United States Patent

Mayer et al.

[15] **3,639,010**

[45] **Feb. 1, 1972**

[54] FLUID PRESSURE AND DYNAMIC BRAKE INTERLOCK VALVE WITH VARIABLE LOAD CONTROL

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[22] Filed: **Dec. 15, 1969**

[21] Appl. No.: **885,237**

[52] **U.S. Cl.** ..... **303/22 A**

[51] **Int. Cl.** **B60t 8/18**

[58] **Field of Search** ..... 188/195; 303/6, 22 R, 22 A

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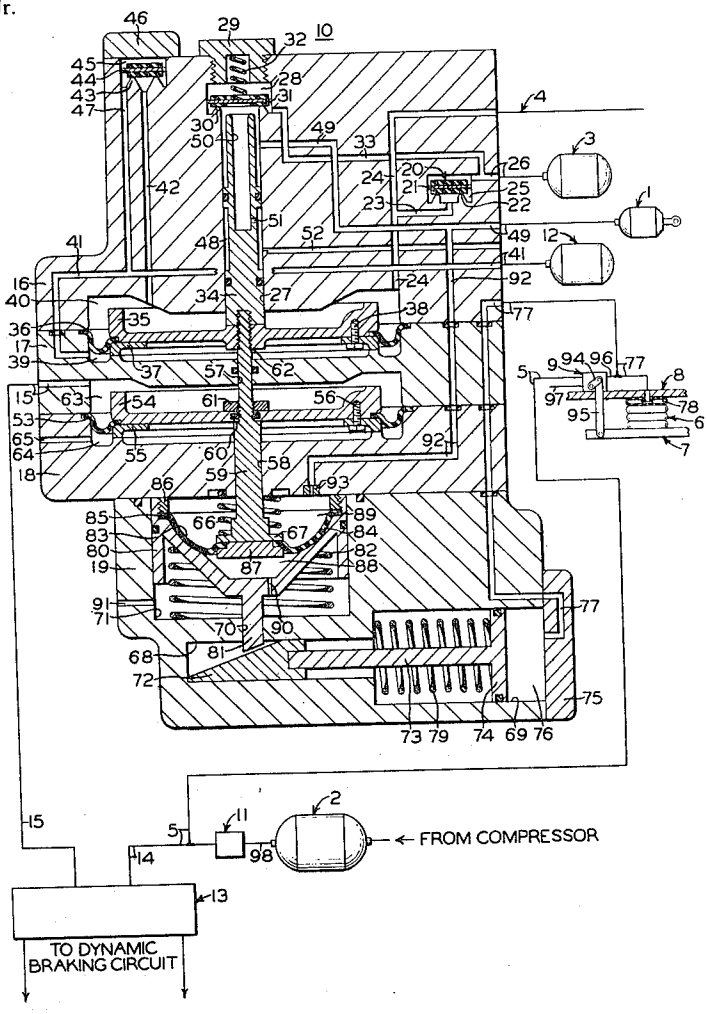
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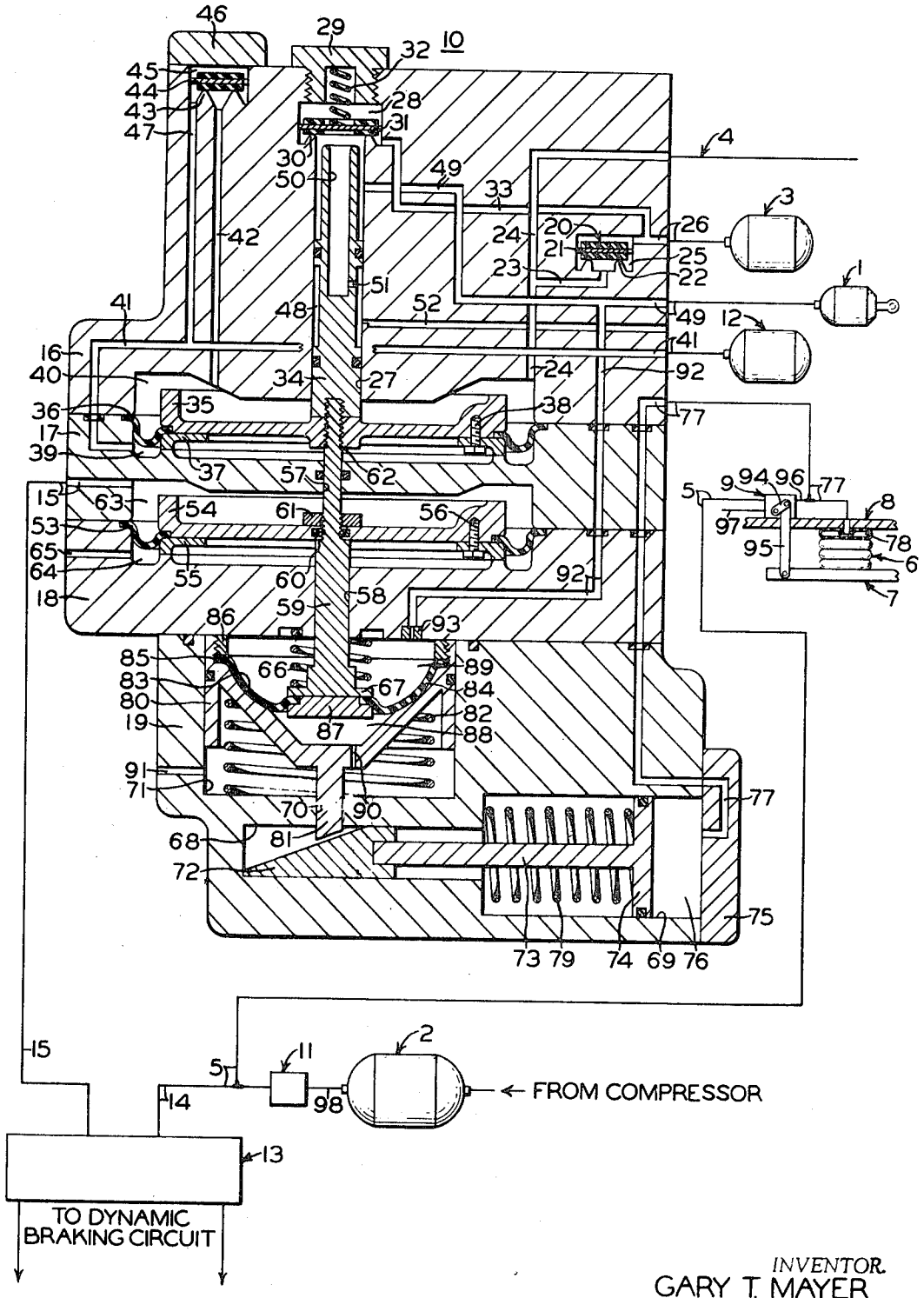
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[57] **ABSTRACT**

This invention relates to a triple-diaphragm pressure-operated variable-load-type brake control valve for rapid transit vehicles wherein the body of the vehicle is supported on air springs, the pressure in which is varied to maintain the body at a substantially constant height above the rails irrespective of the load on the body. Furthermore, air spring pressure varies the effective area of that one of the three diaphragms that is subject to brake cylinder pressure whereby the brake cylinder pressure required to effect movement of the brake control valve to a lap position subsequent to any reduction of brake pipe pressure effective on one side of a second one of the diaphragms relative to a substantially constant control reservoir pressure effective on the opposite side of this second diaphragm, varies directly as the load carried on the body of the vehicle. The third diaphragm is subject to a fluid pressure that corresponds to the degree of dynamic brake and acts thereon in the same direction as brake pipe pressure acts on the second diaphragm. Consequently, as the speed of the vehicle diminishes and the dynamic brake fades out, the brake control valve operates to control the blending therewith of the pneumatic brake in such a manner as to bring a rapid transit train, each car of which is provided with this brake control valve, to a proper stop at a predetermined rate of deceleration.

15 Claims, 1 Drawing Figure





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FLUID PRESSURE AND DYNAMIC BRAKE INTERLOCK VALVE WITH VARIABLE LOAD CONTROL

BACKGROUND OF THE INVENTION

Brake control apparatus heretofore used to effect an application of a fluid pressure braking means as the dynamic brake fades out has often resulted in undesirably heavy applications of the fluid pressure braking means thereby producing severe shocks which in the case of passenger and rapid transit trains result in discomfort to the passengers and possibly bodily injury.

Accordingly, it is the general purpose of this invention to provide a novel combined dynamic and fluid pressure operated variable load brake control service valve for use on air-spring-supported rapid transit vehicles.

SUMMARY OF THE INVENTION

According to the present invention, a novel combined dynamic and fluid pressure-operated brake control valve is provided comprising a valve body having a bore within which is slidably mounted a valve stem for operating a valve mechanism that controls the supply of fluid under pressure to and the release of fluid under pressure from a brake cylinder. This valve stem is operably connected to two spaced-apart diaphragms of equal effective area and to a third diaphragm the effective area of which is variable according to the load on the body of the vehicle. The first of the two diaphragms is subject on its respective opposite sides to the pressure in a control reservoir and in the usual train brake pipe. A differential of pressure is established on this first diaphragm in response to a reduction in the pressure in the brake pipe relative to a substantially constant pressure in the control reservoir to cause operation of the valve mechanism via the valve stem to effect the supply of fluid under pressure to the brake cylinder and to one side of the variable area diaphragm until the pressure acting thereon is increased sufficiently to move the brake control valve to its lap position thereby terminating the supply of fluid under pressure to the brake cylinder.

The second of the two diaphragms is subject on its respective opposite sides to a pressure variable in accordance with the degree of dynamic brake in effect and to atmospheric pressure. Accordingly, as the dynamic brake fades out, the brake control valve is operated in response thereto to increase the pressure in the brake cylinder thereby blending the dynamic and pneumatic brake so as to bring the train to a proper stop at a predetermined rate of deceleration.

In the accompanying drawing:

The single FIGURE is a piping diagram showing a novel variable load combined pneumatic and dynamic brake apparatus, a service brake control valve thereof being shown in section.

As shown in the drawing, the variable load combined pneumatic and dynamic brake apparatus for use on an electric-motor propelled rapid transit vehicle comprises a brake cylinder **1**, a main reservoir **2**, an auxiliary reservoir **3**, a brake pipe **4**, a feed valve or fluid pressure supply pipe **5**, an air spring device **6** interposed between a truck frame **7** and a body **8** of the vehicle for supporting this body **8**, a leveling valve device **9** for maintaining a proper pressure within the air spring device **6** whereby the vehicle body **8** is maintained at a constant height above a railway roadbed irrespective of the load on the body **8**, and a variable load type service brake control valve **10**.

Additional components of the variable load combined pneumatic and dynamic brake apparatus mentioned above include a feed valve device **11** for supplying fluid under pressure from the main reservoir **2** to the feed valve or supply pipe **5**, a control reservoir **12**, and a transducer device **13** connected in parallel across the grids in a dynamic braking circuit that includes the armatures of the traction motors of the vehicle. The transducer device **13** may be of any suitable commercially available type and is operable to establish a fluid pressure corresponding to the degree of energization thereof.

The transducer device **13** is connected to the fluid pressure supply pipe **5** by a pipe **14** and is operable to establish in a pipe **15** connected thereto a pressure proportional to the retardation force being obtained from the dynamic brake since this transducer device is connected in the dynamic braking circuit, as stated above.

The brake control valve **10** has a sectionalized casing comprising four casing sections **16**, **17**, **18** and **19** secured together by any suitable means (not shown). The casing section **16** is provided with an auxiliary reservoir-charging check valve device **20** through which the auxiliary reservoir **3** is charged with fluid under pressure from brake pipe **4**. The auxiliary reservoir-charging check valve device **20** comprises a flat disc-type valve **21** for seated contact with an annular valve seat **22** formed adjacent one end of a passageway **23** in the casing section **16**, the opposite end of which passageway is connected to a passageway **24** in this casing section to one end which is connected the hereinbefore-mentioned brake pipe **4**. As the pressure in the passageways **23** and **24** increases, the flat disc-type valve **21** is moved away from the annular valve seat **22** to provide for a one-way flow of fluid under pressure from the passageway **23** to an outlet chamber **25**. The outlet chamber **25** is in constant communication with the auxiliary reservoir **3** by way of a passageway and corresponding pipe **26**.

During initial charging of the auxiliary reservoir **3** and during recharging of this reservoir after a brake application, whenever the pressure of fluid in brake pipe **4** exceeds the pressure in the auxiliary reservoir **3**, the flat disc-valve **21** will be unseated from the annular valve seat **22** whereupon fluid under pressure will flow from the brake pipe **4** to the auxiliary reservoir **3** via passageways **23** and **24**, pass the unseated flat disc-type valve **21** to the outlet chamber **25** and thence through the passageway and corresponding pipe **26**, until the auxiliary reservoir **3** is charged to substantially the pressure normally carried in the brake pipe **4**.

The service brake control valve **10** serves to control the supply of fluid under pressure from the auxiliary reservoir **3** to the brake cylinder **1**, when a brake application is effected, and from the brake cylinder to atmosphere upon effecting a release of the brakes, and is constructed to be responsive to variations in the brake pipe pressure to be movable to a service position, a lap position, and a brake release position.

The casing section **16** of the service brake control valve **10** is provided with a bore **27** which opens at its lower end at the lower side of the casing **16** and opens at its upper end into a chamber **28** formed by the cooperative relationship of the casing section **16** and a cap nut **29** having screw-threaded engagement with internal screw threads formed on the wall of a bore extending from the upper side of the casing section **16** through this casing section and opening into the chamber **28**. At the upper end of the bore **27** there is formed an annular valve seat **30** against which is normally biased a flat disc-type valve **31** by a spring **32** interposed between this valve and the cap nut **29**. Opening into the chamber **28** is one end of a passageway **33** that extends through the casing section **16** and opens into the hereinbefore-mentioned passageway **26** intermediate the ends thereof so that fluid under pressure may be constantly supplied from the auxiliary reservoir **3** to the chamber **28** via pipe and corresponding passageway **26** and passageway **33**.

Slidably mounted in the bore **27** is a valve stem **34** that at its lower end is secured to a diaphragm follower **35** in a manner hereinafter explained. The diaphragm follower **35** is operatively connected to the center of a diaphragm **36** by means such as a diaphragm follower plate **37** and a plurality of cap-screws **38**, only one of which appears in the drawing, that pass through corresponding smooth bores in the diaphragm follower plate **37** and have screw-threaded engagement with coaxial screw-threaded bores in the diaphragm follower **35**. The outer periphery of the diaphragm **36** is clamped between the lower end of the casing section **16** and the upper end of the casing section **17** which is secured thereto by any suitable means (not shown).

The diaphragm 36 cooperates with the casing sections 16 and 17 to form within the service brake control valve 10 and on opposite sides of the diaphragm a pair of chambers 39 and 40. Opening into the chamber 40 above the diaphragm 36 is one end of the hereinbefore-mentioned passageway 24 so that the chamber 40 is charged with fluid under pressure from the brake pipe 4 via passageway 24.

Opening into the chamber 39 below the diaphragm 36 is one end of a passageway 41 that extends through the casing sections 17 and 16 and is connected by a correspondingly numbered pipe to the control reservoir 12. In order to provide for the charging of the control reservoir 12 from the brake pipe 4, the casing section 16 is provided with a passageway 42 that at its lower end opens into the chamber 40 and at its upper end within an annular valve seat 43 against which rests a flat disc-type valve 44 disposed in a chamber 45 formed by the cooperative relationship of the casing section 16 and a cover member 46 secured thereto by any suitable means (not shown). Opening into this chamber 45 is one end of a passageway 47 that extends through the casing section 16 and at its other end opens into the hereinbefore-mentioned passageway 41 intermediate the ends thereof. Accordingly, it can be seen from the drawing that fluid under pressure supplied to the chamber 40 from the brake pipe 4, in the manner hereinbefore described, will flow from the chamber 40 via the passageway 42 and effect unseating of the valve 44 from the annular valve seat 43 whereupon fluid under pressure will flow from the passageway 42 to the control reservoir 12 via the chamber 45, passageway 47 and passageway and corresponding pipe 41 until the pressure in the control reservoir 12 is charged to substantially the pressure carried in the brake pipe 4.

The valve stem 34 has formed thereon intermediate its ends a peripheral annular groove 48 which, as shown in the drawing illustrating the relative positions of the parts of the service brake control valve 10 in the brake release position, is so located and arranged that the brake cylinder 1 is open to atmosphere via a pipe and corresponding passageway 49 which extends through the casing section 16 and opens at the wall surface of the hereinbefore-mentioned bore 27, a bottomed bore 50 and a port 51 formed in the valve stem 34, the groove 48 thereon, and thence via a passageway 52 in the casing section 16 which at one end opens at the wall surface of the bore 27 and at the other end to the exterior of this casing section.

As shown in the drawing, the outer periphery of a diaphragm 53 having the same effective area as the diaphragm 36 is clamped between the bottom of the casing section 17 and the top of the casing section 18 secured thereto by any suitable means (not shown). The center of this diaphragm 53 is clamped between an annular diaphragm follower 54 and a diaphragm follower plate 55 secured to the follower 54 by a plurality of cap screws 56, only one of which appears in the drawing, that pass through corresponding smooth bores in the follower plate 55 and have screw-threaded engagement with coaxial screw-threaded bores in the diaphragm follower 54.

The diaphragms 36 and 53 are operatively connected to the valve stem 34 in a manner now to be described.

As can be seen from the drawing, the casing sections 17 and 18 are respectively provided with bores 57 and 58 of unequal diameter which bores are coaxial with the bore 27 in casing section 16. Extending through the larger bore 58 is a stem 59 that is provided with a first portion of reduced diameter to form a first shoulder 60 on this stem against which the annular diaphragm follower 54 is secured by a nut 61 having screw-threaded engagement with a first screw thread provided on this stem. The stem 59 above the nut 61 has substantially the same diameter as the smaller bore 57 through which it extends with a sliding fit into the chamber 39.

Adjacent its upper end, the stem 59 is provided with a second portion of reduced diameter to form a second shoulder 62 against which the annular diaphragm follower 35 is secured by the stem 34 which at its lower end is provided with an internal screw-threaded bottomed bore for receiving external screw threads provided on the stem 59 above the shoulder 62 thereon.

The diaphragm 53 cooperates with the casing sections 17 and 18 to form within the service brake control valve 10 and on opposite sides of the diaphragm a pair of chambers 63 and 64. The hereinbefore-mentioned pipe 15 is connected to the chamber 63 by a correspondingly numbered passageway provided in the casing section 17 and the chamber 64 is constantly open to atmosphere via a passageway 65 provided in the casing section 18. Since the transducer device 13 establishes a pressure in the pipe 15 proportional to the retardation force obtained from the dynamic brake, it is apparent that this same pressure is present in the chamber 63 and acts on the diaphragm stack in the same direction as the brake pipe pressure present in the chamber 40.

A spring 66 is interposed between the bottom of the casing section 18 and a collar 67 formed on the stem 59 at the lower end thereof and serves to normally bias the stem 34 to the position shown in which the upper end of this stem is disposed below the valve 31 to thereby provide a communication between the brake cylinder 1 and atmosphere via pipe and passageway 49, bore 27, bottomed bore 50, port 51, groove 48 and passageway 52.

The upper end of casing section 19 is secured to the lower end of casing section 18 by any suitable means (not shown). This casing section 19 is provided with a longitudinal horizontal bottomed square bore 68, a coaxial cylindrical counterbore 69, a bore 70 opening at one end into the square bore 68 and having its axis forming a right angle with the axis of this square bore, and a counterbore 71 coaxial with the bore 70.

Slidably mounted in the square bore 68 is a wedge or cam member 72 that is operatively connected by any suitable means, such as, for example, a press fit to the left-hand end of a piston rod 73 that at its right-hand end is integral with a piston 74 which is slidably mounted in the counterbore 69.

The right-hand end of the counterbore 69 is closed by a cover member 75 that is secured to the casing section 19 by any suitable means (not shown). This cover member 75 cooperates with the piston 74 and the wall surface of the counterbore 69 to form on the right-hand side of this piston a chamber 76 into which opens a passageway 77 that extends through the cover member 75 and casing sections 19, 18, 17 and 16 and is connected by a pipe bearing the corresponding numeral to a chamber 78 within the air spring device 6. Consequently, the right-hand side of the piston 74 is always subject to the pressure in the air spring chamber 78 which is charged with fluid under pressure in a manner hereinafter explained.

Disposed in surrounding relation to the piston rod 73 and interposed between the left-hand end of the counterbore 69 and the piston 74 is a spring 79 which is effective to bias the piston 74 in the direction of the cover member 75.

As shown in the drawing, a cylindrical V-shaped piston member 80 is slidably mounted in the counterbore 71. Formed integral with this piston member 80 is a piston rod 81 that extends through the bore 70, the lower end of this rod being provided with the same taper as the wedge 72.

Disposed in surrounding relation to the piston rod 81 and interposed between the bottom of the counterbore 71 and the piston member 80 is a spring 82 that is normally effective to bias the lower tapered end of the piston rod 81 out of contact with the cam member 72.

Formed on the upper side of the V-shaped piston member 80 is a surface 83 in the form generally of a paraboloid. A diaphragm 84 is clamped around its peripheral edge between a shoulder 85 formed on the piston member 80 and an annular nut member 86 that has screw-threaded engagement with internal screw threads formed in the upper end of the piston member 80. The central portion of the diaphragm 84 is operatively connected to the lower end of the stem 59 by being clamped between the collar 67 and a diaphragm follower plate 87 secured thereto by any suitable means (not shown). An intermediate portion of the diaphragm 84 operatively contacts

the paraboloid surface 83 on the piston member 80, and, as the piston member 80 is moved in a downward direction from the position shown in the drawing, this intermediate portion will contact less and less of this surface 83 until the intermediate portion is entirely out of contact therewith.

The diaphragm 84 cooperates with the casing section 18 and the piston member 80 to form within the service brake control valve 10 and on opposite sides of the diaphragm, two chambers 88 and 89. The chamber 88 is open to atmosphere via a short passageway 90 in the piston member 80, the counterbore 71, and a short passageway 91 provided in the casing section 19, and the chamber 89 is connected by a passageway 92 extending through the casing sections 18, 17 and 16 to the passageway 49 which is connected by the corresponding pipe to the brake cylinder 1. A tuning choke 93 is disposed in the passageway 92 adjacent the chamber 89 to control the rate at which fluid under pressure may flow to this chamber.

The leveling valve device 9 may, for example, be of the type disclosed in U.S. Pat. No. 2,945,690, issued July 19, 1960, to Harry C. May and Joseph F. Frola, and assigned to the assignee of the present invention. This valve device 9 is mounted on the vehicle body 8 or other sprung member and comprises, briefly, valve means (not shown) controlled by a lever 94 pivotally connected at one end to a rotatable cam shaft and at the opposite end to one end of a link 95 that, at its opposite end, is anchored to an unsprung member such as, for example, the truck frame 7; the valve means being operable by the link 95, lever 94, and the cam shaft to effect the supply of fluid under pressure from the supply pipe 5 to the chamber 78 of the air spring device 6 via a choke (not shown), a short pipe 96 that is connected to the pipe 77 intermediate the ends thereof and the pipe 77, and the release fluid under pressure from the chamber 78 to atmosphere via pipes 77 and 96, and a vent pipe 97, as may be required to establish in the chamber 78 different fluid pressures at different times to maintain the vehicle body 8 at the aforementioned preselected height relative to the truck frame and the rails of the railway roadbed. Thus, the pressure of fluid established in the chamber 78 is an accurate measure of the load imposed on the vehicle body 8 that is supported on the truck frame 7 by the air spring 6.

OPERATION

Assume initially that all the passageways and chambers in the service brake control valve device 10 shown in the drawing are devoid of fluid under pressure; and that the feed valve device 11 has been adjusted to provide a desired (such as 70 pounds per square inch) normal charged pressure in the feed valve or fluid pressure supply pipe 5 and in the pipe 14. Under these conditions the various components of the apparatus shown in the drawing with the exception of the vehicle body 8 and the leveling valve device 9, will be in the respective positions in which they are shown. In the absence of fluid under pressure in the chamber 78 of the air spring device 6, it will be understood that the vehicle body 8 occupies a position below that shown, or nearer the rails of the railway roadbed and is supported either on steel springs or car bumpers (not shown).

To initially charge the apparatus, the electric motors are started for operating a fluid compressor (not shown) to effect charging of the main reservoir 2. Fluid under pressure will now charge the brake apparatus shown in the drawing in the following manner:

Fluid under pressure will be supplied from the main reservoir 2 to the feed valve device 11 via a pipe 98. The feed valve device 11, which has been adjusted to supply fluid under pressure at a desired value, which, as hereinbefore stated, may be, for example, 70 pounds per square inch, supplies fluid at this pressure to the pipes 5 and 14 to charge these pipes to the pressure for which the feed valve device 11 has been adjusted.

Since the feed valve pipe 5 is connected to the leveling valve device 9, as the pressure in the feed valve pipe 5 increases in response to the supply of fluid under pressure thereto by the feed valve device 11, the leveling valve device 9 operates to provide in pipes 96 and 77 and hence, respectively, in the chamber 78 of the air spring device 6 and in the chamber 76 in the service brake control valve device 10, fluid at a pressure sufficient to raise or lift the vehicle body 8 upward from the steel springs or car bumpers to the aforementioned preselected height above the railway roadbed, or, in other words, to the position shown in the drawing.

The brake apparatus may now be charged by the engineer moving the handle of a brake valve (not shown) to its running (i.e., release) position. It may be assumed that this brake valve is of the type described in U.S. Pat. No. 2,958,561, issued Nov. 1, 1960, to Harry C. May and assigned to the assignee of the present application. Accordingly, the relay valve of this brake valve operates in the manner described in the aforesaid patent to supply fluid under pressure from the main reservoir 2 to the brake pipe 4. Fluid under pressure flows from the brake pipe 4 to the lower side of the flat disc-type valve 21 via the passageways 24 and 23 and is effective to unseat this valve 21 from its seat 22. When valve 21 is thus unseated from seat 22, fluid under pressure will flow from passageway 23 to the chamber 25 and thence to the auxiliary reservoir 3 via passageway and corresponding pipe 26. Fluid under pressure is thus supplied from the main reservoir 2 to the auxiliary reservoir 3 until the pressure therein is substantially the same as the normal full charged pressure in the brake pipe 4, which for example, may be 70 pounds per square inch, it being understood that the control valve of the brake valve is adjusted to provide for this brake pipe pressure.

Fluid under pressure supplied from the brake pipe 4 to the passageway 24 will also flow to the chamber 40 above the diaphragm 36 so that the pressure in the chamber 40 is increased to t he normal value of the pressure carried in the brake pipe 4 when fully charged.

Fluid under pressure that is supplied to the chamber 40 flows therefrom via the passageway 42 to the lower side of the flat disc valve 44 and is effective to unseat this valve from its seat 43. When valve 44 is thus unseated from its seat 43, fluid under pressure will flow from the passageway 42 to the chamber 45 and thence via the passageways 47 and 41 to the chamber 39 below the diaphragm 36 and to the control reservoir 12 via the pipe 41 until the pressure in the chamber 39 and control reservoir 12 is increased to the normal full charged pressure carried in the brake pipe 4.

The fluid under pressure supplied to the chamber 76 by the leveling valve device 9 in the manner hereinbefore explained will be at a maximum value since it may be assumed that the car is now fully loaded. Accordingly, this fluid under pressure present in the chamber 76 is effective to move the piston 74, piston rod 73 and wedge 72 against the yielding resistance of the spring 79 to the position shown in which wedge 72 abuts the left-hand end of square bore 68.

Initiation of a service brake application can now be effected by the engineer moving the handle of the brake valve from its running position into its application zone to a position corresponding to the degree of brake application desired whereupon the relay valve of the brake valve operates in the manner fully described in detail in hereinbefore-mentioned U.S. Pat. No. 2,958,561 to effect a reduction in the pressure in the brake pipe 4 and chamber 40 in the service brake control valve 10 at a service rate.

Simultaneously as a service brake application is effected, means which form no part of the present invention set up dynamic brake control circuitry as a result of which the transducer device 13 is energized via the dynamic braking circuit to a degree in proportion to the retardation force being obtained from the dynamic brake. Energization of the transducer device 13 is effective to cause operation thereof to supply fluid under pressure from the outlet of the feed valve device 11 to the chamber 63 in the brake control valve 10 via the pipes 5 and 14, transducer device 13, and pipe and passageway 15 until the pressure in the chamber 63 corresponds to the degree of energization of the transducer device 13.

Initially, while the dynamic brake is fully effective, fluid under pressure is supplied to the chamber **63** to increase the pressure therein as fast as fluid under pressure is released from the chamber **40** in the manner explained above. Consequently, the brake control valve **10** remains in the release position shown.

It is well known that as the speed of a train decreases as a result of the application of the dynamic brake, the dynamic braking effect, and the current flowing in the dynamic braking circuit, and therefore, in the transducer device **13**, decreases in accordance with the decrease in the speed of the train. Accordingly, as the current flowing in the dynamic braking circuit decreases as the speed of the train decreases, the transducer device **13** will operate to correspondingly reduce the pressure in the chamber **63** of the brake control valve **10**. Therefore, the higher pressure in the chamber **39**, which pressure is the same as that in the control reservoir **12**, will deflect the diaphragm stack including diaphragms **36, 53** and **84** in an upward direction. Since the valve stem **34** is secured to diaphragm follower **35** by the stem **59**, this upward deflection of the diaphragm stack will move the valve stems **59** and **34** upward and cause the upper end of stem **34** to first contact the bottom face of valve **31** to close communication between the brake cylinder **1** and atmosphere. As the stem **34** continues to move upward, the valve **31** will be unseated from its seat **30**. By unseating of the valve **31**, fluid under pressure from the auxiliary reservoir **3** is permitted to flow to the brake cylinder **1** via pipe and passageway **26**, passageway **33**, chamber **28**, thence past annular valve seat **30**, and through bore **27** and passageway and pipe **49**.

It will be noted that some of the fluid under pressure supplied to the passageway **49** flows therefrom to the chamber **89** via the passageway **92** and choke **93** therein.

Fluid under pressure supplied to the chamber **89** is effective on the upper side of the piston member **80** to move this piston member downward against the yielding resistance of the spring **82** until the lower end of the piston rod **81** is moved into contact with the cam member **72**. It will be noted that as the piston member **80** is thus moved downward, the intermediate portion of the diaphragm **84** is unwrapped or moved away from the paraboloid surface **83** to increase the effective area of the diaphragm **84**. However, since the vehicle has been assumed to be fully loaded in case the cam member **72** occupies the position shown in the drawing, the downward movement of the piston member **80** and therefore the amount of unwrapping of the diaphragm **84** from the paraboloid surface **83** is small. Accordingly, the increase in the effective area of the diaphragm **84** is likewise small. Therefore, it will be understood that the effective area of the diaphragm **84** while the vehicle is loaded is a minimum.

The fluid under pressure supplied to the brake cylinder **1** and chamber **89** in the manner explained above will increase the pressure therein and act in a downward direction on the effective area of diaphragm **84**, which effective area is now a minimum.

Upon the combined force of the spring **66**, the reducing fluid pressure force on the diaphragm **53**, as the result of the fading away of the dynamic brake, and the increasing fluid pressure force acting downward on the effective area of the diaphragm **84** slightly exceeding the force acting upward on the diaphragm **36**, as the result of the reduction of pressure in the chamber **40** caused by the brake pipe reduction, the stems **59** and **34** and diaphragm followers **35** and **54** will be moved downward until the spring **32** seats the valve **31** on its seat **30**. This cuts off flow of fluid under pressure from the auxiliary reservoir **3** to the brake cylinder **1** and chamber **89**. From the foregoing, it will be understood that since the effective area of the diaphragm **84** is a minimum when the vehicle is fully loaded, a maximum pressure is established in the brake cylinder **1** and chamber **89** in order to operate the brake control valve **10** to its lap position to cut off further flow of fluid under pressure to the brake cylinder **1**. Furthermore, it will be understood that this maximum pressure established in the brake cylinder **1** is sufficient to provide a corresponding braking force that is adequate to properly brake the fully loaded vehicle.

In view of the above, it can be seen that as the dynamic brake fades away, the brake control valve **10** operates to increase the pneumatic braking force on the vehicle to compensate for the fading away of the dynamic brake so that the dynamic brake and the pneumatic brake are blended together whereby there is no reduction in the total braking effect on the vehicle as the dynamic brake fades away.

Since the operation of the brake control valve **10** is the same in effecting either a partial or a complete release of the brakes, it is believed that a description of one will suffice for both, it being understood of course that when a partial release of the brakes is effected, the pressure in the brake pipe **4** is not increased to its normal fully charged chosen pressure, and all the fluid under pressure in the brake cylinder **1** is not released to atmosphere as is the case when a complete release is effected.

Let it be supposed that the engineer now desires to effect a complete brake release. Accordingly, he will move the handle of the brake valve from the position it occupies in its application zone back to its running (i.e., release) position.

As the handle is thus returned to its release position, the brake pipe **4** is charged in the manner described in the hereinbefore-mentioned U.S. Pat. No. 2,958,561.

Fluid under pressure flows from the brake pipe **4** via the check valve **21** to charge the auxiliary reservoir **3** to the pressure carried in the brake pipe in the manner hereinbefore described.

Fluid under pressure also flows to the chamber **40** in the manner hereinbefore described. It will be understood that the pressure in the chamber **63** is reduced to atmospheric pressure as the dynamic brake fades away. Consequently, no fluid under pressure will be present in the chamber **63** at the time a brake release is effected. Accordingly, as fluid under pressure flows from the brake pipe **4** to the chamber **40** to increase the pressure therein, a fluid pressure force is established which acts in a downward direction and, upon the pressure in the chamber **40** and brake pipe **4** reaching the normal fully charged pressure, is effective to return the diaphragms **53** and **36**, and stems **59** and **34** to the position shown in the drawing.

Fluid under pressure will now flow from the brake cylinder **1** to atmosphere via pipe and passageway **49**, bore **27**, bottomed bore **50**, port **51**, groove **48** and passageway **52** until all fluid under pressure is released from the brake cylinder **1** thereby **2,958,561**, releasing the brakes on the vehicle.

Since the chamber **89** is connected to the passageway **49** by the passageway **92** having choke **93** therein, fluid under pressure will be released from the chamber **89** to atmosphere at a rate determined by the size of the choke **93** simultaneously as fluid under pressure is released from the brake cylinder **1** to atmosphere. As fluid under pressure is thus released from the chamber **89** to atmosphere, to reduce the pressure in this chamber to atmospheric pressure, the spring **82** is rendered effective to move the piston member **80** and piston rod **81** upward to the position shown in the drawing.

As the stem **59** is moved downward and the piston member **80** is moved upward in the manner explained above in connection with effecting a complete release of the brakes on the vehicle, the diaphragm **84** will be wrapped onto the paraboloid surface **83** until the piston member **80**, stem **59** and diaphragm **84** occupy the position shown in the drawing.

Now let it be supposed that the vehicle provided with the brake equipment shown in the drawing is empty. Therefore, when the brake equipment is initially charged in the manner hereinbefore described, the leveling valve device **9** will operate to provide in the chamber **78** of the air spring device **6** and in the chamber **76** in the service brake control valve **10**, fluid at a pressure sufficient to raise the vehicle body **8** upward from the steel springs or car bumpers to the aforementioned preselected height above the railway roadbed, or in other words, to the position shown.

The fluid under pressure supplied to the chamber **76** by the leveling valve device **9** in the manner hereinbefore explained will be at a minimum value since it has been assumed the vehicle is empty. Accordingly, this minimum fluid under pressure present in the chamber **76** is ineffective to overcome the resistance of the spring **79**. Consequently, the spring **79** is effective to bias the piston **74** into abutting contact with the cover member **75** to thereby position the cam member **72** in a position to the right of that shown in the drawing a distance equal to the distance between the right-hand face of the piston **74** and the left-hand face of the cover member **75**.

It is therefore apparent that with the cam member **72** now in a position to the right of that shown in the drawing, the piston member **80** can move downward a greater distance before the piston rod **81** abuts the cam member **72** than is the case while this cam member occupies the position shown in the drawing. Accordingly, it will be understood that, upon the supply of fluid under pressure to the brake cylinder **1** and chamber **89** when effecting a brake application in the manner hereinbefore described, more of the intermediate portion of diaphragm **84** will be unwrapped from the paraboloid surface **83** than is the case when the vehicle is fully loaded. Therefore, it is seen that the effective area of this diaphragm **84** is a maximum when the vehicle is empty.

Since the effective area of the diaphragm **84** is a maximum when the vehicle is empty, it will be understood that when a service brake application is effected in the manner hereinbefore described, the pressure required in the chamber **89** and the brake cylinder **1** to operate the brake control valve **10** to its lap position to prevent further increase in brake cylinder pressure, is a minimum. It will be understood that this minimum pressure thus established in the brake cylinder **1** is sufficient to provide a corresponding braking force that is adequate to properly brake the empty vehicle.

From the foregoing, it is apparent that if the vehicle is partly loaded, the cam member **72** will occupy a position intermediate the position shown in the drawing and the position it occupies when the right-hand face of the piston **74** abuts the left-hand face of the cover member **75**. Accordingly, it will be understood from the foregoing that when a service brake application is made, the intermediate portion of the diaphragm **84** will be unwrapped from the paraboloid surface **83** to provide the proper effective area for this diaphragm such that the brake cylinder pressure required to act on this diaphragm to move the brake control valve **10** to its lap position provides a braking force that is adequate to properly brake the partly loaded vehicle.

It will be understood that a vehicle provided with the service brake control valve **10** is also provided with some suitable type of emergency valve to provide for effecting an emergency brake application on the vehicle when an emergency brake application is necessary.

Having now described the invention, what we claim as new and desire to secure by Letters Patent, is:

1. A fluid pressure controlled railway vehicle brake apparatus comprising, in combination:

a. a normally charged brake pipe, variations of the fluid pressure in which are effective to control brake applications and brake releases on the vehicle,

b. an auxiliary reservoir normally charged to the pressure carried in said brake pipe,

c. a control reservoir normally charged to the pressure carried in said brake pipe,

d. fluid pressure operated braking means for effecting a brake application on the vehicle, and

e. a fluid pressure operated brake control service valve device comprising:

i. valve means operable to effect the supply of fluid under pressure from said auxiliary reservoir to said fluid pressure operated braking means and the release of fluid under pressure from said fluid pressure operated braking means to atmosphere,

ii. a stem coaxially arranged with respect to said valve means for effecting the operation thereof,

iii. a first movable abutment subject on one side to the pressure of fluid in said brake pipe and subject on the opposite side to the pressure in said control reservoir, said first movable abutment being connected to said stem intermediate the ends thereof to effect its movement in one direction in response to a reduction in brake pipe pressure on said one side relative to control reservoir pressure on said opposite side to cause one end of said stem to operate said valve means to effect the supply of fluid under pressure from said auxiliary reservoir to said braking means to cause a brake application on the vehicle, wherein the improvement comprises:

iv. a second movable abutment subject on one side to a pressure corresponding to the degree of dynamic braking effect exerted by a dynamic braking means on the vehicle and subject on the opposite side to atmospheric pressure, said second movable abutment being connected to said stem intermediate the ends thereof and having the same effective area as said first movable abutment, whereby said second movable abutment renders said first movable abutment inoperative to cause operation of said valve means so long as said pressure corresponding to the degree of dynamic braking effect is equal to said normally charged brake pipe pressure, and renders said first movable abutment operative to cause operation of said valve means in response to a decrease in said pressure resulting from a reduction of the dynamic braking effect as the speed of the vehicle reduces to effect the supply of fluid under pressure to said braking means to a degree proportional to the reduction in said dynamic braking effect whereby said braking means increases its braking effect on the vehicle to compensate for the reduction of the braking effect of the dynamic braking means, and

v. a third movable abutment subject on one side to the fluid pressure supplied by said valve means to said braking means and subject on the opposite side to atmospheric pressure, said third movable abutment being connected to the end of said valve stem opposite said one end to effect movement of said stem in a direction opposite said one direction in response to the force of fluid under pressure acting thereon and on said other movable abutments in said opposite direction slightly exceeding the fluid pressure force acting in said one direction on said first movable abutment to cause operation of said valve means to cut off flow of fluid under pressure from said auxiliary reservoir to said braking means, said first movable abutment being responsive to a subsequent increase in brake pipe pressure on said one side thereof to effect further movement of said stem in said opposite direction to cause said valve means to establish a venting communication whereby the fluid under pressure supplied to said braking means is released to atmosphere.

2. A fluid pressure controlled railway vehicle brake apparatus, as recited in claim **1**, further characterized by means operative in response to the degree of dynamic braking effect to establish a corresponding degree of fluid pressure on said one side of said second movable abutment.

3. A fluid pressure controlled railway vehicle brake apparatus, as recited in claim **2**, further characterized in that said means is a transducer device, and said vehicle dynamic braking means comprises a dynamic braking circuit connected to said transducer device.

4. A fluid pressure controlled railway vehicle brake apparatus, as recited in claim **2**, further characterized in that said means is a transducer device connected in parallel across the grids of the dynamic braking circuit.

5. A fluid pressure controlled railway vehicle brake apparatus, as recited in claim **1**, further characterized by a first one-way flow valve means for effecting charging of said auxiliary reservoir from said brake pipe, and by a second one-way flow valve means for effecting charging of said control reservoir from said brake pipe.

6. In a vehicle variable load fluid pressure brake equipment, the combination of:

a. fluid pressure operated braking means for effecting a brake application on the vehicle according to the pressure of fluid supplied thereto, wherein the improvement comprises:

b. a movable member having a paraboloidal surface thereon,

c. a first diaphragm having its outer periphery secured to said movable member and cooperatively contacting said paraboloidal surface whereby its effective pressure area is varied according to the area of said surface in contact with the diaphragm,

d. valve means connected to said first diaphragm and operable to effect the supply of fluid under pressure to and the release of fluid under pressure from said braking means and one side of said first diaphragm,

e. a pair of spaced-apart diaphragms of constant effective area subject on their respective opposite sides to fluid under pressure and operatively connected to said valve means for effecting operation thereof to effect the supply of fluid under pressure to said braking means accordingly as the degree of dynamic braking effect exerted by a dynamic brake means on the vehicle decreases as the speed of the vehicle reduces, and

f. means responsive to the load on the vehicle to correspondingly limit movement of said movable member and thereby the area of said first diaphragm in contact with said paraboloidal surface to thereby vary the effective area of said one side of said first diaphragm subject to the pressure supplied by said valve means whereby, upon the fluid pressure force acting thereon and on said pair of diaphragms in one direction slightly exceeding the fluid pressure force acting on said pair of diaphragms in an opposite direction, said first diaphragm operates said valve means to cut off supply of fluid under pressure to said one side thereof and to said braking means.

7. A vehicle variable load fluid pressure brake equipment, as recited in claim 6, further characterized in that said load responsive means comprises cam means for decreasing the travel of said movable member accordingly as the load on the vehicle increases.

8. A vehicle variable load fluid pressure brake equipment, as recited in claim 7, further characterized in that said movable member is provided with a tapered surface, and said cam means is provided with a correspondingly tapered surface whereby as the load on the vehicle increases the tapered surface of said cam means is so positioned with respect to the tapered surface of said movable member as to reduce the travel of said movable member.

9. A vehicle variable load fluid pressure brake equipment, as recited in claim 6, further characterized in that said load responsive means comprises:

a. cam means so positionable with respect to said movable member as to determine the degree of travel thereof,

b. a piston operably connected to said cam means for moving said cam means to different positions,

c. biasing means effective on one side of said piston to move said cam means to a position to provide for maximum movement of said movable member, and

d. fluid pressure operated means for establishing on the opposite side of said piston a pressure variable in accordance with the load carried by the vehicle whereby said piston and cam means are moved against the yielding resistance of said biasing means to a position corresponding to said load thereby to correspondingly reduce the travel of said movable member as said load increases.

10. A vehicle variable load fluid pressure brake equipment, as recited in claim 9, further characterized in that said movable member is provided with a first inclined plane, and said cam means is provided with a second inclined plane having the same degree of inclination as said first inclined plane whereby movement of said cam means in one direction in response to a decrease in load on the vehicle increases the travel of said movable member and movement of said cam means in an opposite direction in response to an increase in load on the vehicle decreases the travel of said movable member thereby to increase the effective area of said first abutment as said load decreases and to decrease the effective area of said first abutment as said load increases.

11. For use in a vehicle fluid pressure brake apparatus, a valve device for controlling the degree of fluid pressure supplied to effect a brake application, said valve device comprising:

a. a casing having a bore provided with an annular supply valve seat at one end thereof,

b. a hollow valve operating stem having an annular exhaust valve seat at one end thereof and being slidably mounted in said bore,

c. a disc valve movable away from said supply valve seat by movement of said stem in one direction, subsequent to movement of said exhaust valve seat into contact with said disc valve,

d. resilient means for biasing said disc valve toward seating contact with said annular supply valve seat, wherein the improvement comprises:

e. three fluid pressure responsive diaphragm means for controlling movement of said valve operating stem with respect to said disc valve, one of said diaphragm means being effective at one time to establish a fluid pressure force opposite in direction to the fluid pressure force established by the other two, one of said other two diaphragm means being of a variable effective area and arranged to be subjected to fluid under pressure supplied upon said stem moving said disc valve away from said supply valve seat, said one diaphragm means and the third diaphragm means being of uniform effective area, said one of which is arranged to be subjected to a selected pressure established according to a desired degree of a pneumatic brake application and said third diaphragm means being arranged to be subjected to a selected pressure established according to a desired degree of dynamic braking effect exerted by a dynamic braking means on the vehicle whereby said valve operating stem is rendered ineffective to unseat said disc valve from said supply valve seat so long as said selected pressure in accordance with the degree of dynamic braking effect is a maximum, and said operating stem is effective to unseat said disc valve from said supply seat to cause pressure supplied past said disc valve to increase as said selected dynamic braking pressure decreases as the speed of the vehicle reduces to thereby maintain a constant braking force on said vehicle notwithstanding said decrease in vehicle speed.

12. For use in a vehicle fluid pressure brake apparatus, a valve device as recited in claim 11, in which the casing is provided with a second bore, and the variable effective area diaphragm means includes a piston member slidably mounted in said second bore and having a paraboloidal surface formed thereon, and an annular flexible diaphragm the outer periphery of which is secured to said piston member and the inner periphery of which is secured to said valve operating stem, said diaphragm cooperating with said paraboloidal surface is varied according to the axial position of said piston member within said second bore.

13. For use in a vehicle fluid pressure brake apparatus, a valve device as recited in claim 12, further including means for so positioning said piston member in said second bore in accordance with the load on the vehicle as to increase the effective area of said annular flexible diaphragm as the load on the vehicle decreases.

14. For use in a vehicle fluid pressure brake apparatus, a valve device as recited in claim 13, further characterized in that said positioning means comprises two parallel and inclined surfaces one of which is carried by said piston member and the other of which is positioned with respect to said one inclined surface in accordance with the load carried by the vehicle thereby to limit the movement of said piston member.

15. For use in a vehicle fluid pressure brake apparatus, a valve device as recited in claim 14, further characterized by spring means for moving said other inclined surface in one direction, and a fluid motor for moving said other inclined surface in an opposite direction.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,639,010 Dated February 1, 1972

Inventor(s) Gary T. Mayer and Daniel G. Scott

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

In the Abstract, line 1, after "diaphragm" insert --fluid- --

Column 12, lines 59 & 60, after "surface" insert --in such a manner that the effective area of said diaphragm--

Signed and sealed this 25th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents