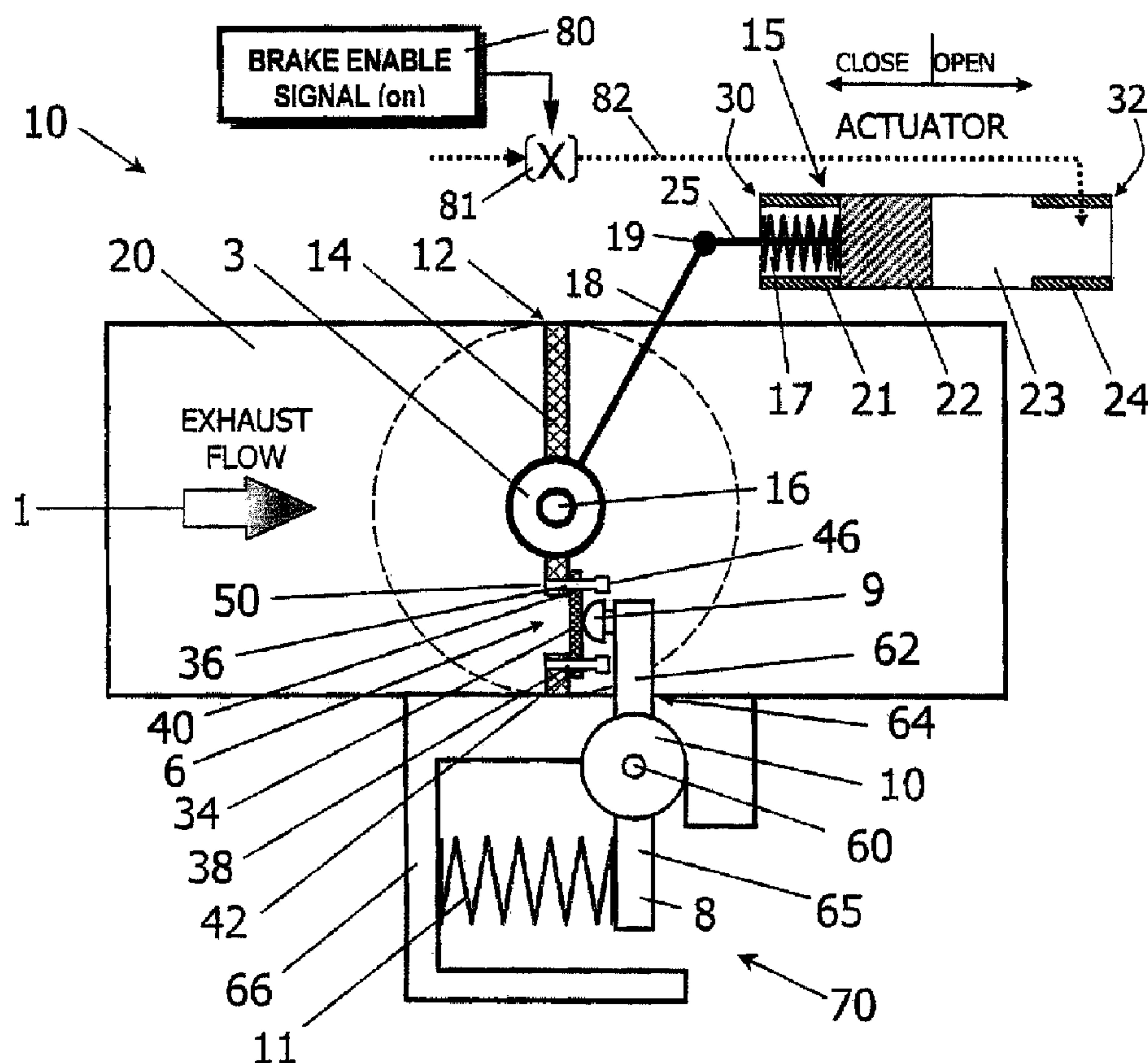


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(54) Title: PRESSURE RELIEF EXHAUST BRAKE



An exhaust brake has a body with a passageway for exhaust gases therein. A valve member is movably located within the passageway for selective movement between an open position where the valve member opens the passageway and exhaust

**(57) Abrégé(suite)/Abstract(continued):**

gases are free to move through the passageway and a closed position where the valve member blocks the passageway and the passage of exhaust gases through the passageway. The valve member has an aperture therethrough to permit a limited flow of exhaust gases through the aperture when the aperture is open. An exhaust valve actuator mechanism is coupled to the valve member for moving the valve member between the open position and the closed position. A closure member is positioned adjacent to the aperture. The closure member has an open position where the closure member is spaced apart from the valve member and permits a flow of exhaust gases through the aperture and the closure member having a closed position where the closure member contacts the valve member about the aperture and inhibits a flow of exhaust gases through the aperture. An actuator member operatively engages the closure member. There is a relief actuator mechanism, the relief actuator mechanism including an actuator member that operatively engages the closure member. The relief mechanism brings the closure member into operative engagement with the valve member with sufficient force, when the valve member is closed, to maintain the closure member in the closed position when the exhaust gases are below a predetermined pressure.

## ABSTRACT

An exhaust brake has a body with a passageway for exhaust gases therein. A valve member is movably located within the passageway for selective movement between an open position where the valve member opens the passageway and exhaust gases are free to move through the passageway and a closed position where the valve member blocks the passageway and the passage of exhaust gases through the passageway. The valve member has an aperture therethrough to permit a limited flow of exhaust gases through the aperture when the aperture is open. An exhaust valve actuator mechanism is coupled to the valve member for moving the valve member between the open position and the closed position. A closure member is positioned adjacent to the aperture. The closure member has an open position where the closure member is spaced apart from the valve member and permits a flow of exhaust gases through the aperture and the closure member having a closed position where the closure member contacts the valve member about the aperture and inhibits a flow of exhaust gases through the aperture. An actuator member operatively engages the closure member. There is a relief actuator mechanism, the relief actuator mechanism including an actuator member that operatively engages the closure member. The relief mechanism brings the closure member into operative engagement with the valve member with sufficient force, when the valve member is closed, to maintain the closure member in the closed position when the exhaust gases are below a predetermined pressure.

## PRESSURE RELIEF EXHAUST BRAKE

This invention relates to an exhaust brake with a pressure relief device.

- 5 Diesel engines in vehicles, particularly larger trucks, are commonly equipped with an exhaust brake for engine retarding. An exhaust brake consists of a restrictor element mounted in the exhaust system. When this restrictor closes, back pressure resists the exit of gases during the exhaust cycle and provides braking power for the vehicle.
- 10 With conventional fixed geometry exhaust brakes, the retarding power decreases sharply as engine speed decreases. This occurs because the restriction is typically optimized to generate maximum allowable back pressure at rated engine speed. The restriction is accordingly too small to be effective with the lower mass flow rates encountered at lower engine speeds.
- 15 Systems have been developed to optimize the retarding power of exhaust brakes over a range of engine speeds. One approach has been to implement pressure relief as a means to limit maximum developed exhaust pressure. Engine braking mainly occurs at lower engine speeds where exhaust pressures are lower and the pressure relief device is not active. The pressure relief device only operates when engine speeds are higher and the exhaust pressure is
- 20 accordingly higher. This means that the exhaust pressure can be increased for engine braking purposes without being excessive at high engine speeds.

In the drawings:

- 25 Figure 1 is a diagrammatic, cross-sectional view of a pressure relief exhaust brake according to an embodiment of the invention, showing the main exhaust restrictor closed and the pressure relief valve closed;

- 30 Figure 2 is a view similar to Figure 1, showing the main exhaust restrictor valve member closed and the pressure release valve open;

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Figure 3 is a view similar to Figure 1, showing the main exhaust restrictor valve member open;

5 Figure 4 is a diagrammatic, cross-sectional view of a pressure relief exhaust brake according to a second embodiment of the invention, showing the main exhaust restrictor closed and the pressure relief valve closed, the pressure relief valve member being bi-metal construction;

10 Figure 5 is a diagrammatic, cross-sectional view of a pressure relief exhaust brake according to a third embodiment of the invention, showing the main exhaust restrictor closed and the pressure relief valve open, the pressure relief valve spring being acted on by a solenoid actuator, the brake being shown in the engine braking mode; and

Figure 6 is a view similar to Figure 5, showing the pressure relief valve in warm-up mode.

15 Referring to Figures 1-3, pressure relief exhaust brake 10 in this example includes a butterfly valve 12 including a valve member 14 that is rotatable about a shaft 16. Other types of valves could be used in other embodiments, such as gate valves. The valve member 14 may be replaced by other movable elements that may be placed in the engine exhaust system.

20 The valve member 14 is located in exhaust conduit 20 that is connected to the exhaust manifold of an engine (not shown). When closed, as seen in Figure 1, the valve member in this example occupies the entire area of the exhaust conduit and accordingly blocks the flow of exhaust gases from the engine. When open, as seen in Figure 3, the exhaust flow is relatively unrestricted. An actuator 15 dictates movement of the valve member. In this  
25 embodiment actuator 15 includes a piston 22 reciprocatingly mounted within a cylinder 23 between the positions shown in Figure 1 and Figure 3. Movement of the piston is restricted by stops 21 and 24 at opposite ends of the cylinder. A coil spring 17, mounted between the piston and end 30 of the cylinder, biases the piston towards the opposite end 32 of the cylinder, which represents the open position of the valve member. A rod 25 is connected to

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the piston and extends outwardly from end 30 of the cylinder. The rod is pivotally connected at 19 to a lever 18, which is connected to a cylindrical member 3 extending about the shaft 16. The valve member is connected to the cylindrical member so that pivoting of lever 18 by the actuator 15 opens or closes the valve member. The actuator is directed to move the valve member 14 to the open or closed position by an electronic signal from control unit 80, which operates solenoid valve 81. When solenoid valve 81 is open, actuating fluid 82 is provided to act on piston 22 to cause the valve member 14 to close. When solenoid valve 81 is closed, actuating fluid 82 is vented and valve member 14 is allowed to close.

As discussed thus far, the exhaust brake is generally conventional. However this exhaust brake departs from the conventional type in having an aperture 6 in the valve member which, when open, allows exhaust gases to flow through the valve member of the butterfly valve. There is an aperture plate 34 sized to close the aperture 6 when pressed against the valve member as shown in Figure 1. In particular, the aperture plate 34 is pressed against, i.e. contacts, the valve member 14 about the aperture 6. The aperture plate has a number of mounting holes. Two such holes 36 and 38 are shown in Figure 1. A pin extends slidably through each of these holes including pins 40 and 42 shown in Figure 1. Typically more than two such sets of pins and holes would be positioned about the aperture plate in spaced apart relationship. Each of the pins has a head 46 as shown for pin 40. The opposite end of each pin is rigidly connected to the valve member, in this case by tight engagement with a hole 50 extending through the valve member. Thus the aperture plate is free to move towards or away from the valve member by sliding on the pins 40 and 42.

There is an actuator 70 including a lever 8 mounted for rotation about an axle 60 located exterior to the exhaust conduit. The lever has an arm 62 that extends through a slot located at 64 on the exhaust conduit. The arm 62 is fitted with a button 9, which in the position of Figure 1, is against the aperture plate that seals the aperture 6. The lever 8 has an arm 65 located within the housing 66. A coil spring 11 is biased between the housing and the arm 65 so as to urge arm 62 and button 9 against the aperture plate to seal the aperture 6.

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When the valve member is closed, as seen in Figure 2, and the pressure of exhaust gases in the conduit 20 increases, a pressure is reached whereby the force of exhaust gases on the aperture plate is sufficient to compress the spring 11 and cause the aperture plate to move away from the valve member of the butterfly valve. This allows exhaust gases to escape through the aperture 6 and accordingly limits the maximum pressure in the exhaust conduit.

When the butterfly valve is open, as seen in Figure 3, the aperture plate moves away from the button 9. However it may be seen that the aperture plate is loosely mounted since it is free to slide on the pins 36 and 38. This inhibits the aperture plate from adhering to the valve member of the butterfly valve in the hot temperatures encountered in the exhaust conduit.

It may be seen that the spring 11 is mounted exterior to the exhaust conduit and accordingly is not subject to the high temperatures encountered in the exhaust conduit. This exterior mounting of the spring accordingly provides substantial benefits compared to arrangements where there are springs within the exhaust conduit, which may be incapable of withstanding prolonged exposure to the hot exhaust gases. Exposure to hot exhaust gases may cause loss of spring preload, which would change the pressure at which the pressure is relieved.

The outboard location of the actuator 70 provides more space for the actuator and therefore more flexibility for spring design.

Only the relatively low-profile arm 62 extends into the exhaust gas flow when the exhaust brake is wide open, as seen in Figure 3, thereby minimizing flow restriction.

In an alternative embodiment, the aperture plate or some other valve closure member could be mounted directly on the arm 62 instead of being loosely mounted on the valve member as in the illustrated embodiment. In such an embodiment the valve member would simply have an aperture that would be closed by the valve closure member on the arm 62 in the position of Figure 1.

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In another alternative embodiment, there could be a smaller bleed orifice in the butterfly valve to generate the exhaust pressure for warming the engine at low engine speeds, this pressure being lower than the pressure which would open the orifice plate against the pressure of spring 11. This could be done by inhibiting the orifice plate from fully closing when acted on by the lever 8. Alternatively a small hole could be drilled in the butterfly disk, for example approximately 5 mm, to provide for engine warm-up. Alternatively there may be an annular clearance between the butterfly disk and the exhaust conduit to provide sufficient warm-up bypass mass flow.

Another way to provide for engine warm-up operation with the pressure relief exhaust brake is to provide a two-step opening of the orifice plate. This embodiment is shown in Figure 5 where nested springs are acted on by a solenoid actuator to provide one spring preload and rate for braking operation and another spring preload and rate for warm-up operation. In Figure 5 solenoid 90 has an armature 91. A first spring 92, with relatively high force preload, is captured between solenoid armature 91 and pressure relief valve actuator lever 8.1. A second spring 93, with relatively low force preload is captured between actuator housing 66 and actuator lever 8.1. Spring 93 acting alone provides the force to invoke a relief pressure suitable for engine warm-up. Spring 92 and spring 93 acting together provide the force to invoke a relief pressure suitable for engine exhaust braking. In the braking mode, as shown in Figure 5, solenoid valve member 91 is extended to engage spring 92 and a spring preload for engine braking is provided. In engine warm-up mode, as shown in Figure 6, solenoid armature 91 is retracted to disengage spring 92 and a spring preload for engine warm-up is provided.

Compression springs typically have the characteristic of relaxing to a reduced preload level at the elevated temperatures encountered in an internal combustion engine. With a reduced spring preload, the exhaust brake relief pressure is reduced, thereby reducing brake performance.

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Another embodiment of the present invention, shown in Figure 4, resolves this issue by providing a variable actuator spring preload. Arm 65.2 of actuator lever 8.2 is bi-metal construction, calibrated to provide a force "F" in the direction to compress spring 11.2 an additional amount as temperature increases. This additional amount of compression recovers the preload force that is lost to spring relaxation.

The exhaust brakes described above also reduces loading and wear on the shaft 16 compared to a conventional exhaust brake. When the actuator 15 starts to open the butterfly valve as it moves from the position of Figure 1 towards the position of Figure 3, there is a large loading on the shaft 16 due to the high pressure of exhaust gases acting against the valve member. In a conventional exhaust brake, this high loading causes significant friction and wear between the shaft and the bearing supporting the shaft. However, the shaft of the illustrated embodiment only encounters this high loading for a relatively small amount of movement. Once the orifice plate moves away from button 9, the exhaust gases are free to move through the aperture 6 and thus the pressure against the valve member is significantly reduced, to decrease loading on the shaft.

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1. An exhaust brake comprising:

a body having a passageway for exhaust gases therein;

a valve member movably located within the passageway for selective movement between an open position where the valve member opens the passageway and exhaust gases are free to move through the passageway and a closed position where the valve member blocks the passageway and the passage of exhaust gases through the passageway, the valve member having an aperture therethrough to permit a limited flow of exhaust gases through the aperture when the aperture is open;

an exhaust valve actuator mechanism coupled to the valve member for moving the valve member between the open position and the closed position;

a closure member positioned adjacent to the aperture, the closure member having an open position where the closure member is spaced apart from the valve member and permits a flow of exhaust gases through the aperture, and the closure member having a closed position where the closure member is pressed against a side of the valve member about the aperture and inhibits a flow of exhaust gases through the aperture; and

a relief actuator mechanism, the relief actuator mechanism including an actuator member which operatively engages the closure member, the relief mechanism bringing the closure member into operative engagement with the valve member with sufficient force, when the valve member is closed, to maintain the closure member in the closed position when the exhaust gases are below a predetermined pressure.

2. The exhaust brake as claimed in claim 1, wherein the actuator member is pivotally mounted and is biased against the closure member.

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3. The exhaust brake as claimed in claim 2, wherein the actuator member is pivotally mounted at a pivot point exterior to the passageway.
4. The exhaust brake as claimed in claim 3, wherein the actuator member is biased by a biasing mechanism exterior to the passageway.
5. The exhaust brake as claimed in claim 4, wherein the biasing mechanism includes a spring.
6. The exhaust brake as claimed in claim 4, wherein the biasing mechanism includes a fluid actuator.
7. The exhaust brake as claimed in claim 4, wherein the biasing mechanism includes an electric actuator.
8. The exhaust brake as claimed in claim 1, wherein the closure member is movably connected to the valve member.
9. The exhaust brake as claimed in claim 8, wherein the actuator member is separate from the closure member and contacts the closure member to bias the closure member towards the closed position.
10. The exhaust brake as claimed in claim 8, including elongated projections extending from the valve member about the aperture, the closure member having apertures slidably receiving the elongated projections.
11. The exhaust brake as claimed in claim 10, wherein the projections are pins.
12. The exhaust brake as claimed in claim 1, wherein the closure member is connected to the actuator member.

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13. The exhaust brake as claimed in claim 1, wherein the actuator member is selectively biased against the closure member by a spring, a secondary actuator being engageable with the spring to selectively engage said spring with the actuator member.
14. The exhaust brake as claimed in claim 13, including a controller for disengaging said spring from the actuator member, whereby engaging or disengaging said spring provides two different levels of pressure relief.
15. The exhaust brake as claimed in claim 3, wherein the actuator member includes a bimetallic element exterior to the passageway to compensate for temperature fluctuations exterior to the passageway.
16. The exhaust brake as claimed in claim 1, wherein said relief actuator mechanism allows the closure member to move to the open position when the exhaust gases are above the predetermined pressure.
17. The exhaust brake as claimed in claim 1, wherein the body and the valve member are components of a butterfly valve.
18. The exhaust brake as claimed in claim 4, wherein the actuator member is selectively biased against the closure member by a pair of nested springs, a secondary actuator engaging one or both of said springs with the actuator member.
19. The exhaust brake as claimed in claim 4 including a secondary actuator connected to a member which holds the closure member selectively in a closed position against the pressure of exhaust gases.
20. The exhaust brake as claimed in claim 19, wherein the secondary actuator is electronically controlled.

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21. The exhaust brake as claimed in claim 20, wherein the secondary actuator is electronically controlled by a controller according to pressure of exhaust gases.
22. The exhaust brake as claimed in claim 21, wherein the secondary actuator is electronically controlled by a controller according to temperature of exhaust gases.
23. A method for preventing excessive pressure buildup in an exhaust brake for an internal combustion engine, said brake having a passageway for exhaust gases, a valve member movably located within the passageway for selective movement between an open position, where the valve member opens the passageway and exhaust gases are free to move through the passageway, and a closed position where the valve member blocks the passageway and inhibits the passage of exhaust gases through the passageway, the method comprising :  
  
providing an aperture through the valve member to permit a limited flow of exhaust gases through the aperture when the aperture is open;  
  
positioning a closure member adjacent to the aperture so the closure member has an open position where the closure member is spaced apart from the valve member and permits a flow of exhaust gases through the aperture, the closure member having a closed position where the closure member is pressed against a side of the valve member about the aperture and inhibits a flow of exhaust gases through the aperture;  
  
providing a relief actuator mechanism, the relief actuator mechanism including an actuator member which operatively engages the closure member; and  
  
bringing the closure member into operative engagement with the valve member with sufficient force, when the valve member is closed, to maintain the closure member in the closed position when the exhaust gases are below a predetermined pressure.

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24. The method as claimed in claim 23, wherein the actuator member is pivotally mounted and is biased against the closure member.
25. The method as claimed in claim 24, wherein the actuator member is pivotally mounted at a pivot point exterior to the passageway.
26. The method as claimed in claim 25, wherein the actuator member is biased by a biasing mechanism exterior to the passageway.
27. The method as claimed in claim 26, wherein the biasing mechanism includes a spring.
28. The method as claimed in claim 26, wherein the biasing mechanism includes a fluid actuator.
29. The method as claimed in claim 26, wherein the biasing mechanism includes an electric actuator.
30. The method as claimed in claim 23, wherein the closure member is movably connected to the valve member.
31. The method as claimed in claim 30, wherein the actuator member is separate from the closure member and contacts the closure member to bias the closure member towards the closed position.
32. The method as claimed in claim 31, including elongated projections extending from the valve member about the aperture, the closure member having apertures slidably receiving the elongated projections.
33. The method as claimed in claim 32, wherein the projections are pins.

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34. The method as claimed in claim 23, wherein the closure member is connected to the actuator member.
35. The method as claimed in claim 23, wherein the actuator member is selectively biased against the closure member by a spring, a secondary actuator being engageable with the spring to selectively engage said spring with the actuator member.
36. The method as claimed in claim 35, including a controller for disengaging said spring from the actuator member, whereby engaging or disengaging said spring provides two different levels of pressure relief.
37. The method as claimed in claim 23, wherein the actuator member includes a bimetallic element exterior to the passageway to compensate for temperature fluctuations exterior to the passageway.
38. The method as claimed in claim 23, wherein said relief actuator mechanism allows the closure member to move to the open position when the exhaust gases are above the predetermined pressure.
39. The method as claimed in claim 23, wherein the passageway and the valve member are components of a butterfly valve.
40. The method as claimed in claim 23, wherein the actuator member is selectively biased against the closure member by a pair of nested springs, a secondary actuator being engageable with the spring to selectively engage one or both of said springs with the actuator member.

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41. The method as claimed in claim 23 including a secondary actuator connected to a member that holds the closure member selectively in a closed position against the pressure of exhaust gases.
42. The method as claimed in claim 41, wherein the secondary actuator is electronically controlled.
43. The method as claimed in claim 42, wherein the secondary actuator is electronically controlled by a controller according to pressure of exhaust gases.
44. The method as claimed in claim 43, wherein the secondary actuator is electronically controlled by a controller according to temperature of exhaust gases.
45. An internal combustion engine having an exhaust conduit with an exhaust brake connected thereto, the exhaust brake having a body with a passageway for exhaust gases therein;  
  
a valve member movably located within the passageway for selective movement between an open position where the valve member opens the passageway and exhaust gases are free to move through the passageway and a closed position where the valve member blocks the passageway and inhibits the passage of exhaust gases through the passageway, the valve member having an aperture therethrough to permit a limited flow of exhaust gases through the aperture when the aperture is open;  
  
an exhaust valve actuator mechanism coupled to the valve member for moving the valve member between the open position and the closed position;  
  
a closure member positioned adjacent to the aperture, the closure member having an open position, where the closure member is spaced apart from the valve member and permits a flow of exhaust gases through the aperture, and the closure member having a closed position

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where the closure member is pressed against a side of the valve member about the aperture and inhibits a flow of exhaust gases through the aperture; and

a relief actuator mechanism, the relief actuator mechanism including an actuator member which operatively engages the closure member, the relief mechanism bringing the closure member into operative engagement with the valve member with sufficient force, when the valve member is closed, to maintain the closure member in the closed position when the exhaust gases are below a predetermined pressure.

46. The engine as claimed in claim 45, wherein the actuator member is pivotally mounted and is biased against the closure member.
47. The engine as claimed in claim 46, wherein the actuator member is pivotally mounted at a pivot point exterior to the passageway.
48. The engine as claimed in claim 47, wherein the actuator member is biased by a biasing mechanism exterior to the passageway.
49. The engine as claimed in claim 48, wherein the biasing mechanism is a spring.
50. The engine as claimed in claim 48, wherein the biasing mechanism is a fluid actuator.
51. The engine as claimed in claim 48, wherein the biasing mechanism includes an electric actuator.
52. The engine as claimed in claim 45, wherein the closure member is movably connected to the valve member.

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53. The engine as claimed in claim 52, wherein the actuator member is separate from the closure member and contacts the closure member to bias the closure member towards the closed position.
54. The engine as claimed in claim 53, including elongated projections extending from the valve member about the aperture, the closure member having apertures slidably receiving the elongated projections.
55. The engine as claimed in claim 54, wherein the projections are pins.
56. The engine as claimed in claim 45, wherein the closure member is connected to the actuator member.
57. The engine as claimed in claim 45, wherein the actuator member is selectively biased against the closure member by a spring, a secondary actuator being engageable with the spring to selectively engage said spring with the actuator member.
58. The engine as claimed in claim 57, including a controller for disengaging said spring from the actuator member, whereby engaging or disengaging said spring provides two different levels of pressure relief.
59. The engine as claimed in claim 45, wherein the actuator member includes a bimetallic element exterior to the passageway to compensate for temperature fluctuations exterior to the passageway.
60. The engine as claimed in claim 45, wherein said relief actuator mechanism allows the closure member to move to the open position when the exhaust gases are above the predetermined pressure.

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61. The engine as claimed in claim 45, wherein the body and the valve member are components of a butterfly valve.
62. The engine as claimed in claim 45, wherein the actuator member is selectively biased against the closure member by a pair of nested springs, a secondary actuator being engageable with the springs to selectively engage one or both of said springs with the actuator member.
63. The engine as claimed in claim 45 including a secondary actuator connected to a member that holds the closure member selectively in a closed position against the pressure of exhaust gases.
64. The engine as claimed in claim 63, wherein the secondary actuator is electronically controlled.
65. The engine as claimed in claim 64, wherein the secondary actuator is electronically controlled by a controller according to pressure of exhaust gases.
66. The engine as claimed in claim 65, wherein the secondary actuator is electronically controlled by a controller according to temperature of exhaust gases.

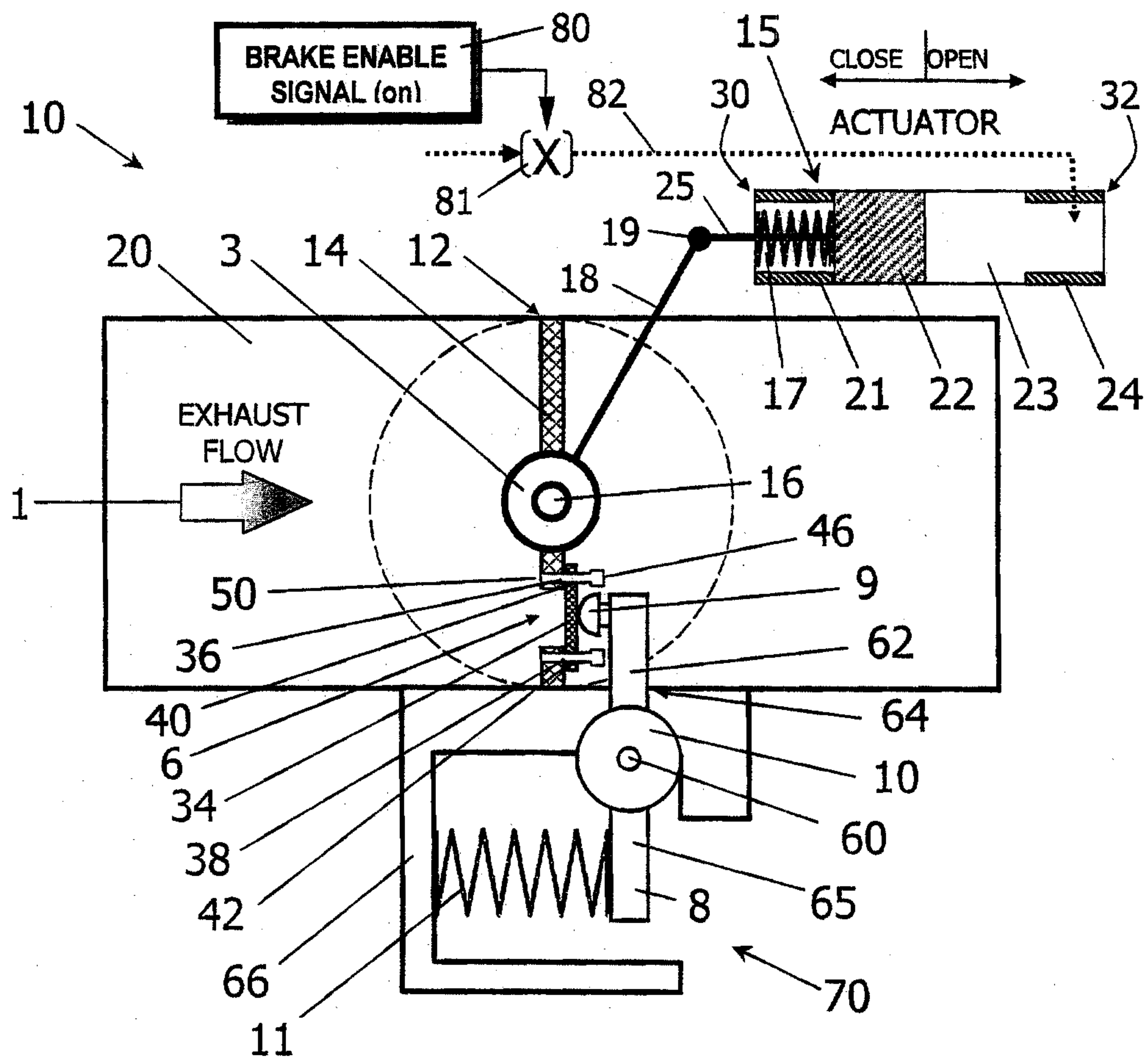


Figure 1

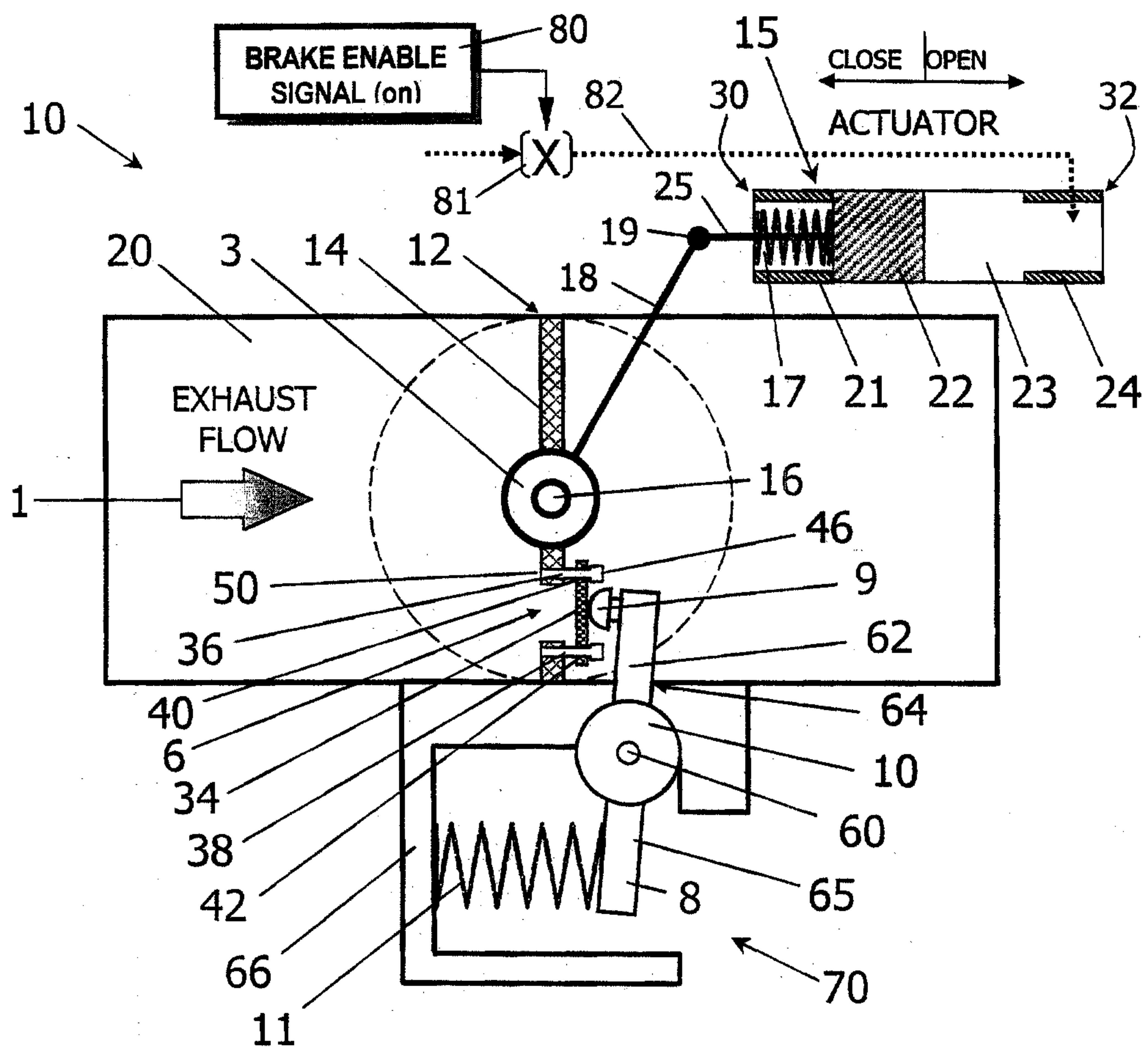


Figure 2

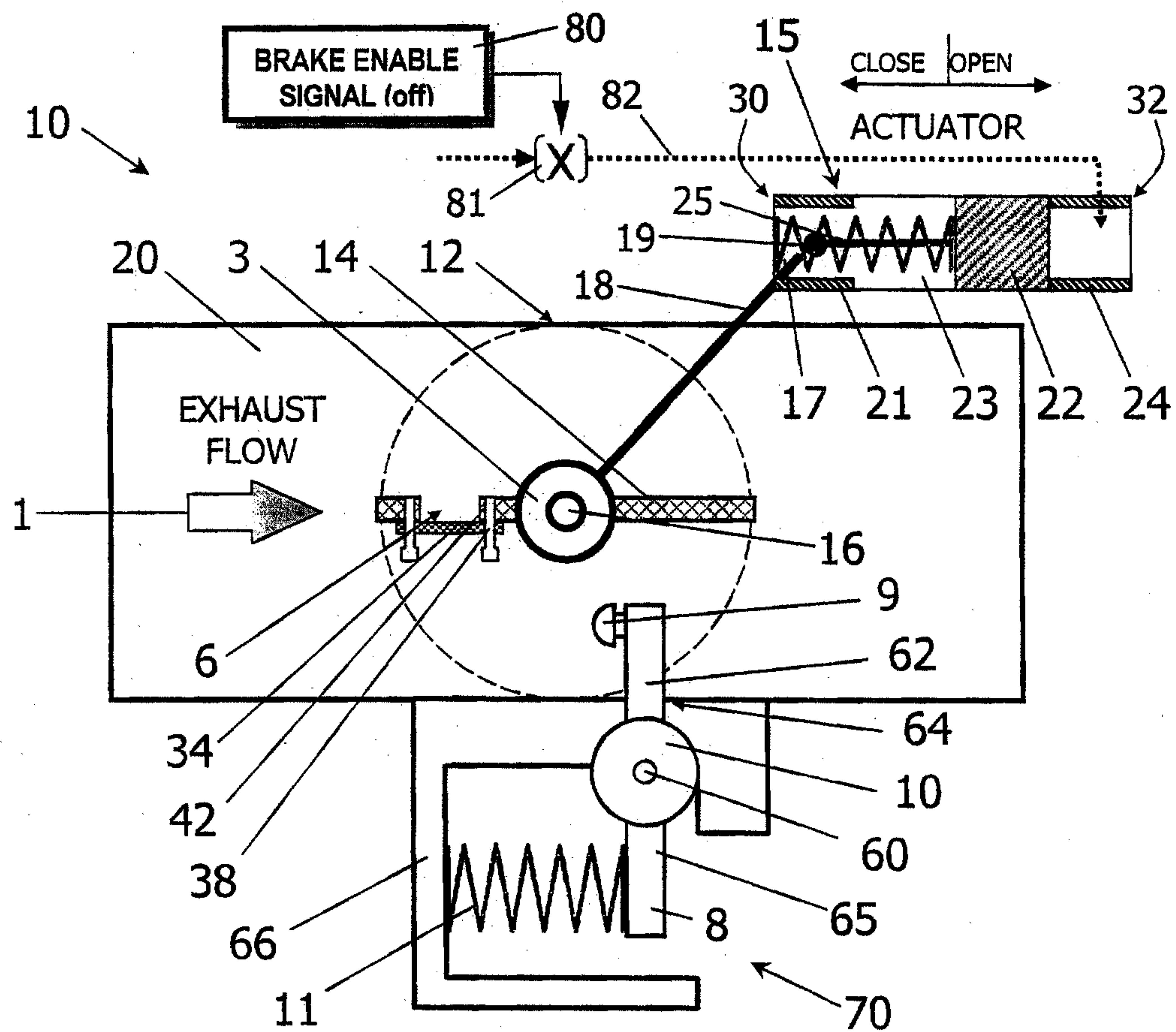


Figure 3

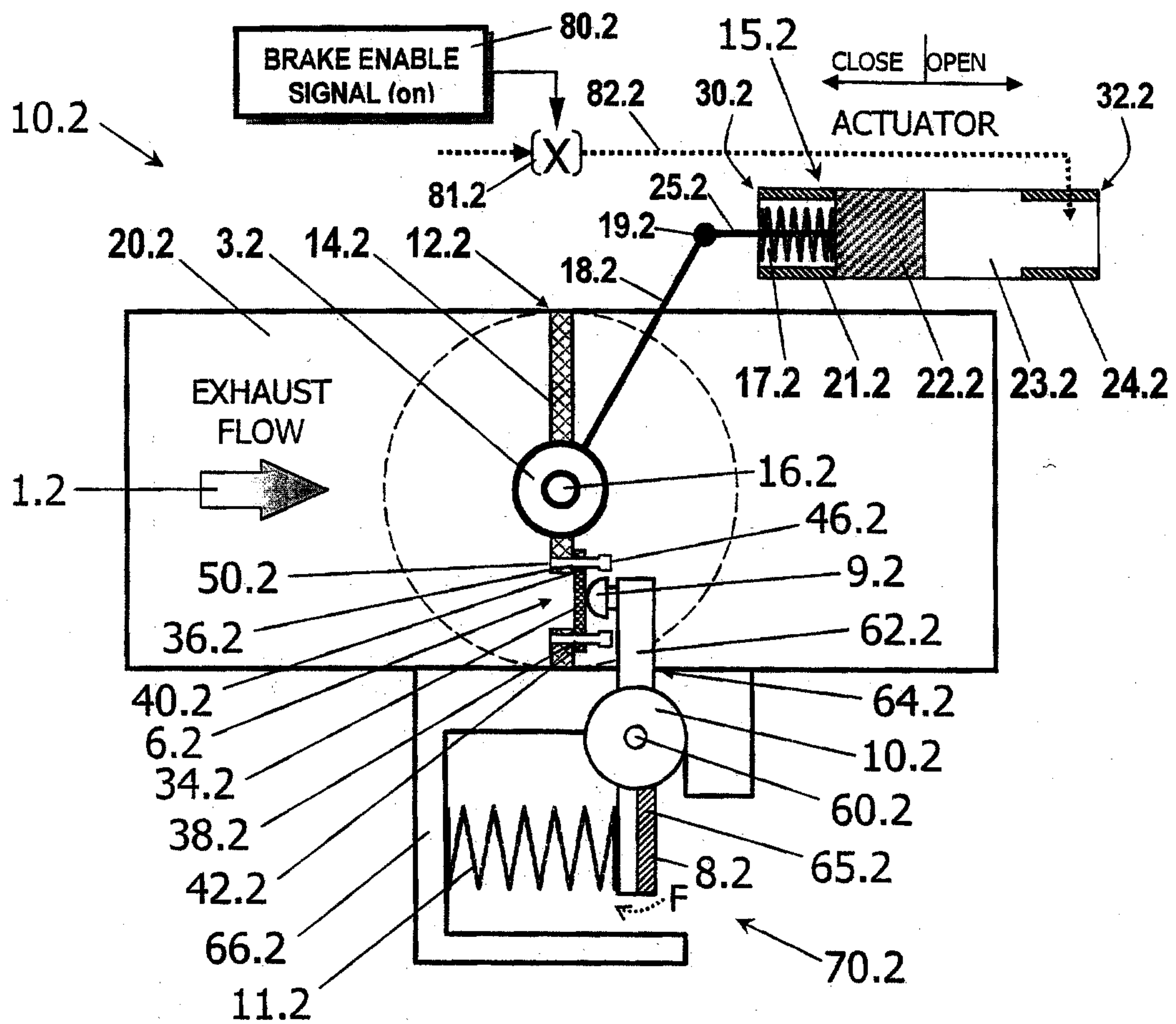


Figure 4

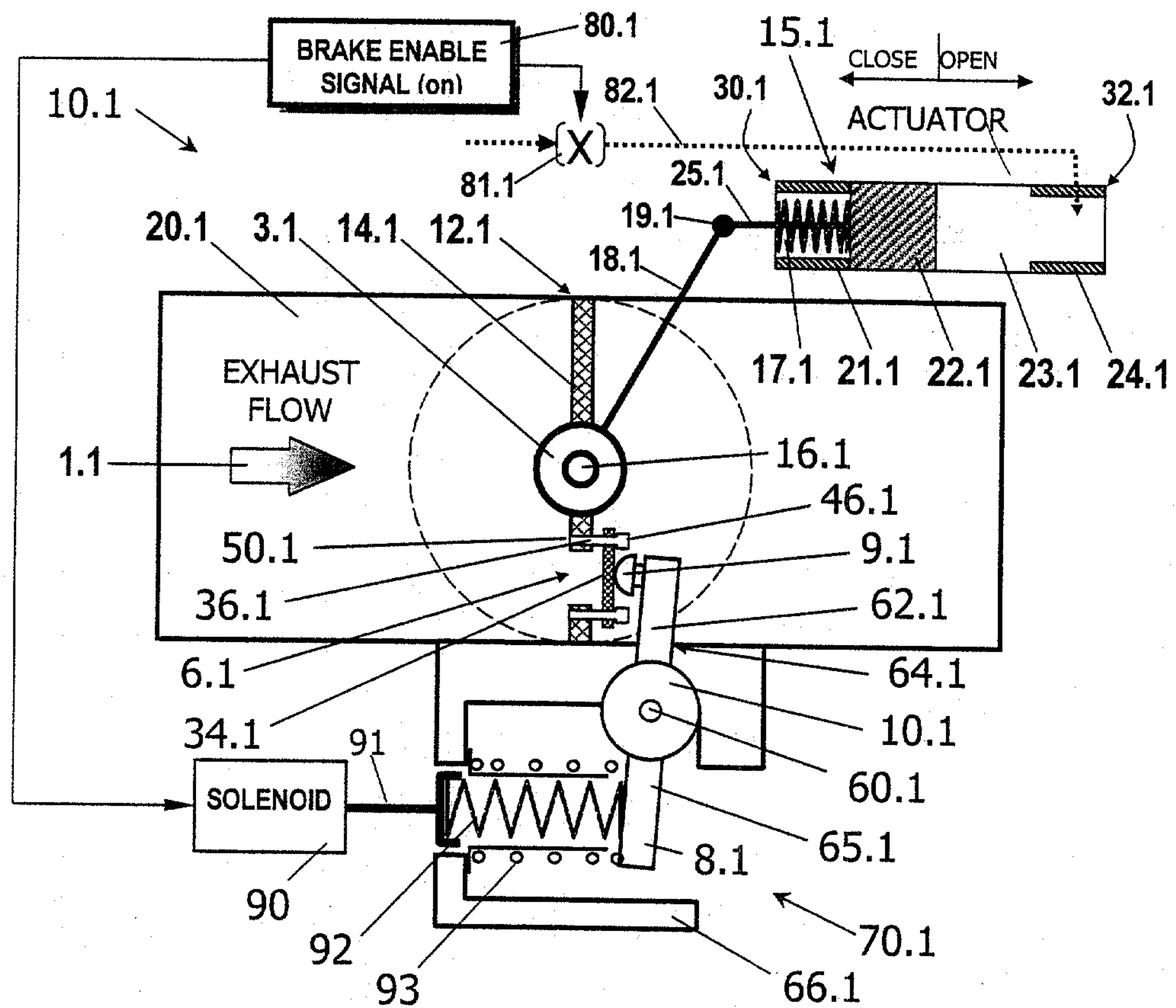


Figure 5

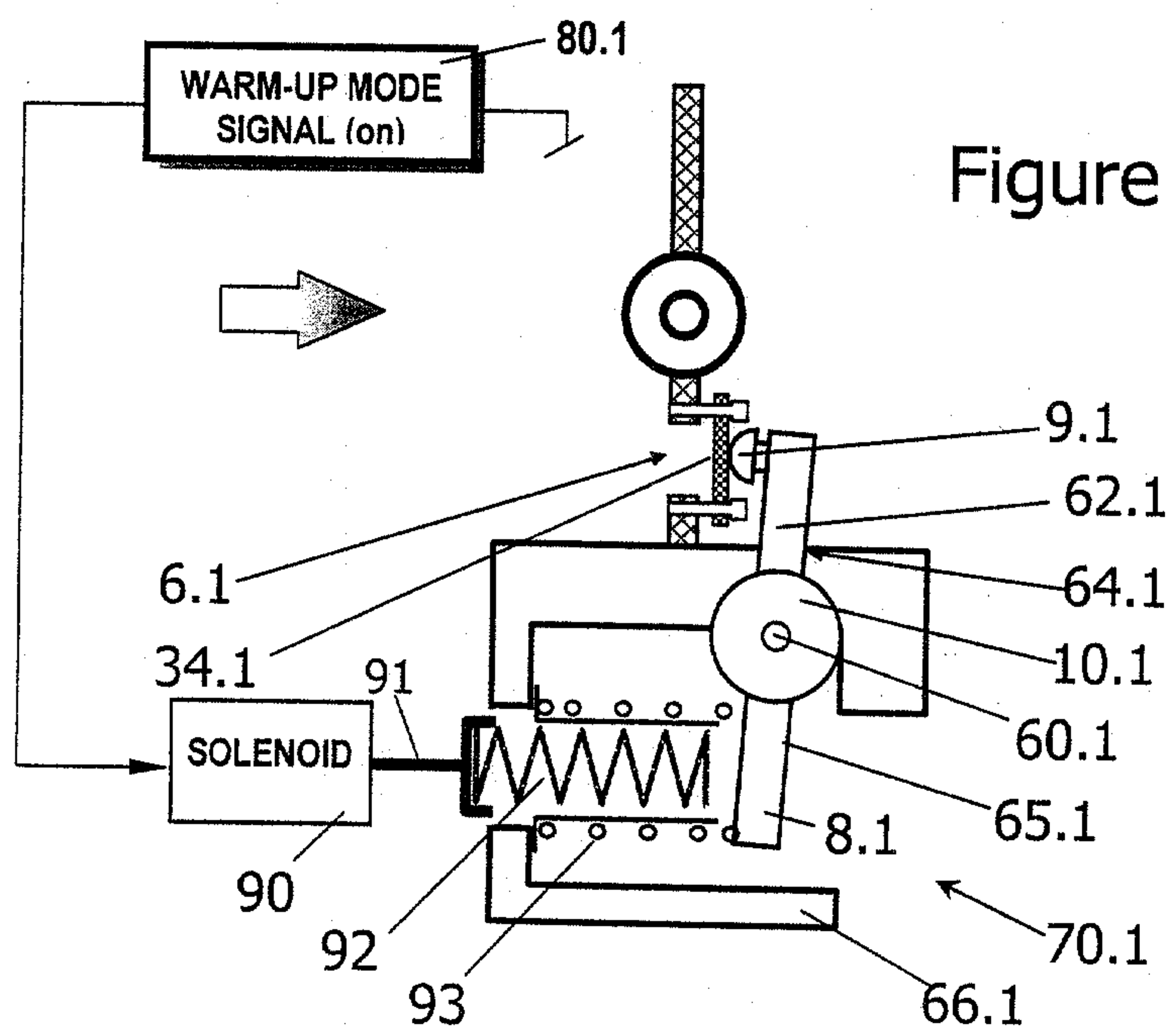


Figure 6

