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(54) A CLUTCH OPERATOR

(71) We, DANA CORPORATION, a Corporation of the State of Virginia, United States of America, of 4500 Dorr Street, Toledo, Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement—:

This invention relates to a vehicle clutch operator.

The clutch in a conventional automobile or a light truck is controlled by a clutch pedal connected through a linkage to a clutch throwout bearing. However, when the clutch must transmit relatively high loads such as in heavy duty trucks and construction equipment, the force required to move the clutch pedal is sufficiently high to warrant power assist devices. Furthermore, in some applications it is desirable not to have the rigid linkages often used between the clutch pedal in the vehicle cab and the clutch. For example, in the "cab over" truck the linkage must be flexible or detachable for servicing purposes. A fluid actuated operator can be utilized to actuate the clutch with reduced pedal effort in response to control of the driver through the clutch pedal and allows the use of a flexible cable or the like between the cab and the clutch. The fluid utilized is usually pressurized air, although it will be understood that other gas or liquid can be used.

Normally, clutch operators are connected to a pivoted link to transmit force to the throwout bearing. Most clutches have a bearing load curve that increases from full engagement to full disengagement and are readily controlled. However some clutches, generally known as declining pedal effort clutches, have a lower bearing load at full disengagement than at some point between full engagement and full disengagement. The prior art fluid actuated clutch operators are not satisfactory in operating such clutches.

The prior art air actuated opeators can be of the type which are operated from a source of vacuum, such as the intake manifold of the vehicle engine, or of the type which are operated from a source of air under pressure where a relatively high operator force is required. The operator requires a valve for connecting to and disconnecting from the source when it is desired to actuate the clutch.

According to the present invention there is provided a fluid actuated opeator for a clutch, comprising: a housing; a clutch operator rod axially slidably mounted within the housing; a control sleeve having an axial bore through which the operator rod extends; and a movable wall connected to the operator rod to define, with the housing, a working chamber, the operator rod having a first passage and a second passage, the first passage being adapted for connection to a source of fluid under pressure and opening at a location disposed outside the working chamber, and the second passage opening at a first location disposed outside the working chamber and spaced from the location at which the first passage opens, and opening at a second location disposed within the working chamber, the control sleeve having at least one bridging duct opening into the axial bore at two axially spaced locations, the sleeve being movable, in use, into a clutch operating position on the operator rod in which the or each bridging duct provides communication between the first passage and the second passage to allow fluid under pressure to be supplied to the working chamber to displace the movable wall thereby to displace the clutch operator rod to operate a clutch.

A preferred embodiment of the present invention provides a fluid actuated operator which is particularly useful in operating declining pedal effort clutches. In such clutches, the pressure springs of the clutch generate a bearing load curve which increaes from the fully engaged position to a maximum at an initial engagement position and decreases from the initial engagement position to a fully disengaged position.

The control sleeve may be connected to the vehicle clutch pedal by a flexible cable for movement into and out of the clutch operating position. In a preferred embodiment as the clutch pedal is depressed, there is movement of the sleeve relative to the operator rod to compress a biasing spring. The biasing spring is provided to overcome any friction which would prevent the sleeve from returning to the full exhaust position when the cable is relaxed. The sleeve and the operator rod preferably are provided with a stop means to allow the rod to be directly moved to the clutch disengaging position by the cable and the control sleeve to provide for manual actuation of the clutch should the source of air pressure fail.

The operator functions as a power assisted servomechanism with the operator rod following the movement of the clutch pedal and the control sleeve.

For a better understanding of the present invention and to show how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Figure 1 is a schematic view of a vehicle clutch linkage including an air actuated operator;

Figure 2 is a partial sectioned view of the operator in one operative condition;

Figure 3 is a view corresponding to Figure 2 showing the operator in another operative condition; and

Figure 4 is a view corresponding to Figures 2 and 3 showing the operator in a third operative condition.

As shown in Figure 1, a clutch pedal 11 is pivotally mounted for movement between a released position (shown) and a depressed position. A clutch pedal return spring 12 is connected to the clutch pedal 11 to return it to the released position after it has been depressed and released. A flexible cable 13 is connected between the clutch pedal 11 and an air actuated operator 14. The operator 14 is pivotally connected to a part 15 on the vehicle which is stationary with respect to the vehicle transmission and has an operator rod or arm 16 pivotally connected to one end of an operator link 17. The other end of the operator link 17 is connected to a cross-shaft 18 pivotally attached to a fixed point on the vehicle such as a transmission case (not shown).

A clutch operating lever 19 has one end fixed to the cross-shaft 18 such that the operator link 17 and the lever 19 both rotate with the cross-shaft. The other end of the lever 19 is attached to a throwout bearing 21 of the clutch 22. The clutch 22 is associated with a flywheel 23 of the vehicle engine (not shown). A source of air under pressure 24 is connected by a flexible hose 25 to an air inlet on the operator rod 16.

As the clutch pedal 11 is depressed, that movement is transmitted to the air actuated operator 14 by the flexible cable 13 to open a valve, shown in Figures 2 to 4, within the operator. The valve allows air from the source of air under pressure 24 to flow to a chamber also within the operator to generate a force to extend the operator rod 16 from the operator 14 in the direction towards the operator link 17, as shown by the arrow in Figure 4. This rotates the operator link 17 and the cross-shaft 18 in a clockwise direction. As the operator link 17 rotates, the operator 14 will rotate about its pivotal connection to the part 15 to accommodate the operator link movement. The lever 19 rotates with the operator link 17 to move the throwout bearing 21 in a direction away from the flywheel 23 to allow a pressure plate 26 and a driven disk 27 of the clutch 22 to disengage from a driven relationship with the flywheel. The pressure plate 26 is connected to rotate with the flywheel 23. Under the influence of the operator 14, the pressure plate 26 compresses clutch pressure springs represented by the spring 28, to the fully disengaged position of the clutch 22.

As the clutch pedal 11 is released to return to the released position, the valve in the operator 14 closes to block the admission of air to the chamber in the operator 14 in response to the movement of the flexible cable 13. The air in the chamber is exhausted to reduce the force applied to the operator rod 16. The clutch pressure springs 28 move the pressure plate 26 and the driven disk 27 towards engagement with the flywheel 23. The clutch pressure springs also move the throwout bearing 21 toward the flywheel 23 to rotate the lever 19, the operator link 17 and the cross-shaft 18 in a counter-clockwise direction. The rotation of the operator link 17 forces the operator rod 16 back into the operator 14 toward the position at which the clutch 22 is fully engaged.

In a conventional clutch, the pressure springs must be capable of exerting a biasing force of a relatively high magnitude to obtain sufficient pressure between the driving and the driven members in the engaged position. Since the pressure springs are usually mounted to provide the biasing force only in a direction parallel to the direction of movement of the throwout bearing, they will generate an increasing throwout bearing load curve as the clutch is operated from the fully engaged to the fully disengaged positions. If an air actuated operator is utilized to operate the clutch, the optimum operating characteristics are obtained when the operator link 17 of Figure 1 is positioned with its longitudinal axis generally normal to the longitudinal axis of the operator rod 16 when the clutch is in the fully disengaged position and the operator rod is extended from the operator. This relationship will generate the maximum moment about the pivot point 18 and the maximum force for compressing the clutch pressure springs when the clutch is fully disengaged. As the clutch moves toward the fully engaged position, the operator link 17 is rotated in a counter-clockwise direction to reduce its effective length. When the operator 14 is actuated, the operator link will be rotated in a clockwise direction to increase both its effective length and the force applied to the throwout bearing to overcome its increasing load curve.

As shown in Figure 1, the clutch pressure springs 28 of the clutch are mounted so that their mounting means move axially toward each other at a constant radial distance from each other. The axial change in the distance for the mounting means results in a shift in the angular relationship of each spring such as that the effective spring force component providing the biasing force in the direction of movement of the throwout bearing 21 reduces at a lower than normally expected rate between the fully engaged position when new and the fully engaged position after wear and increases at a lower than normally expected rate between the fully engaged position and the fully disengaged position. This arrangement provides a clutch having a substantially constant clutch operating pressure over the full range of wear conditions. The load curve increases from the engaged position to a maximum beyond the force at which the clutch disengages and decreases toward the fully disengaged position. Therefore, the force required to hold the clutch in the fully disengaged position is less than the maximum force required during movement between full engagement and full disengagement.

When the valve of the air actuated operator closes to disconnect the source of air under pressure, the operator will be vented to reduce the air pressure in the operator so as to reduce the force applied to the throwout bearing. As the operator applied force falls below the reaction force exerted by the compressed clutch pressure springs 28, the clutch will begin to move from the fully disengaged position to the fully engaged position.

In a conventional clutch and clutch linkage, the throwout bearing load and the operator force both decrease as the clutch moves towards full engagement such that the clutch smoothly follows the bearing load curve for proper operation. However, when a conventional clutch linkage and air actuated operator are utilized with a declining pedal effort clutch, the force/displacement curves of the clutch and the operator and linkage do not complement one another so that optimum operation of the clutch is not achieved. The operator typically has some lost motion between the air supply and the exhaust positions of the valve so that the declining pedal effort clutch may actually continue to move in the desired direction of travel until the lost motion is taken up and the valve is actuated to stop that travel.

The air actuated operator 14 and the operator link 17 shown in Figure 1 provide a means for operating the declining pedal effort clutch 22 whereby optimum operation of the clutch is achieved. The operator rod 16 and the operator link 17 are positioned so that the longitudinal axis of the operator link forms an approximately forty-five degree angle with an imaginary line drawn through the centre of the cross-shaft 18 normal to the longitudinal axis of the operator rod 16 when the clutch 22 is in the fully engaged position. As the air actuated operator 14 is operated by the depression of the clutch pedal 11 and the movement of the flexible cable 13, the operator arm 16 will be extended from the operator. The operator rod 16 will apply a force to rotate the operator link in a clockwise direction thereby releasing the clutch 22 from engagement. After the operator link 17 has been rotated through an angle of approximately twenty-five degrees, the clutch pressure plate 26 and the driven disk 27 will be in the fully disengaged position. It will be evident that during this rotation the effective length of the operator link 17 has decreased to reduce the moment applied by the operator about the pivot point, the cross-shaft 18, and so to decrease the force applied to the clutch pressure springs which is consistent with the declining pedal effort clutch bearing load.

To engage the clutch 22, the clutch pedal 11 is pivoted upwards towards its released position to close the valve in the operator 14. The valve disconnects the source of air under pressure 24 and begins venting to reduce the operator applied force. When the operator applied force falls below the bearing load exerted by the compressed clutch pressure springs, the clutch will begin to move from the fully disengaged position toward the fully engaged position. As the clutch pressure springs force the operator link 17 to rotate in a counter-clockwise direction, the effective length of the operator link increases and therefore, even if the operator force is decreasing, the applied torque resisting the clutch pressure spring force increases to follow the bearing load curve for proper operation. The operator rod 16 follows the movement of the clutch pedal since the valve in the operator is position sensitive to apply air pressure or vent as required to adjust the movement of the rod.

As shown in Figure 1, the effective length of the operator link 17 decreases as the angle between the operator link 17 and the normal to the operator rod 16 increases, and increases as this angle decreases. This effective length is proportional to the cosine of the angle. The moment about the pivot point, the cross-shaft 18, is equal to the effective length times the force applied by the operator 14. This moment is applied by the lever 19 as a force to the throwout bearing 21.

Figure 2 shows a preferred form of the air actuated opeator 14 of Figure 1 in an enlarged longitudinal partial section view. The operator 14 has a housing comprising a front housing part 41 and a rear housing part 42 connected together by a plurality of suitable fastening means represented by a bolt 43. The rear housing part 42 is shown as being pivotally connected to the vehicle frame by a clevis pin 44 inserted through a hole in the housing part 42 and corresponding holes in a mounting bracket 45 fixed to the part 15 of Figure 1. However, the housing part 42 can be pivotally connected to any convenient part of the vehicle, such as the transmission, by any suitable fastening means. The end of the front housing part 41 away from the rear housing part 42 has a face plate 46 attached thereto by a plurality of suitable fastening means represented by a bolt 47.

The face plate 46 has a central aperture through which the operator rod 16 extends. The outer end of the operator rod 16 is screwed into an axial aperture formed in one end of an adapter rod 48. A lock nut 49 on the operator rod 16 is screwed against the adapter rod 48 to prevent relative rotation between the two rods. The end of the adapter rod 48 away from the operator rod 16 has a hole for receiving a clevis pin 51 which connects the adapter rod to the operator link 17.

The inner end of the operator rod 16 is slidably received in a pair of sleeve bushings 52 and 53. The sleeve bushing 52 is press fitted into an aperture in the front housing part 41 and, along with a ring seal 54, is retained by the face plate 46. The sleeve bushing 53 is press fitted into an aperture formed in the rear housing part 42. The seal 54 prevents dirt and dust from entering the housing and could be replaced by a flexible boot connected between the face plate 46 and the outer end of the operator rod 16.

The inner end of the operator rod 16 extends through a centrally located aperture in a movable wall constituted by a gas impervious diaphragm 55 which is retained between opposing faces of the front housing part 41 and the rear housing part 42 to seal along its circumference. A central portion of the diaphragm 55 is retained between a pair of retainers 58 and 59. A collar 56 having a pair of flanges is retained by a split ring 57 against a shoulder formed on the operator rod 16. The split ring 57 is received in an annular groove in the operator rod 16. The retainer 58 is positioned on the front housing part side of the diaphragm 55 and retainer 59 is positioned on the rear housing part side of the diaphragm 55. The retainers 58 and 59 and the diaphragm 55 are assembled on a sleeve with a flange on one end whereupon the flange on the other end is formed to produce the collar 56. The distance between the flanges and the thickness of the retainers 58 and 59 and the diaphragm 55 are such that the retainers and the diaphragm are held in abutting relationship with one another to seal around the edge of the diaphragm aperture to prevent radial movement of the diaphragm away from the operator rod 16. The area between the operator rod 16 and the bore of the collar 56 is sealed by an "O" ring 61 retained in an annular groove in the operator rod. However, the rod 16 can be rotated without rotating the collar 56 to prevent damaging the diaphragm. The retainers 58 and 59 form a piston against which the pressurized air can act to move the operator rod 16.

A collar 62 is retained between a first shoulder on the operator rod 16 and one end of a compression spring 63. The other end of the compression spring 63 acts against an end surface of a sleeve 64. The sleeve 64 has formed therein an annular groove for receiving a ball 65 attached to the end of the flexible cable 13. The flexible cable 13 extends through the bore of a flanged bushing 66 which is located in an eccentric aperture in the end of the front housing 41. The bushing 66 also extends through an aperture in the face plate 46 and a nut 67 is screwed on to it to attach the bushing to the face plate and to seal the aperture. The ball 65 is retained in the annular groove by a cup shaped retaining ring 68 which is biased against a shoulder on the sleeve 64 by a compression spring 69. The spring 69 acts against a split ring 71 which is received in an annular groove formed in the sleeve 64. This arrangement has been found to be convenient, but other suitable means for connecting the cable to the sleeve could be utilized.

The operator 14 is shown in Figure 2 in the position corresponding to the clutch being fully engaged. As the clutch pedal of Figure 1 is depressed, the flexible cable 13 is drawn through the flanged bushing 66 to move the sleeve toward the face plate 46 while the operator rod 16 remains stationary. The spring 63 will be compressed between the sleeve 64 and the collar 62 as shown in Figure 3. No matter what the position of the operator rod 16 and the sleeve 64 relative to the face plate 46, the clutch pedal will be working against the force of the return spring 12. Relative movement of the sleeve 64 towards the face plate 46 with respect to the operator rod 16 is limited by a second shoulder formed on the operator rod spaced from the first shoulder by a distance slightly greater than the fully compressed length of the spring 63. If the air pressure source has failed, the sleeve and rod will move in unison to manually operate the clutch.

The operator rod 16 and the sleeve 64 also form a valve for controlling the application of pressurized air to the operator 14 and the venting thereof. The operator rod 16 includes an axial fluid passage having the outer end blocked by a plug 72 (Figure 2). An air inlet boss 73 formed on the operator rod 16 has a fluid inlet passage which connects with the axial fluid passage. A fitting 74 on the end of the flexible hose 25 threadably engages the inlet boss 73 to supply pressurized air to the axial fluid passage. The axial fluid passage is also blocked by a ball 75 pressed into it at a position between the inlet boss 73 and the end of the operator rod which slidably engages the sleeve bearing 53. The ball 75 divides the axial fluid passage into two for diverting fluid through the valve elements as discussed below.

One or more first radially extending fluid passages, formed adjacent the ball 75 on the inlet boss side, connect the axial fluid passage with a first annular groove formed in the operator rod 16. One or more second radially extending fluid passages, formed adjacent the ball 75 on the diaphragm side, connect the axial fluid passage with a second, wider, annular groove formed in the operator rod 16. One or more third radially extending fluid passages, formed approximately equidistant from the ball 75 and the diaphragm 55, connect the axial fluid passge with a third annular groove formed in the operator rod 16. One or more fourth radially extending fluid passages, formed on the side of the diaphragm 55 opposite the other radial fluid passages, connect the axial fluid passage with a working chamber bounded by the diaphragm 55 and the rear housing part 42. Four seals 76 are provided on the operator rod 16 alternately with and adjacent to the first, second and third radially extending fluid passages. Each seal 76 comprises an "O" ring retained in an annular groove with a sealing ring formed of polyetrafluoroethylene or a similar material to prevent leakage between the operator rod 16 and the sleeve 64.

The sleeve 64 also includes fluid passages which cooperate with the corresponding fluid passages in the operator rod 16 to connect the source of pressurized air to the working chamber or to vent the working chamber. One or more first radially extending fluid passages, formed adjacent the retaining ring 68, connect the bore of the sleeve 64 with one or more axial fluid passages formed in the sleeve parallel to the bore and radially spaced therefrom. One or more second radially extending fluid passages, formed between the first passages and the split ring 71, connect the bore of the sleeve 64 with the axial fluid passages. One or more third radially extending fluid passages formed on the diaphragm side of the split ring 71, connect the bore with the interior of the housing part 41. The front housing part 41 has a vent plug 77 which permits the venting to atmosphere.

As shown in Figure 2, in the clutch fully engaged position the second and third radially extending fluid passages of the operator rod 16 and the sleeve 64 respectively are in fluid communication. The working chamber is in fluid communication with the interior of the housing part 41 through the fourth radially extending fluid passages, the axial fluid passage in the operator rod 16 and the third radially extending fluid passages of the operator rod and the sleeve. Since both sides of the diaphragm 55 are at the same air pressure, there will be no force exerted on the operator rod 16 and the clutch will remain in the fully engaged position.

As shown in Figure 3, as the clutch pedal is initially depressed, the flexible cable moves the sleeve 64 towards the face plate 46 as the operator rod 16 is maintained in position. The forward movement of the sleeve 64 relative to the operator rod

16 will first move the third radially extending fluid passages out of register and then will place the first radially extending fluid passages into register while the second radially extending fluid passages remain in register. Now the source of air under pressure is connected to the working chamber through the axial fluid passage of the operator arm 16, the first radially extending fluid passages, the axial fluid passges in the sleeve 64, the second radially extending fluid passages, the axial fluid passage in the operator rod and the fourth radially extending fluid passages.

The pressurized air will exert a force on the diaphragm 55 and the piston formed from the retainers 58 and 59 which will tend to force the operator rod 16 through the face plate 46 toward the disengaged position of the clutch. If continued pressure is applied to further depress the clutch pedal, the sleeve 64 will move in unison with the operator rod 16 to the clutch fully disengaged position shown in Figure 4. If the clutch pedal is held at a partially depressed position, the operator rod 16 will continue to move relative to the sleeve to move the first radially extending fluid passages out of register and disconnect the source of fluid under pressure from the working chamber. Now the operator force and the clutch pressure spring force are equal and the clutch is held in partial disengagement.

As the clutch pedal is raised, the cable 13 will force the sleeve 64 toward the diaphragm 55 to close the air pressure path and connect the vent path. The working chamber will now vent through the path to reduce the air pressure and the force applied by the operator 14. The clutch pressure springs will force the operator rod back into the operator 14. The operator rod 16 will follow the movement of the clutch pedal and the sleeve to return to the clutch fully engaged position shown in Figure 2 where it is ready for the next clutch pedal operation.

If the operator 14 should fail, due, for example, to the breakage of the cable 13 or a decrease in the air pressure, the clutch pressure springs will force the operator rod into the housing until the second shoulder on the operator rod 16 contacts the sleeve 64. Then the operator rod 16 and the sleeve 64 will be forced to the fully retracted position of the operator 14 such that in the failure mode the vehicle clutch is engaged. If the failure is not due to the breakage of the cable 13, the operator 14 can be actuated manually. Pressure applied to the clutch pedal 11 will be transmitted through the cable 13 to draw the sleeve 64 against the second shoulder on the operator rod 16 and then draw both the operator rod and the sleeve toward the face plate 46 to operate the clutch linkage to disengage the clutch. The clutch pressure springs and the clutch pedal return spring will return the operator 14 to the fully retracted position as the pressure is removed from the clutch pedal.

Our co-pending patent application No. 7,903,521 relates to another embodiment of fluid actuated operator. Reference is directed to this application.

WHAT WE CLAIM IS:—

1. A fluid actuated operator for a clutch, comprising: a housing; a clutch operator rod axially slidably mounted within the housing; a control sleeve having an axial bore through which the operator rod extends; and a movable wall connected to the operator rod to define, with the housing, a working chamber, the operator rod having a first passage and a second passage, the first passage being adapted for connection to a source of fluid under pressure and opening at a location disposed outside the working chamber, and the second passage opening at a first location disposed outside the working chamber and spaced from the location at which the first passage opens, and opening at a second location disposed within the working chamber, the control sleeve having at least one bridging duct opening into the axial bore at two axially spaced locations, the sleeve being movable, in use, into a clutch operating position on the operator rod in which the or each bridging duct provides communication between the first passage and the second passage to allow fluid under pressure to be supplied to the working chamber to displace the movable wall thereby to displace the clutch operator rod to operate a clutch.

2. An operator as claimed in claim 1, in which the second passage of the operator rod opens at a third location disposed outside the working chamber and in which the control sleeve has at least one passage extending between the axial bore and the exterior of the sleeve, the control sleeve being movable, in use, into a clutch engaged position on the operator rod, in which the or each passage in the sleeve communicates with the second passage at the third location to allow fluid flow out of the working chamber.

3. An operator as claimed in claim 1 or claim 2, in which the housing and the movable wall define, on the side of the movable wall opposite to the working chamber, a further chamber which encloses the control sleeve.

4. An operator as claimed in claim 3, in which the further chamber is vented to atmosphere.

5. An operator as claimed in claim 2, or

in claim 3 or claim 4 when appendant to claim 2, in which the second passage is provided at the third location with a plurality of passages which open into an annular groove of the operator rod, and in which the sleeve has a plurality of passages which register with the annular groove when the sleeve is in the clutch engaged position.

6. An operator as claimed in any one of the preceding claims, in which the first passage in the operator rod is provided at the said location with a plurality of radially extending passages which open at the exterior of the operator rod.

7. An operator as claimed in claim 6, in which the radially extending passages open into an annular groove of the operator rod.

8. An operator as claimed in claim 7, in which a plurality of bridging ducts is provided, each of which communicates with the annular groove when the control sleeve is in the clutch operating position.

9. An operator as claimed in any one of the preceding claims, in which the second passage in the operator rod is provided at the first location with a plurality of radially extending passages which open at the exterior of the operator rod.

10. An operator as claimed in claim 9, in which the radially extending passages open into an annular groove of the operator rod.

11. A fluid actuated operator substantially as described herein with reference to the accompanying drawings.

12. A motor vehicle having a clutch and a clutch pedal which are operatively interconnected by a clutch control linkage having a fluid actuated operator in accordance with any one of claims 1 to 11.

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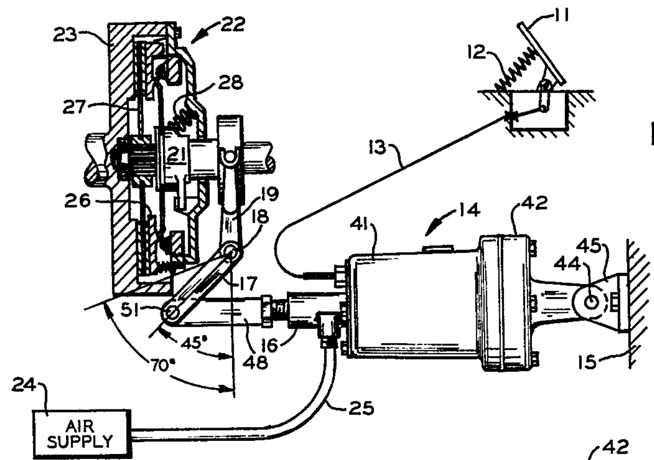

FIG. 1

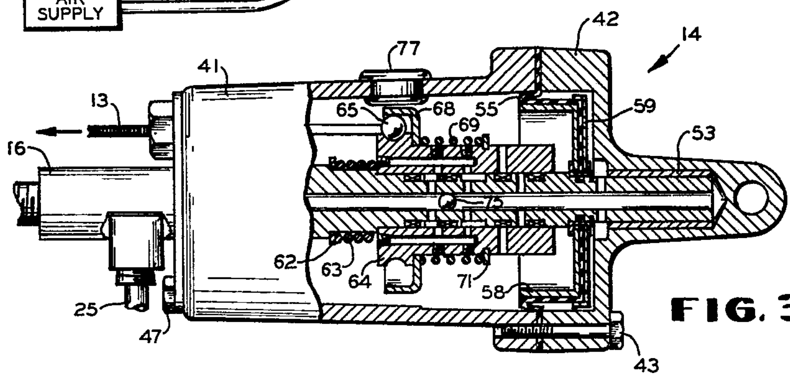

FIG. 3

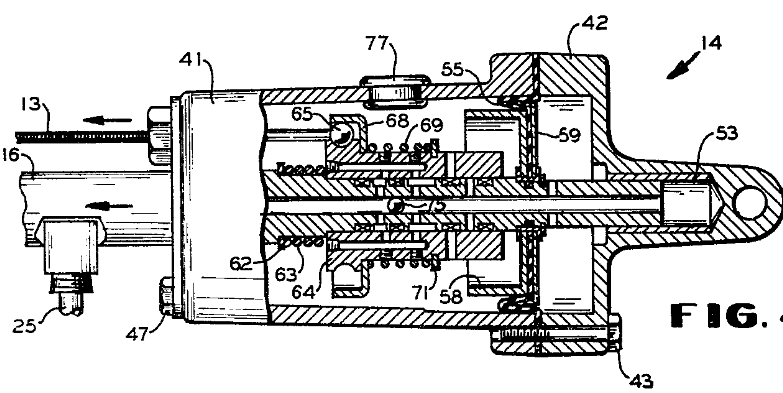

FIG. 4

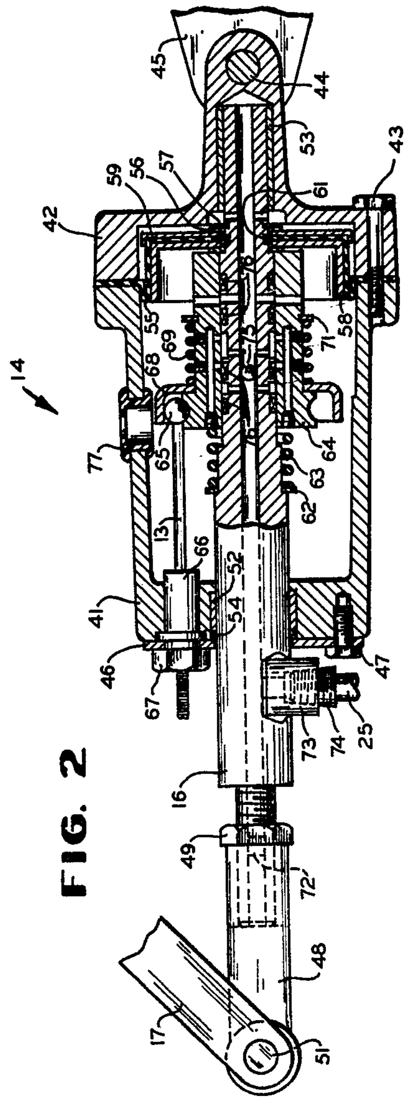

FIG. 2