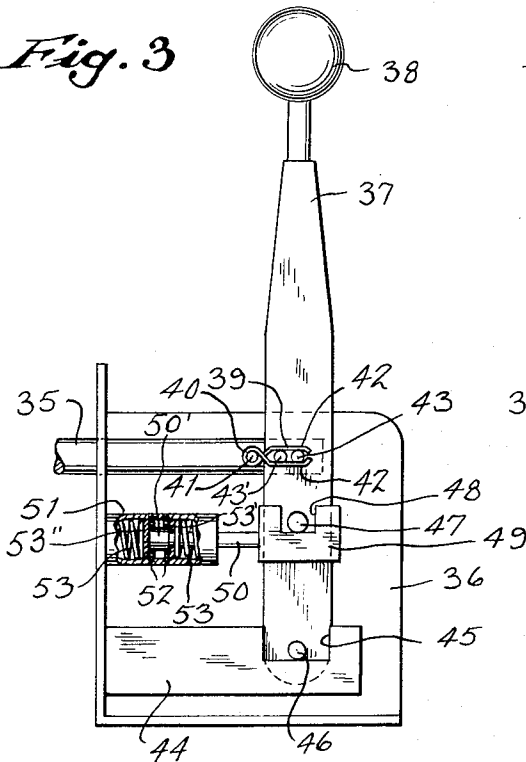


Fig. 3a

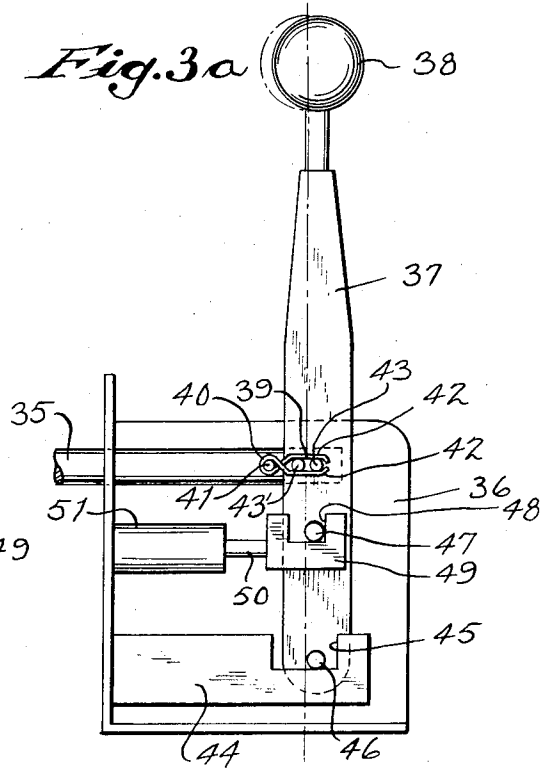


Fig. 3b

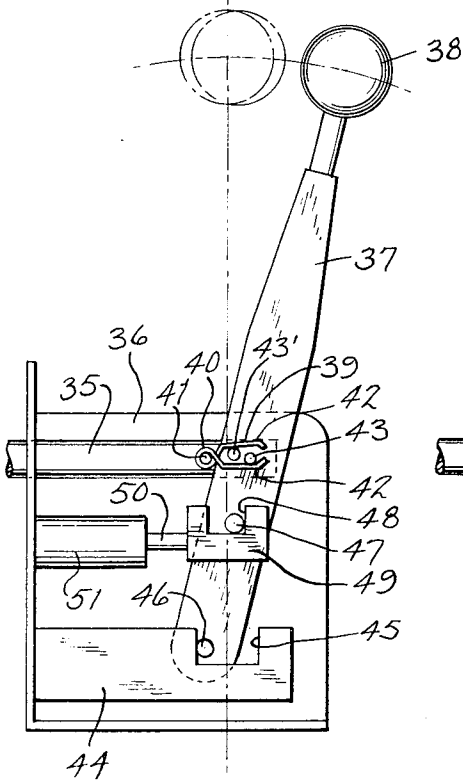
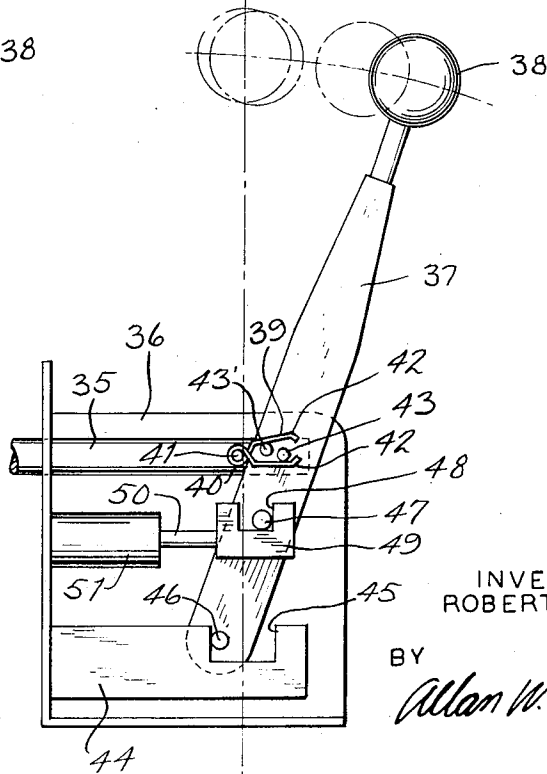


Fig. 3c

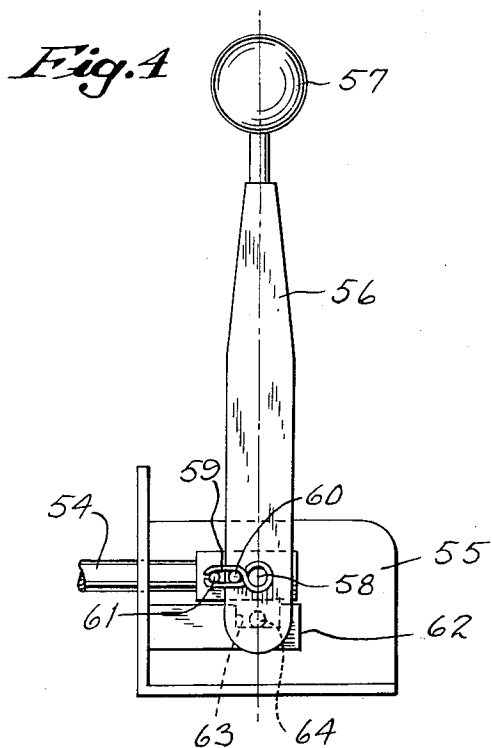
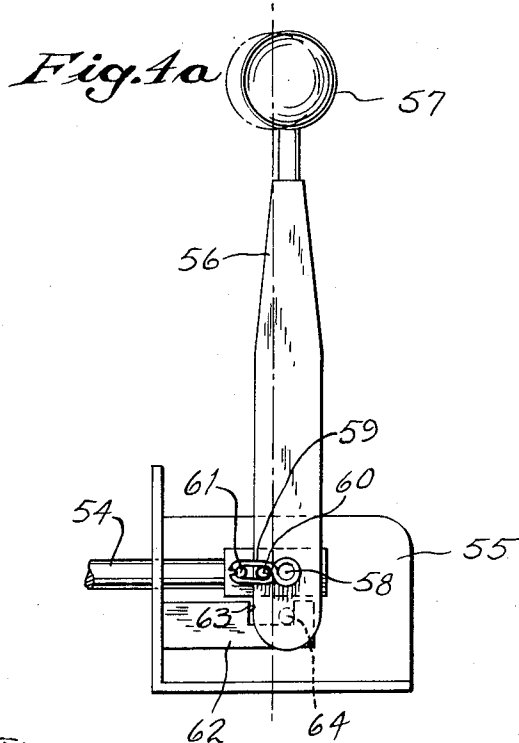
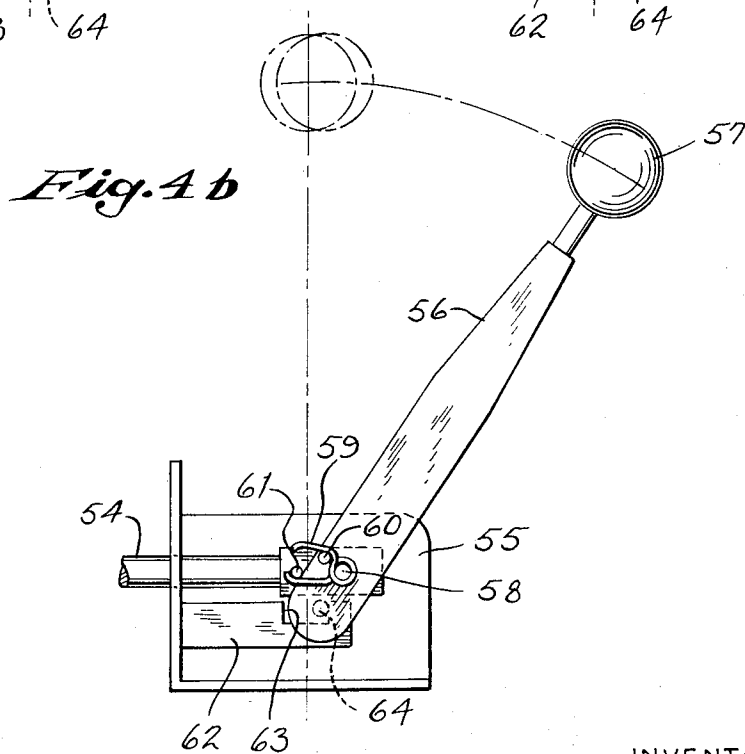


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MULTIPLE FULCRUM VALVE OPERATING LEVER

BACKGROUND OF THE INVENTION

The invention relates to shifting fulcrum control lever arrangements for axially movable valve stems or the like. The preferred embodiments are particularly effective for directional control valves of large excavating machines, but the invention is not limited to this application and may be useful wherever it is desired to actuate an axially movable member by means of a pivotal lever.

Directional control valves are usually actuated by means of pivotal control levers which connect to a stem extending from the valve spool and which pivot about a fulcrum point defined by a connection between the lever and a base. The fulcrum is generally fixed, so that movement of the valve stem is at all times directly proportional to lever movement in a fixed ratio dependent upon the length of the lever arm between the fulcrum and the point where the lever is connected to the stem. This fixed ratio presents two problems. First, any valve has a deadband resulting from the initial movement required before actual operation; and if the control lever must move the same proportional distance to cross the deadband as it must move to cross an equal part of the remaining range of movement, there is a significant waste of control lever travel and the range of movement left for control purposes is reduced. Second, there is inherently a significantly greater rate of flow increase immediately after opening a valve than there is as the valve nears a full open position; and, therefore, it is highly desirable to be able to use a greater proportion of the allowable control lever travel during the initial opening phase to provide enhanced control. These two problems can be extremely serious in large excavating or other equipment using heavy elements which move considerable distances and where very high flow rates are necessary.

The foregoing problems can be solved by providing a shifting fulcrum arrangement in which one fulcrum is used during one phase of the lever movement and a differently spaced fulcrum is used for the remainder. For such a shifting fulcrum arrangement to be fully satisfactory, however, it must meet several requirements: it should operate when the control lever is moved in either direction; it should allow the operator to feel the fulcrum shift; and in at least some cases it should provide for both deadband reduction and improved initial control which are to some extent inconsistent. While shifting fulcrum arrangements have been known for some time, see for example U.S. Pat. No. 555,738, they have not satisfactorily met all of these requirements.

SUMMARY OF THE INVENTION

It is the object of this invention to provide a shifting fulcrum control lever arrangement which provides for deadband reduction and/or enhanced initial control, which operates as the control lever is moved in either direction, and which allows an operator to distinctly feel a fulcrum shift. The embodiments shown are highly effective and durable, and are readily adaptable to very large equipment. Nevertheless, they are still relatively simple and inexpensive to manufacture, assemble, maintain and use. Other objects and advantages will appear from the description to follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation, with parts shown broken away and in cross section, of a first embodiment of the invention which provides for deadband reduction.

FIGS. 1a and 1b are similar to FIG. 1, but show successive positions of the embodiment of FIG. 1 during operation.

FIG. 2 is a schematic representation similar to FIG. 1 but showing a second embodiment of the invention which provides improved initial control.

FIG. 2a is similar to FIG. 2, but shows an intermediate position assumed by the embodiment of FIG. 2 during operation.

FIG. 3 is a schematic representation similar to FIG. 1 but showing a third embodiment which is a modification of the embodiment shown in FIG. 2 and which provides both deadband reduction and improved initial control.

FIGS. 3a, 3b and 3c are similar to FIG. 3, but show successive positions of this embodiment during operation.

FIG. 4 is a schematic representation of a fourth embodiment which provides for deadband reduction, and

FIGS. 4a and 4b are similar to FIG. 4, but show successive positions of the embodiment therein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the embodiment shown in FIGS. 1-1b, the reference numeral 1 designates the stem of a directional control valve spool (not shown), which is fitted with a suitable extension 2. As previously indicated, the invention herein is particularly suited for controlling large directional control valves, but it is also suited for any other application where it is desired to move an axially movable member by means of a pivotal lever. For this reason, and since the construction and operation of directional control valves is well known to those skilled in the art, the valve spool and body are not shown. It is sufficient to note that the stem 1 is axially movable in either direction to cause corresponding operation of the valve spool or other element to which it is attached.

The numeral 3 designates a base which is formed as a component of the valve body or any other support. The base 3 may be of any configuration, and serves only as a fixed support for the several elements to be described.

A control lever 4 is fulcrumed on the base 3 as will be described and has an operating handle 5 at its outer end. The lever 4 is connected to the valve stem extension 2 through a rigid link 6 which has one end pivotally connected to the outer end of the extension 2 by a pin 7. The outer end of the link 6 is in turn pivotally connected to the lever 4 by a pin 8. The pivotal mounting of the link 6 allows it to compensate for the difference between the pivotal movement of the lever 4 and the axial movement of the stem 1, and the pin 8 defines one end of the lever arm which determines the ratio of movement of the stem 1 in response to movement of the lever 4.

The lever 4 is provided with a transverse slot 9 which receives a pin 10 that is fixed to and projects from the base 3. The slot 9 and pin 10 together define one fulcrum for the lever 9, the fulcrum being relatively radi-

ally close to the pin 8 to produce a relatively short lever arm.

The lower end of the lever 4 is pivotally connected to a floating abutment member 11 by means of a pin 12. The pin 12 defines a second fulcrum for the lever 4 which is radially further from the pin 8 than the first fulcrum to define a relatively long lever arm. A rod 13 is fixed to and extends from the abutment 11 to be slidably received in a substantially closed, cylindrical spring housing 14 which is pivotally mounted on the base 3 by means of a pin 15. The pivotal movement allowed by the pins 15 and 12 compensates for the difference between the pivotal motion of the lever 4 and the axial movement of the rod 13.

The far end of the rod 13 is within the housing 14 and is provided with an enlargement 13' which is movable through opposite stops 16 defined by axially spaced snap rings fitted into grooves near the center of the housing 14. Opposite compression springs 17 are disposed within the housing 14 between respective closed ends and stops 16. A free washer 17' is disposed around the rod 13 between the inner end of the right hand spring 17 and the right stop 16 as seen in FIG. 1; and is engageable with the stop to limit spring extension and is engageable by the annular shoulder of the enlargement 13' to cause compression. A free disc 17'' is disposed between the inner end of the left spring 17 and left stop 16; and is engageable with the stop to limit spring extension and by the end of the enlargement 13' to cause compression. This arrangement provides a spring centering action wherein the rod 13 can move axially in either direction against a respective spring 17 and is automatically returned to an exact centered position, but while a particular construction is shown to accomplish this it will be obvious that other centering arrangements could be used. The sizing of the several parts will depend on the particular application, but the springs 17 must be strong enough to overcome the force of any centering springs (not shown) or other forces tending to retard axial movement of the stem 1.

As seen in FIG. 1, the valve stem 1, control lever 4, and abutment 11 are all in neutral or centered positions, and each is capable of being moved in either direction. The slot 9 allows limited relative movement of the lever 4 with respect to the base 3 in either direction. If it is desired to move the valve stem 1 to the right as seen in the drawings, the lever 4 is pivoted in a clockwise direction. During the first phase of this movement, the lever 4 will pivot about the second fulcrum defined by the pin 12, this fulcrum being relatively fixed because the springs 17 are strong enough to overcome any force that retards movement of the stem 1. During this phase of movement, the relatively long lever arm defined by the greater distance between the pins 8 and 12 is operative, resulting in a relatively great movement of the stem 1 per given movement of the lever 4. As previously indicated, this embodiment is intended to provide for deadband reduction, and the long lever arm insures that the deadband of the valve will be transversed quickly with the use of a minimum percentage of the allowable travel of the lever 3.

Pivotal movement about the pin 12 will continue until the elements reach the position shown in FIG. 1a, wherein the pin 10 has, in effect, moved to the left hand end of the slot 9. At this point, the pin 10 serves as a

rigid fulcrum, and further clockwise pivoting of the lever 4 will cause it to pivot about the pin 10 until the elements reach the position of FIG. 1b. During the course of this additional pivotal movement, the left hand spring 17 is simply compressed and overridden, the additional force required on the part of the operator to compress the spring 17 enabling the operator to feel distinctly the shift in operation.

During pivotal movement from the position of FIG. 1a to the position of FIG. 1b, the short lever arm defined by the distance between the pins 8 and 10 will be operative, and thus there will be correspondingly less movement of the stem 1 per increment of pivotal movement of the lever 4. As a result, a greater percentage of allowable lever travel is used for actually controlling operation of the valve. Thus, the embodiment of FIGS. 1-1b serves to reduce deadband by providing for fast travel across the deadband and then shifts to provide slower travel during the actual control period. In one actual installation similar to FIG. 1, for example, as the elements move from the position of FIG. 1 to the position of FIG. 1a, the first 36 percent of the valve stem movement requires only 19 percent of the lever stroke, leaving 81 percent of the lever travel for the remaining 64 percent of stem movement. The sizes and locations of the several elements will of course depend to some extent on the deadband characteristics of the particular valve to be controlled, but these are readily determinable. It will be apparent that the arrangement will function in the same way when it is desired to move the valve stem 1 to the left by pivoting the lever 4 in a counterclockwise direction, except that in such case the pin 10 will move to the right hand end of the slot 9 and the right hand spring 17 will be compressed after the fulcrum shift.

The embodiment of FIGS. 2 and 2a is substantially the same as the embodiment of FIGS. 1-1b, except for a reversal of certain elements. There is a stem 18, provided with an extension 19, and a base 20. A lever 21, with a handle 22, connected to the extension 19 through a link 23 and inner and outer pivot pins 24 and 25. The lever 21 is provided with a transverse slot 26 which receives a pin 27 on the base 20. There is a floating abutment 28 which is connected to the lever 21 by a pivot pin 29. A rod 30 leads from the abutment 28 into a spring housing 31 pivotally mounted on the base 20 by a pin 32. A centering arrangement includes an enlargement 30' at the end of the rod 30, snap ring stops 33, opposite compression springs 34, a washer 34' and a disc 34''. The elements 18 through 34'' correspond to the elements 1 through 17 of the embodiment of FIG. 1, the only significant difference being that the abutment pin 29 is closer to the pin 25 than is the pin 27, as the result of which operation is reversed.

When it is desired to move the stem 18 to the right, the lever 21 is pivoted in a clockwise direction. In the first phase of this movement the elements move to the position of FIG. 2a, which corresponds to FIG. 1a. Initial pivotal movement will again be around the fulcrum defined by the pin 29. However, because of the reversal of elements a relatively short lever arm defined by the distance between the pins 29 and 25 will be operative during this phase, so that there will be relatively less movement of the stem 18 per given increment of the lever 21. When the parts reach the position of FIG. 2a,

the pin 27 is at the right hand end of the slot 26. Further pivotal movement will be about the pin 27, thus causing a longer lever arm to become operative, resulting in greater movement of the stem 18 for a given increment of movement of the lever 21. The right hand spring 34 will be compressed and overridden as the lever 21 pivots further from the position of FIG. 2a.

The embodiment of FIGS. 2 and 2a is intended for use in situations where deadband is not a particular problem but where it is desired to provide for enhanced initial control. As previously indicated, it is a characteristic of most valves that the rate of flow increase is greater immediately after the valve opens than it is as the valve spool nears the end of its travel. Accordingly, during this period it is desirable to be able to use a greater proportion of the allowable control lever travel per given increment of stem travel. This objective is accomplished by providing an initially short lever arm. Again, the requirement for compressing one of the springs 34 provides the operator with a distinct indication that there has been a fulcrum shift. Operation of this embodiment will, of course, be the same if the control lever 21 is pivoted in either direction. Again, the size and location of the parts will depend upon the relatively easily determinable characteristics of the particular valve being controlled.

The embodiment of FIGS. 3-3c is functionally similar to the embodiment of FIGS. 2 and 2a, but provides for deadband reduction in addition to enhanced initial control. It includes a valve stem 35, a base 36, and a control lever 37 with a handle 38, all substantially the same as the corresponding elements of the preceding embodiments. The lever 37 is, however, pivotally connected to the stem 35 by means including a torsion spring 39. The spring 39 has a closed loop end 40 seated on a pin 41 on the stem 35 and opposite legs 42 which are disposed on either side of a pin 43 which pivotally connects the stem 35 to the lever 37 and a laterally spaced pin 43' on the lever 37. This configuration allows the lever 37 to pivot with respect to the stem 35 only when there is enough pivotal force on the lever 37 to cause the pins 43 and 43' to spread the legs 42, all for a purpose to be described. The pin 43 defines one end of the lever arm which determines the ratio of movement of the lever 37 to stem 35. Although the particular form of torsion spring 39 shown herein is preferred, it will be obvious that any other torsion spring arrangement which suitably retards pivotal movement between the lever 37 and stem 35 could be substituted. As will become obvious, the spring 39 must be strong enough to effectively overcome any centering spring or other force tending to limit axial movement of the stem 35.

A rigid arm 44 is fixed to the base 36 and extends across the lower end of the lever 37, where it is provided with a rectangular cut out 45. A pin 46 fixed to the lower end of the lever 37 extends into the cut out 45. The pin 46 and cut out 45 together serve, in effect, as a pin and slot connection or fulcrum which allows limited relative movements of the lever 37 with respect to the base 36. The cut out 45 is provided with relatively high sidewalls, and as a result it is not necessary to pivotally mount the arm 44 to compensate for the pivotal movement of the lever 37 since during such relative movement the pin 46 can simply ride up the sidewalls of the cut out 45.

Disposed on lever 37 is another pin 47 which is received in a rectangular cut out 48 of a floating abutment member 49. The abutment 49 is provided with a rod 50 which is slidably received in a spring housing 51 fixed to the base 36. A centering arrangement includes an enlargement 50' at the end of the rod 50, snap ring stops 52, opposite compression springs 53, a washer 53' and a disc 53'', all corresponding to the elements in the previous embodiments, the abutment 49 normally being held in the centered position shown in FIG. 3. The pin 47 and cut out 48 together define a lost motion connection between the lever 37 and abutment 49, which connection affords the lever 37 limited relative movement in either direction, but the movement thus allowed is less than that allowed by the pin and slot connection defined by the pin 46 and cut out 45. Again, the relatively high sidewalls of the cut out 48 make it unnecessary to pivotally mount the spring housing 51 since the pin 47 can ride up the sidewalls to compensate for the pivotal movement of the lever 37.

As seen in FIG. 3, all of the movable elements are in centered or neutral positions, and are capable of being moved in either direction. When it is desired to move the stem 35 to the right the lever 37 is moved to the right, and the elements accordingly move to the position shown in FIG. 3a. During the first phase of operation, however, there is no pivotal movement of the lever 37, this being prevented by the torsion spring 39. Therefore, both the lever 37 and stem 35 move in a straight line to the right to cross the deadband of the valve with the shortest possible movement of the lever 37. In effect, it can be said that the torsion spring 39 develops an infinite lever arm so that movement of the stem 35 actually equals movement of the lever 37.

The linear movement of lever 37 and stem 35 continues until the pin 47 traverses to the right hand side of the cut out 48 as seen in FIG. 3a. Further movement of the lever 37 to the right will then cause the lever 37 to pivot about the pin 47 until the elements move to the position shown in a FIG. 3b. During this pivotal movement there is, of course, a relatively short lever arm defined by the distance between the pin 47 and pin 43, so that given movement of the lever 37 will produce relatively little movement of the stem 35, resulting in enhanced initial control as in the embodiment of FIGS. 2 and 2a.

When the elements reach the positions shown in FIG. 3b, the pin 46 is against the left side of the cut out 45, and further pivotal movement will be about the fulcrum defined by the pin 46, as the result of which the parts will move to the position shown in FIG. 3c. During this further movement, the right hand spring 53 will be compressed or overridden. In addition, a relatively long lever arm defined by the greater distance between the pin 46 and torsion spring 39 will produce for a given movement of the lever 37 a correspondingly greater movement of the stem 35.

The embodiment of FIGS. 3-3c provides, in effect, three different lever arms—an infinite lever arm which allows the deadband to be quickly traversed, a relatively short lever arm which provides for enhanced initial control, and a relatively long lever arm which allows movement of the stem 35 to be completed quickly once the initial phase has been passed. The operator is able to distinctly feel the shifts in operation, first as the result of the additional force required to overcome the

torsion spring 39, and then as the result of the additional force required to overcome the springs 53. Operation will, of course, be the same in either direction. Again, the sizing and location of the parts will depend on the characteristics of the particular valve to be controlled. Obviously, pin and slot connections and pivotal mountings such as those shown in the embodiments of FIGS. 1-2a could be substituted for a cut out-pin arrangement shown in the embodiment of FIGS. 3-3c, or vice versa.

The embodiment of FIGS. 4-4b simply uses a torsion spring to provide deadband reduction. It includes a valve stem 54, a base 55, and a lever 56 with a handle 57, all corresponding to the elements of the previous embodiments. The lever 56 is pivotally connected to the stem 54 by means of a pin 58, but pivotal movement is restricted by a torsion spring 59 which is generally similar to the spring 39. However, the spring 59 has its closed loop end seated around the pin 58 and its legs on either side of a pin 60 on the lever 56 and another pin 61 on the stem 54.

A rigid arm 62 is fixed to the base 55 and extends across the lower end of the lever 56 where it is provided with a rectangular cut out 63. A pin 64 fixed to the lever 56 is received in the cut out 63. The pin 64 and cut out 63 together provide a lost motion connection which allows limited relative movement of the lever 56 with respect to the base 55.

As seen in FIG. 4, the movable elements are all centered. When it is desired to move the stem 54 to the right the lever 56 is moved to the right whereupon the elements move to the positions shown in FIG. 4a. As in the embodiment of FIGS. 3-3c, there is no pivotal movement of the 56 with respect to the stem 54 during this phase. Such movement is prevented by the spring 59 which is strong enough to overcome any retarding force on stem 54. In the position of FIG. 4a, the pin 64 has traversed to the right hand sidewall of the cut out 63. Further movement of the lever 56 will cause the lever 56 to pivot about the pin 64, the lever arm being constant in this embodiment throughout the entire range of further movement of the lever 56. Thus, this embodiment provides for deadband reduction through the use of a torsion spring which, in effect, defines an infinite lever arm during the initial phase of the movement.

Although four preferred embodiments of the invention have been shown and described herein, it will be apparent that other embodiments and modifications might readily be conceived or developed without departure from the spirit of the invention. The invention is not, therefore, intended to be limited by the showing herein, or in any other manner, except insofar as may specifically be required by the following claims.

I claim:

1. In a control lever arrangement for a directional control valve or the like having an axially movable stem operatively connected to a control lever fulcrumed on a fixed base, which lever is pivotally movable between a normal position and at least one actuated position to cause corresponding axial movement of the stem, the improvement wherein:

there are two fulcrum connections between the lever and the base which are differently spaced with respect to the point of connection between

the lever and the stem; one of said fulcrum connections comprises a pin and slot connection which allows the lever limited movement with respect to the base as the lever begins to move toward actuated position; and the other of said connections comprises an abutment operatively connected to the base and pivotally connected to the lever to define a fulcrum, there being bias means operatively interposed between the abutment member and the base which holds the abutment member in a normal position with respect to the base, but which can be overridden as the lever completes its movement toward actuated position, initial movement of the lever toward actuated position causing the lever to pivot about the fulcrum defined by the abutment member until the limit of movement afforded by the pin and slot connection has been reached, further movement of the lever then causing the lever to pivot about the pin and slot connection and override the bias means.

2. The arrangement of claim 1 wherein, the lever is pivotally movable to two actuated positions on opposite sides of its normal position; the pin and slot connection allows limited movement of the lever relative to the base as it begins to move toward either actuated position; and there are two bias means of the abutment which together hold the abutment in its normal position, the bias means being adapted to be respectively overridden as the lever completes its movement toward either actuated position.

3. The arrangement of claim 2 wherein, the abutment comprises an elongated member pivotally connected at one end to the lever and has a radially extending spring seat near its opposite end; there is a closed, generally cylindrical housing pivotally connected to the base which axially slidably receives the opposite end of the elongated member; and the bias means comprises two compression springs seated between the spring seat and respective ends of the housing.

4. The arrangement of claim 2 wherein, there is an operative pivotal connection between the lever and stem; the fulcrum defined by the abutment is closer to the pivotal connection than the fulcrum defined by the pin and slot connection; there is a lost motion connection between the lever and the abutment which allows limited movement of the lever relative to the base as the lever begins its move toward either actuated position, the extent of such movement being less than that allowed by the pin and slot connection; and there is a torsion spring interposed between the lever and stem which resists pivotal movement of the lever in either direction relative to the stem.

5. In a control lever arrangement for a directional control valve or the like having an axially movable stem operatively pivotally connected to a control lever fulcrumed on a fixed base, which lever is pivotally movable between a normal and at least one actuated position to cause corresponding movement of the stem, the improvement wherein:

the fulcrum comprises a lost motion connection which allows the lever limited movement with respect to the base as the lever begins to move toward actuated position; and there is a torsion spring interposed between the lever and the

stem which resists pivotal movement of the lever relative to the stem so that initial movement of the lever from a normal position is linear, such linear movement continuing until the limit of movement afforded by the lose motion connection has been reached, further movement then causing the lever to pivot about the lost motion connection overriding the torsion spring.

6. The arrangement of claim 5 wherein, the lever is

pivotally movable to two actuated positions on opposite sides of its normal position, the lost motion connection allows limited movement of the lever relative to the base as it begins to move toward either actuated position; and the torsion spring resists pivotal movement of the lever in either direction relative to the stem.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,693,474 Dated September 26, 1972

Inventor(s) Robert E. Trick

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4,	line 48,	"amounted" should read -- mounted --
Column 5,	last line,	"of the sidewalls" should be deleted
Column 6,	line 41,	"a" appearing before "Fig. 3b" should be deleted
Column 7,	line 36,	-- lever -- should be inserted before "56"
Column 8,	line 28,	"of the abutment" should be deleted
Column 9,	line 5,	"lose" should read -- lost --

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents