

June 15, 1943.

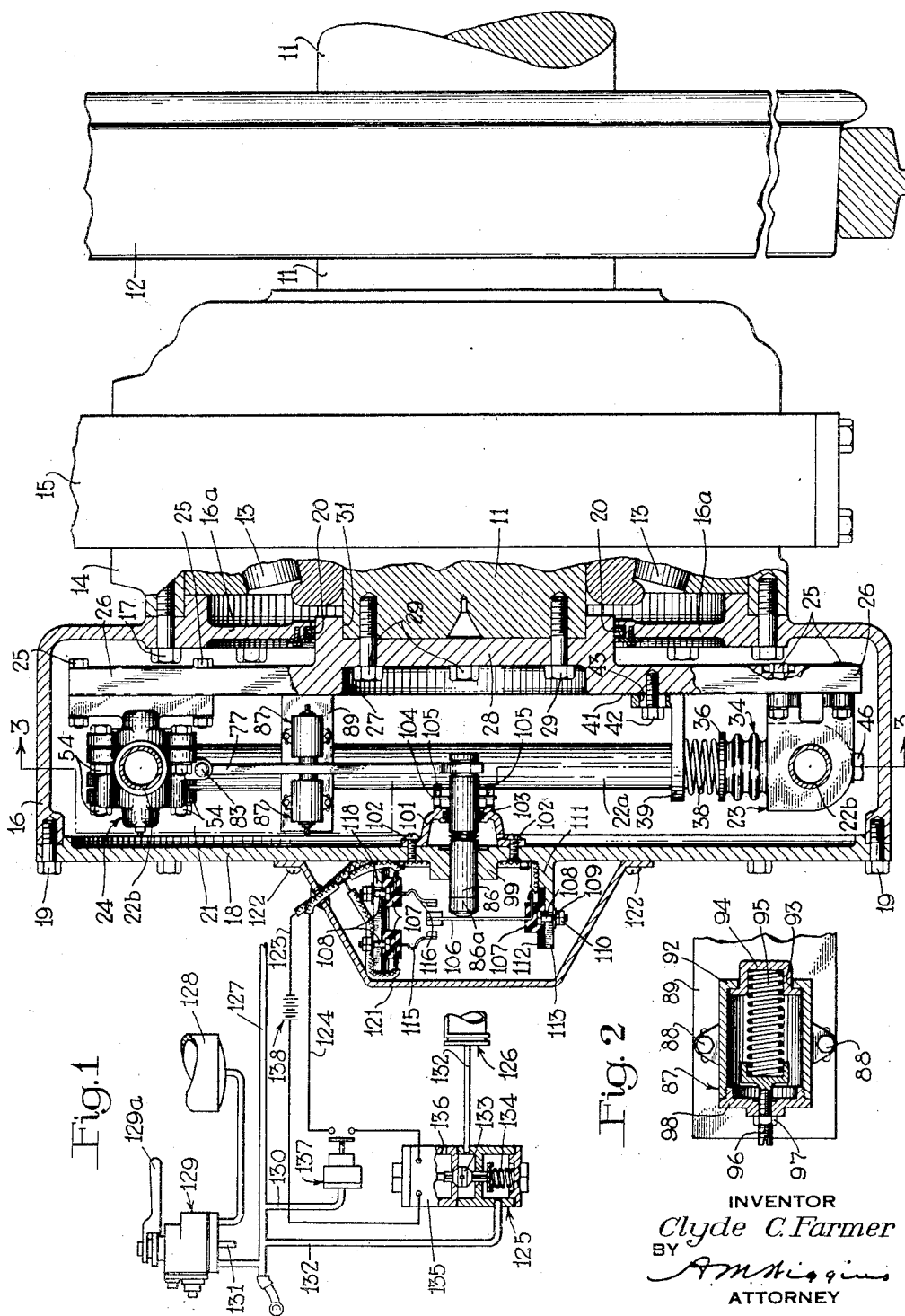
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2,322,003

FLUID TYPE INERTIA DEVICE

Filed Aug. 29, 1942

6 Sheets-Sheet 1



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Fig. 3

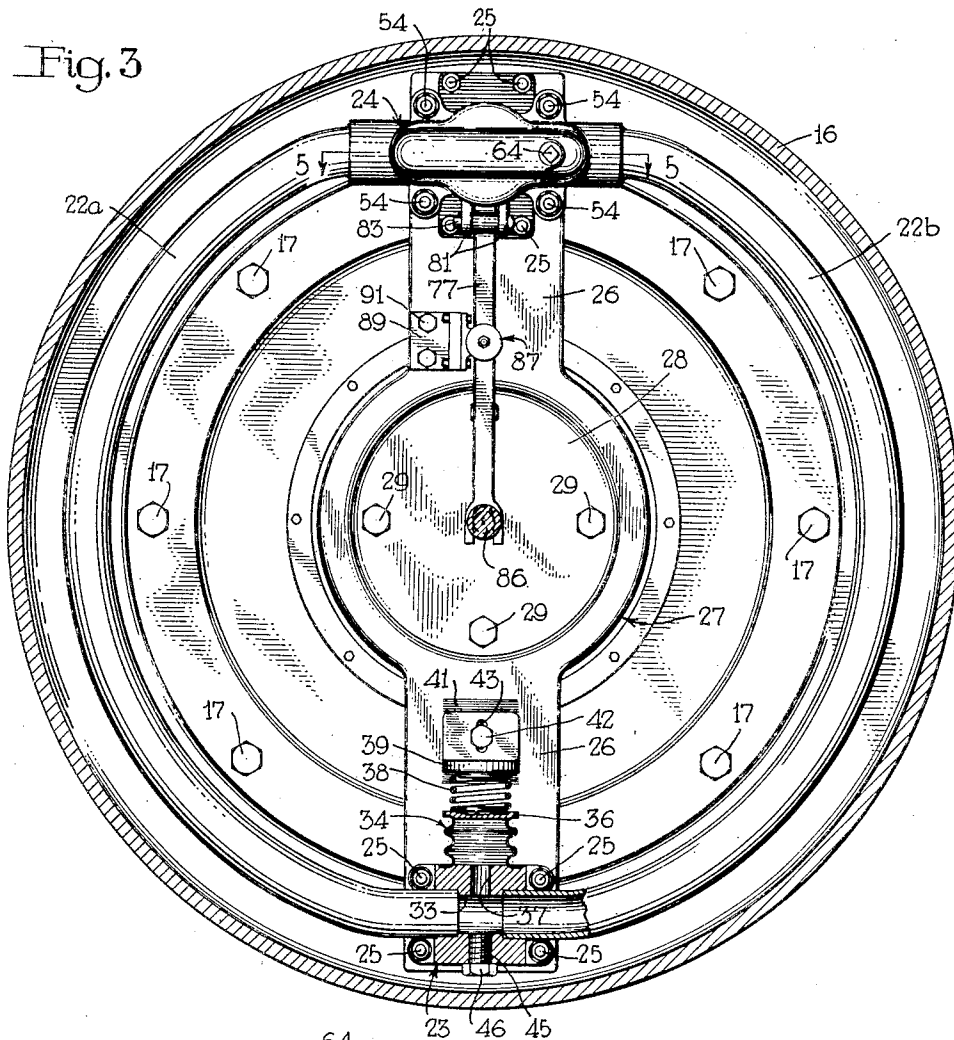
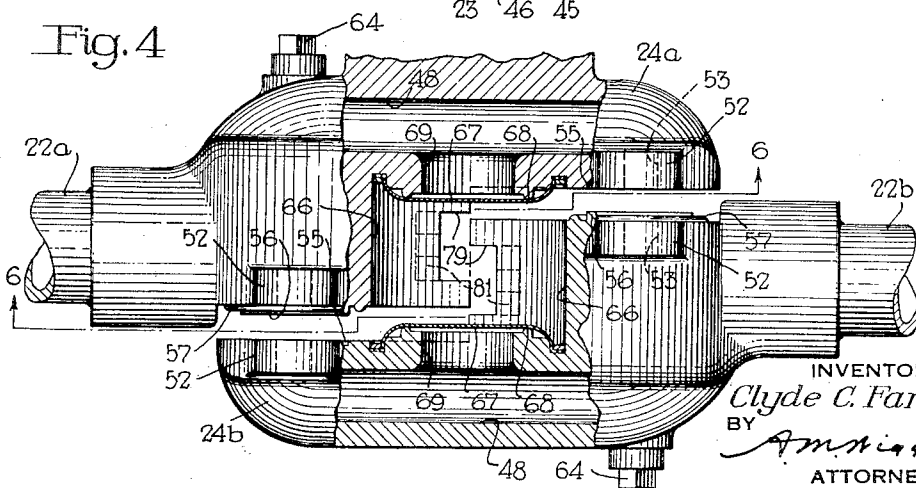


Fig. 4



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Fig. 5

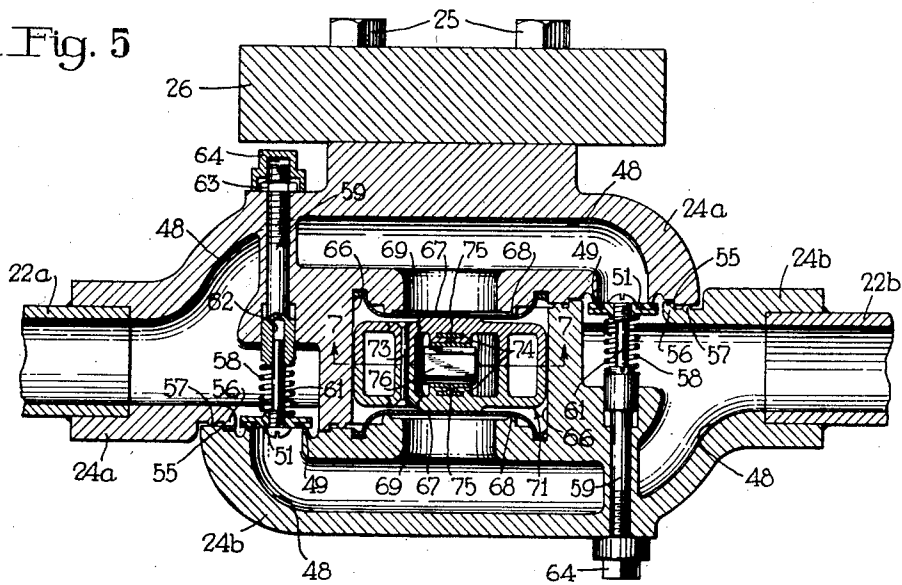


Fig. 6

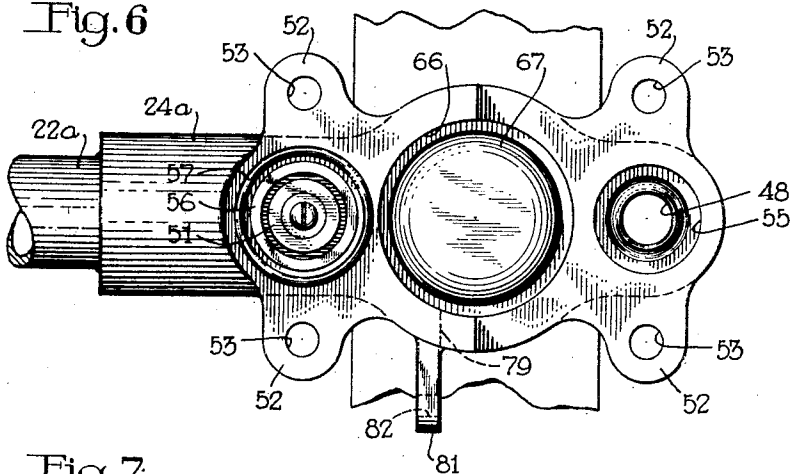
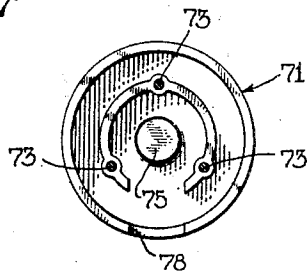


Fig. 7.



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Fig. 8

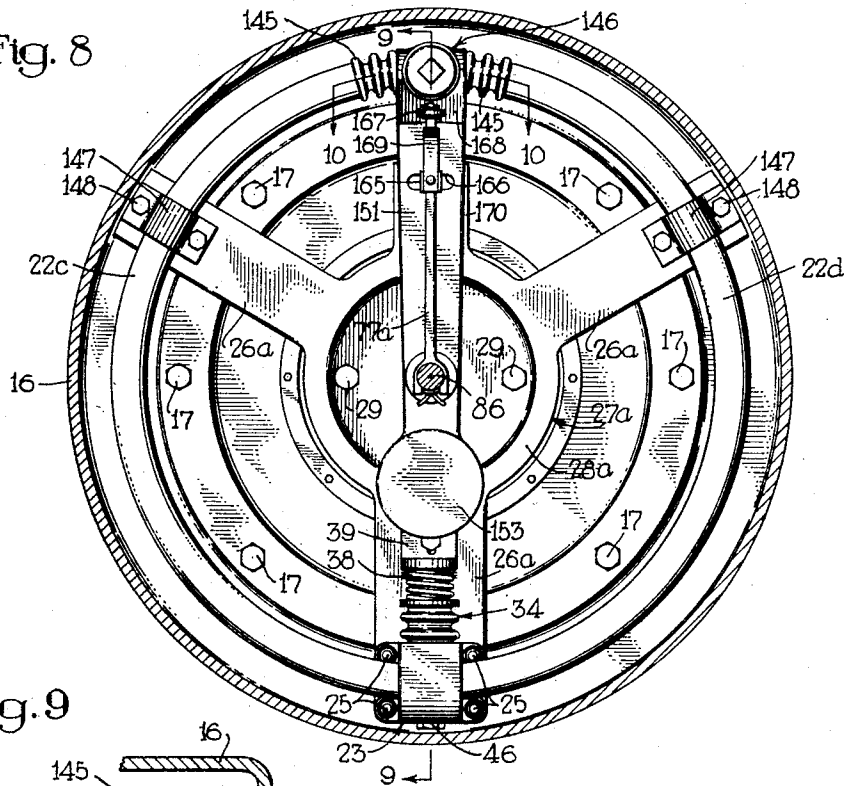


Fig. 9

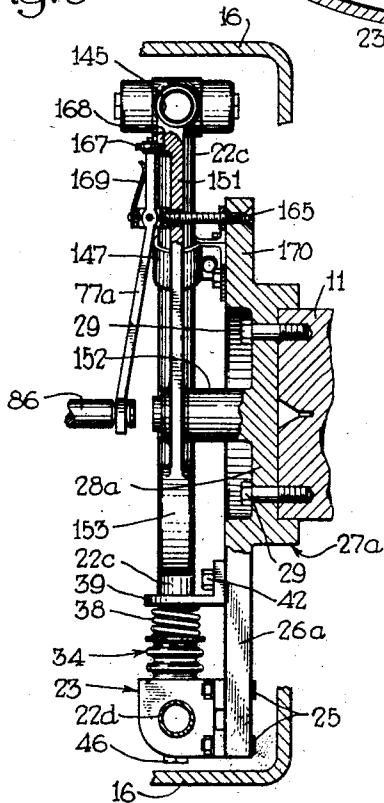
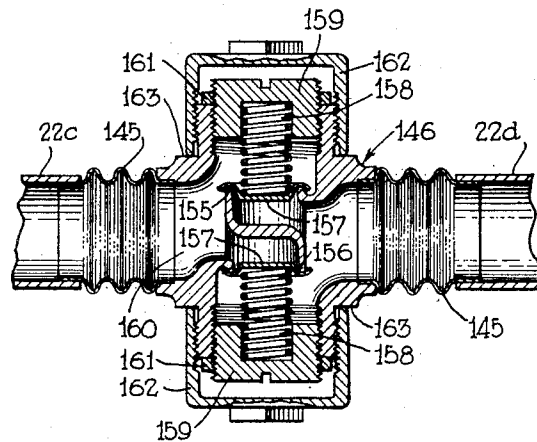


Fig. 10



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Fig. 11

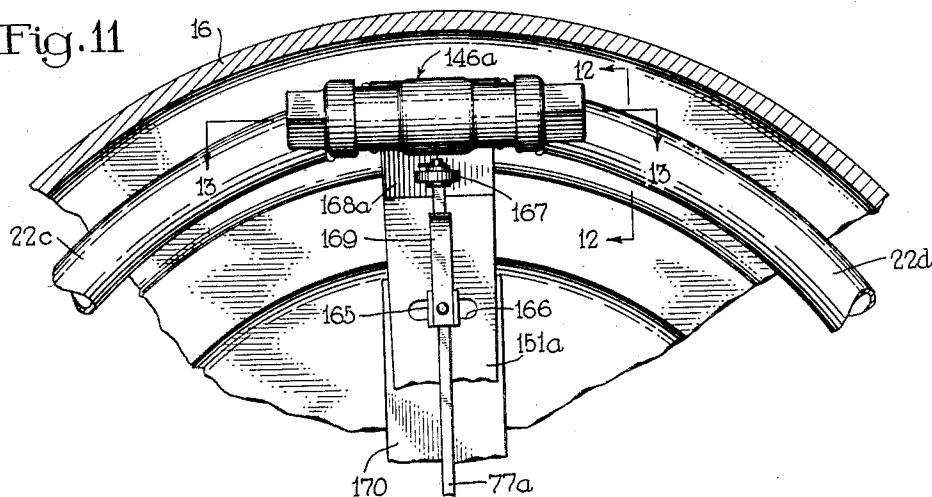


Fig. 13

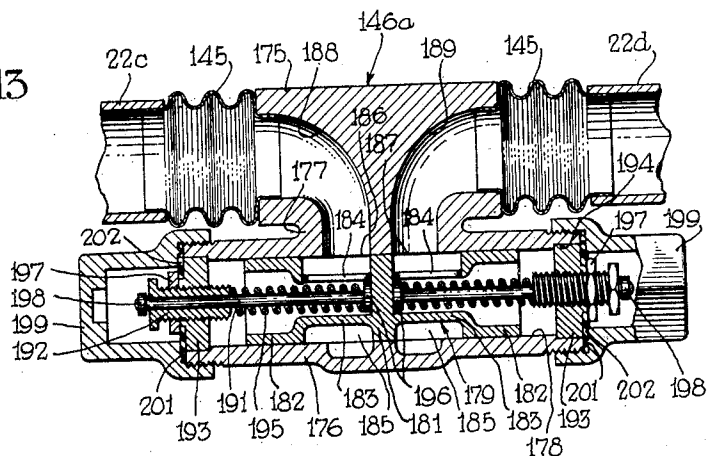
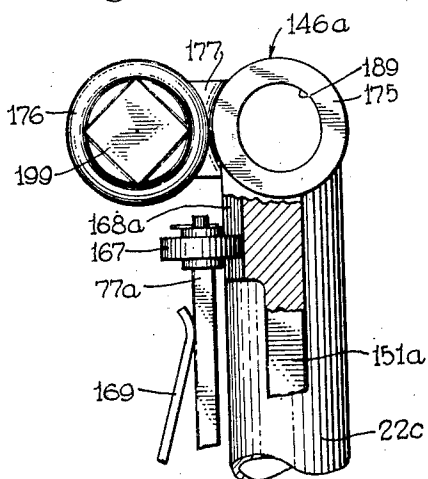


Fig. 12



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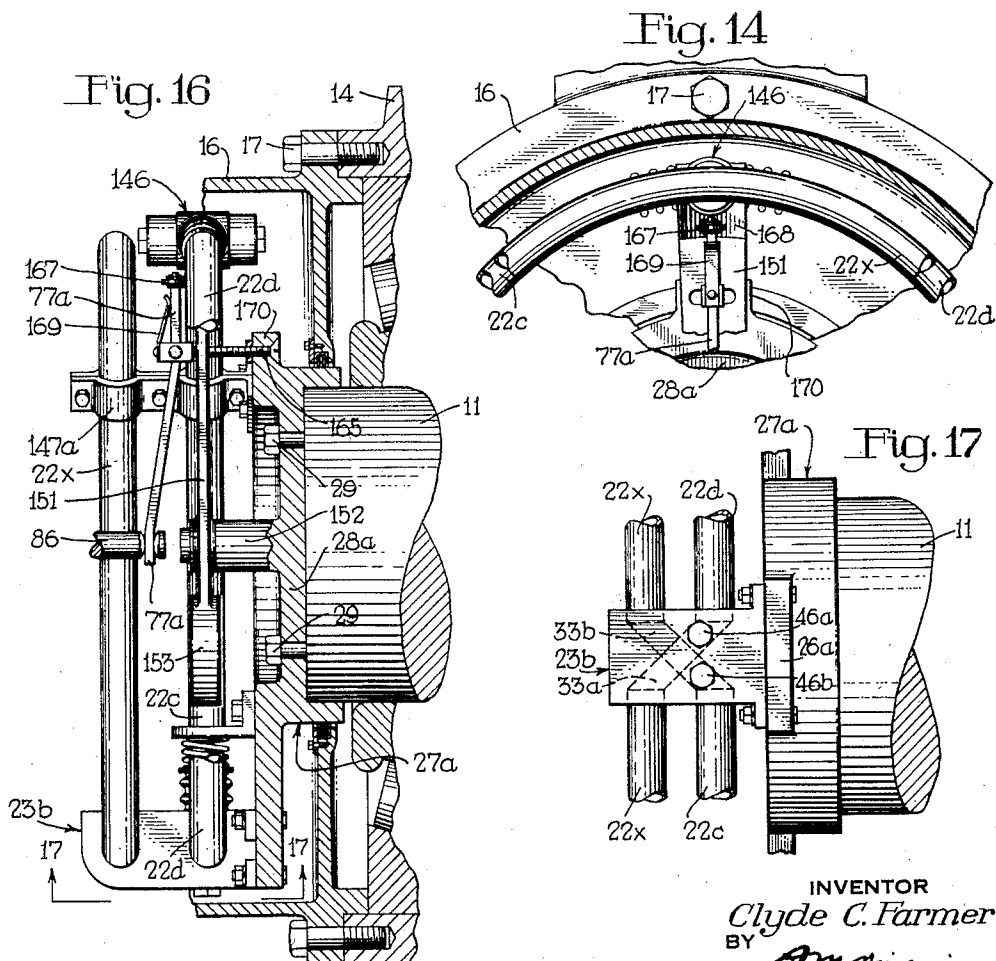
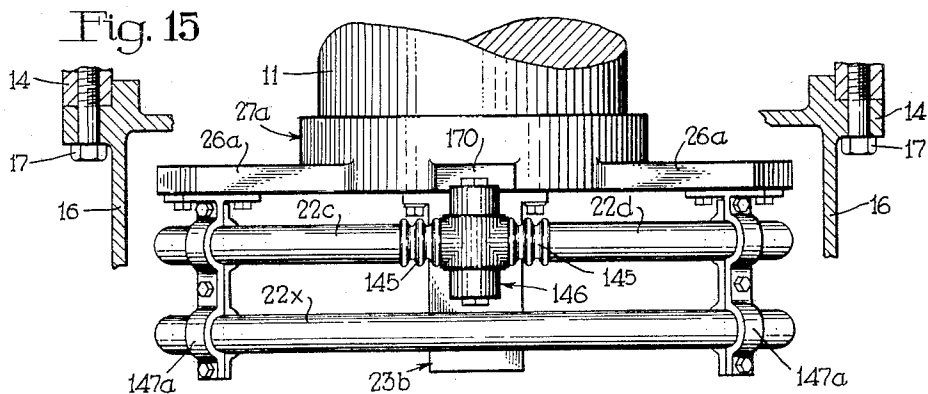
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FLUID TYPE INERTIA DEVICE

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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

2,322,003

FLUID TYPE INERTIA DEVICE

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Application August 29, 1942, Serial No. 456,688

28 Claims. (Cl. 264—1)

This invention relates to fluid type inertia devices for detecting the rate of change of speed of a rotary element, such as a railway car wheel or wheel and axle assembly, for a desired indicating or control purpose.

In Patent 2,225,716 to Everett P. Sexton there is disclosed and claimed a fluid type inertia device illustratively applied to the end of a railway car wheel axle and operative in response to the slipping condition of the wheels to cause a rapid release of the brakes associated with the wheels, whereby to cause a restoration of the slipping wheels back to a speed corresponding to car speed before the wheels decelerate to a locked condition and slide.

In the present application, the term "slipping condition" as applied to a car wheel refers to the rotation of the wheel at a speed either less or greater than a speed corresponding to car speed at a given instant, due to the application of excessive braking or propulsion torque, respectively, sufficient to exceed the limit of adhesion between the wheels and the rail. As is well known, when the brakes are applied to a vehicle wheel to a degree sufficient to exceed the limit of adhesion between the wheel and the rail, the wheel decelerates at an abnormally rapid rate far in excess of the maximum normal rate, which is of the order of three to four miles per hour per second. The rotative deceleration of a vehicle wheel at a rate exceeding a certain rate in excess of the normal rate is thus positive indication of a slipping condition of the wheel.

The fluid inertia device shown in the Sexton patent detects the slipping condition of a vehicle wheel due to excessive braking by registering the rate of rotative deceleration of the car wheel at a rate exceeding seven miles per hour.

The term "sliding condition," as employed herein in connection with a car wheel, refers to the dragging of the car wheel along the rail in a locked or non-rotative condition. The sliding of a car wheel produces flat spots on the wheel which is objectionable because this necessitates repair or replacement of the wheel.

Essentially, the device disclosed in the Sexton patent comprises a member, such as a pipe, forming an annular passage and so mounted on the end of a car wheel axle that the annular passage rotates in coaxial relation to the axis of rotation of the axle. The annular passage is provided with two adjacent abutments in the form of "Sylphons" or metallic bellows and the passage is filled with a liquid of relative heavy specific gravity, such as mercury. Interposed between

the outer closed ends of the "Sylphons" is a follower which actuates a contact or switch lever pivoted on the passage member or an equivalent member rotated with the axle.

Whenever the axle accelerates or decelerates, the inertia force or force of momentum of the annular body of mercury is exerted on the closed end of one or the other of the "Sylphons," causing pivotal movement of a switch lever to close one or more switches dependent upon the degree of displacement of the switch lever out of its normal centered position.

The "Sylphons" in the Sexton device are subject to severe shocks and jars transmitted thereto from the car axle during travel of the car. Moreover at high rotational speeds of the axle the "Sylphons" are also subject to high stress due to high centrifugal forces of the mercury. These "Sylphons" must, therefore, be mechanically strong enough to withstand the stresses exerted thereon and at the same time flexible enough to permit the expansion and contraction thereof in response to the inertia forces of the mercury.

It is accordingly an object of my present invention to provide a fluid type inertia device, of the type shown in the Sexton patent, characterized by a novel arrangement for supporting the "Sylphons" in a manner to reduce the possibility of mechanical failure of the "Sylphons" due to stresses exerted thereon by centrifugal force of the mercury or by shocks and jars on the axle.

It is a further object of my invention to provide a fluid type inertia device which avoids the difficulties inherent in the use of the "Sylphons" in a fluid type inertia device, such as that shown in the Sexton patent, by providing a construction which does not employ "Sylphons."

In the fluid type inertia device shown in the Sexton patent the degree of relative rotational movement of the annular body of mercury with respect to the casing forming the annular chamber in which the mercury is contained is limited to the degree of expansion and contraction of the "Sylphons." When the annular body of mercury is suddenly stopped in its tendency to overrun the casing due to the rotative deceleration of the axle-driven casing at a high rate, there may be a tendency for the pressure exerted on the "Sylphons" to pulsate thereby causing a vibratory movement of the switch lever and a possible consequent fluttering of the switches between open and closed positions.

It is accordingly a further object of my invention to provide a fluid type inertia device comprising an arrangement for permitting the an-

nular body of mercury to continue rotation at a certain limited rate of change of speed, either acceleration or deceleration, whenever the shaft or axle changes its speed at exceptionally high rates, in order to enable the continued application of an inertia force to a switch lever to maintain it positively in a closed position until such time as the rotational speeds of the annular mercury column and the rotational speed of the axle or shaft are again synchronized.

In the control of the brakes to prevent sliding of the wheels, it is essential that the reduction of brake cylinder pressure be maintained after the wheel begins to slip in order to insure the return of the wheel to a speed corresponding to car speed without decelerating to a locked condition. It is thus imperative to maintain a control switch of a fluid type inertia device positively in its closed position in order to insure the continued reduction of brake cylinder pressure. My improved fluid type inertia device is operative to initiate a reduction of brake cylinder pressure whenever slipping of the car wheel is initiated and inherently causes such reduction of brake cylinder pressure to be positively continued during the slipping cycle until the slipping wheel has been restored substantially to car speed.

The above objects, and other objects of my invention, which will be made apparent herein-after, are attained by several embodiments of my invention subsequently to be described and shown in the accompanying drawings, wherein

Fig. 1 is a diagrammatic view showing one embodiment of a fluid type inertia device as applied to the end of a car wheel axle and functioning in a fluid pressure brake control system to control the brakes associated with the car wheel in a manner to prevent sliding thereof,

Fig. 2 is an enlarged sectional view showing, in detail, the construction of a centering spring mechanism for the switch operating lever shown in Fig. 1,

Fig. 3 is a sectional view, taken on the line 3—3 of Fig. 1, showing further details of construction of the device shown in Fig. 1,

Fig. 4 and Fig. 5 are enlarged views, showing separated and assembled relation of parts respectively of the mechanism for transmitting the inertia forces of the annular mercury column to a switch lever.

Fig. 6 is a view, taken on the line 6—6 of Fig. 4, showing further details of the parts shown in Fig. 4,

Fig. 7 is a fragmental sectional view, taken on the line 7—7 of Fig. 5, showing details of construction of the diaphragm follower of Fig. 5,

Fig. 8 is a sectional view of a second embodiment of my invention,

Fig. 9 is a fragmental sectional view taken substantially on the line 9—9 of Fig. 8,

Fig. 10 is an enlarged sectional view, taken on the line 10—10 of Fig. 8,

Fig. 11 is an enlarged fragmental view showing a modification of the embodiment shown in Fig. 8,

Fig. 12 is a fragmental side view partly in section taken substantially on the line 12—12 of Fig. 11, with the end of the tubular member removed for clarity.

Fig. 13 is an enlarged sectional view, taken on the line 13—13 of Fig. 11,

Fig. 14 is a fragmental view showing a second modification of the embodiment shown in Fig. 8,

Fig. 15 is a fragmental plan view of the modification shown in Fig. 14,

Fig. 16 is a fragmental side elevational view

of the embodiment shown in Figs. 14 and 15, and Fig. 17 is a fragmental view taken on the line 17—17 of Fig. 16.

Description of embodiment shown in Figures 1 to 7

Referring to Fig. 1, the embodiment of my fluid type inertia device shown is illustrated as associated with the axle 11 of a car wheel 12, the axle being rotatably supported in the usual manner, as by roller bearings 13, in a journal casing 14. The pedestal jaws 15 of the side frame of a railway car truck engage in the usual side grooves in the journal casing for limited vertical movement relative thereto.

Substituted for the usual end cover secured to the outer open end of the journal casing 14 is a casing member 16, screws 17 being provided for securing the casing member 16 to the journal casing 14 in the same manner as the usual end cover. The outer open end of the casing member 16 is closed by an end cover 18 that is secured to the rim of the casing member 16 as by a plurality of screws 19. The casing member 16 and the end cover 18 accordingly provide a chamber 21 within which the fluid type inertia device comprising my invention is contained.

The fluid type inertia device comprises two semi-circular tubular members or pipes 22a and 22b, preferably of circular cross-section, disposed in complementary circular form with the adjacent lower ends secured, as by welding, in a lower supporting bracket 23 and with the adjacent upper ends secured, as by welding, a diaphragm casing member 24. The bracket member 23 and the diaphragm casing member 24 are provided with suitable flanges that are secured, as by a plurality of bolts 25 to corresponding ones of two oppositely extending arms 26 of supporting spider member 27. Spider member 27 has a central circular hub portion 28 which is secured to the outer end of the axle 11 as by a plurality of screws 29. The hub portion 28 has a bore 31 in which the outer end of axle 11 fits closely, thereby accurately positioning the spider member 27 in coaxial alignment with the axle and at the same time reducing the shearing stresses on the screws 29.

Casing 16 has an annular flange 16a, in the central opening of which is secured an oil retainer ring 20 that surrounds the hub portion 28 of member 27 to prevent oil from the axle journal entering chamber 21.

The disposition of the tubular members 22a and 22b is such as to form an annular passage rotatable coaxially to the axle 11, that is, with the center of curvature of the annular passage in coincidence with and intersected by the axis of rotation of the axle 11.

A through passage or bore 33, having a cross-section corresponding to that of the tubular members 22a and 22b, is provided in bracket 23. The adjacent lower ends of the tubular members fit tightly in the opposite open ends of the passage 33 and are welded to the bracket member 23.

In order to provide a means for filling the tubes 22a and 22b with mercury or other suitable liquid of high specific gravity, the bracket member 23 has a threaded port opening out of the passage 33, a screw plug 46 being provided for closing the port after filling the tubes.

Due to the fact that the coefficient of thermal expansion of mercury is relatively high compared to the thermal coefficient of expansion of steel, nickel, or other metal of which the tubular members 22a and 22b may be made, it is necessary

to provide means for enabling the tubes to remain filled at all times and yet prevent the bursting of the tubes and the consequent loss of the mercury due to increase of ambient temperature. This is especially necessary where the device is subject to large variations in ambient temperature, as in railway service, where the climatic temperature may vary from sub-zero (Fahrenheit) to temperatures of one-hundred degrees or more. Accordingly, I provide an expansible and contractable chamber, in the form of a flexible bellows or "Sylphon" 34, one end of which is attached as by welding to the bracket member 23 and the other end of which is closed by a disk 36 welded thereto, the interior of the "Sylphon" being connected to the passage 33 through a port 37.

A loading spring 38 is interposed between the disk 36 on the end of the "Sylphon" and one leg of an angle bracket 39 that is adjustably secured, as by a screw 42, to the adjacent arm 26 of the spider member 27. The arm 26 and the leg of the bracket 39 are provided with cooperating serrated surfaces 41 for locking the bracket in a fixed position to which adjusted. The loading spring is so designed and adjusted as to permit the expansion of the "Sylphon" 34 in response to thermal expansion of the mercury and at the same time prevent the expansion of the "Sylphon" in response to inertia or momentum forces of the mercury.

The diaphragm casing member 24 comprises two complementary parts or casing members 24a and 24b, generally similar in appearance to the cooperating parts of hose couplings of fluid pressure brake apparatus on railway cars. The two casing members are substantially identical, the member 24a differing from the member 24b in having integrally formed flanges whereby to secure the casing member 24a to the arm 26 of the spider member 27.

Referring particularly to Figs. 4 and 5, each casing member has an end portion into which the corresponding end of the tubular member 22a or 22b is received and suitably secured as by brazing or welding. Formed within each of the members 24a and 24b is a passage 48 opening at one end into the tubular member 22a or 22b and terminating at the opposite end within an annular rib seat 49 at the contact face of the member, on which seat a by-pass check valve 51 carried by the other member is adapted to seat.

The two casing members 24a and 24b are provided with suitable cooperating lugs 52 having holes 53 that register when the two members are fitted together. Suitable securing bolts 54 extending through the holes in the lugs 52 hold the two members together.

Formed in the contact face of each of casing members 24a and 24b and surrounding the annular rib 49 is a suitable annular aligning groove 55 for receiving a cooperating annular aligning rib 56 on the cooperating contact face of the complementary member 24a or 24b.

Concentrically surrounding the annular aligning rib 56 on each of the members 24a and 24b is an annular sealing rib 57 which engages the smooth contact face of the complementary member when the two members are clamped together.

The location of the lugs 52 is such as to cause the bolts 54 to exert a clamping force on diametrically opposite sides of the sealing rib 57 and closely adjacent thereto whereby to insure a tight metal-to-metal seal at the contact faces of the members 24a and 24b.

Each by-pass check valve 51 is urged into seated relation on the annular rib seat 49 of the complementary member 24a or 24b by a coil type loading spring 58 which is interposed between the valve 51 and the inner end of an adjusting screw 59. Each valve 51 has a stem 61 that is slidably supported in a bore 62 in the end of the corresponding adjusting screw 59.

Each adjusting screw 59 extends to the exterior of the corresponding member 24a or 24b and is provided with a suitable lock nut 63 and cap nut 64. The cap nut seals on an annular sealing face formed on the outer surface of the casing member to guard against the possibility of leakage of mercury along the adjusting screw 59.

It will be apparent from Fig. 5 that the relation of the by-pass check valves 51 and the passages 48 in the two members 24a and 24b is such that when the check valves are unseated, mercury is permitted to flow from the passage 48 in one of the members 24a or 24b to the passage 48 in the other member, thereby also providing communication from the upper end of one of the tubular members 22a or 22b to the corresponding end of the other tubular member. It will at the same time be apparent that the check valve 51 carried by the member 24a is unseated only to permit the flow of mercury circularly in the tubes 22a and 22b in one direction whereas the check valve 51 carried by the member 24b is unseated only to permit the circular flow of mercury in the tubes 22a and 22b in the opposite direction.

The portion of the casing member between the two contact faces of the members 24a and 24b is formed to provide a circular bore 66 when the two members are in assembled relation. Each of the members 24a and 24b is provided with a circular flexible diaphragm 67 having a peripheral ring of metal which is in turn welded to the casing member 24a or 24b at the base of the bore 66. The diaphragms 67, which may be of suitable rubber material or of suitable thin sheet metal, are dish-shaped and the flat portions of the diaphragm are held against an annular rib 68 surrounding a relatively large passage or bore 69 opening out of the passage 48 of the corresponding member 24a or 24b. The diaphragms 67 are accordingly subject to the pressure of the mercury in the passages 48 transmitted to the inner face of the diaphragms through the passages 69.

The manner in which the diaphragms 67 are secured to the casing members 24a and 24b in engagement with the annular rib 68 is such as to prevent sharp bends in the diaphragm and thus to minimize the bending stresses due to flexure of the diaphragm.

In view of the fact that mercury has a corrosive effect on certain materials or metals, it will be understood that all of the various elements, thus far described or hereinafter to be described, with which the mercury comes in contact must be of a material not corroded by mercury. Thus, various metals such as steel, nickel, or alloys thereof are not corroded by mercury. Certain plastics or molded materials such as "Bakelite," "Micarta" or rubber are likewise not corroded by mercury.

Conforming closely to the diameter of the bore 66 and slidably shiftable therein is a diaphragm follower 71 of sufficient width to conform closely to the normal spacing between the diaphragms 67 so as to be shiftable in opposite directions in

the bore 66 in response to pressures exerted on the diaphragms in opposite directions.

The diaphragm follower 71 is preferably of a molded material, such as "Bakelite" or "Micarta" and is formed preferably in two complementary sections secured together in abutting relation by means of a plurality of rivets 73.

Formed concentrically to the axis of the follower 71 on the inside face of each of the complementary portions is a circular boss 74 in which a suitable metallic member 75 is embedded for providing an outer metallic contact face for the boss. The two bosses 74 of the complementary portions of the follower 71 extend toward each other and the ends thereof are normally spaced apart a certain distance for receiving therebetween the curve-sided contact head 76 of a switch operating arm or lever 77.

The periphery of the follower 71 has a suitable opening 78 which is in radial alignment with a corresponding opening 79 (see Figs. 4 and 6) formed at the inner side of the two members 24a and 24b when the members are in assembled relation. Formed at the edge of the opening 79 on each of the members 24a and 24b is a pivot lug 81, the two lugs being aligned when the two members 24a and 24b are assembled and having aligned holes 82 for receiving a pivot pin 83 on which the switch lever 77 is pivoted. The portion of the switch lever 77 on one side of the pivot pin 83 extends radially outward through the opening 79 in casing members 24a and 24b and the opening 78 in the follower 71 and has the contact head 76 secured or formed at the end thereof. The portion of the switch lever 77 at the opposite side of the pivot pin 83 extends radially inward and is provided with a forked end which straddles a switch operating plunger 86 between two shoulders formed by a portion of reduced diameter on the plunger. (See Fig. 1.)

Associated with the switch lever 77 at a point between the pivot pin 83 and the plunger 86 are two centering spring devices 87 (Fig. 1), adjustably secured as by screws 88 to a bracket 89 that is in turn secured as by screws 91 to the adjacent arm 26 of the spider member 27.

As shown in Fig. 2, each of the centering spring devices 87 comprises a small cylinder 92 having an opening 93 at one end through which a contact member 94 extends. The contact member 94 has a peripheral flange which engages an inwardly extending flange on the end of the cylinder 92 to limit the outward movement of the contact member 94. A loading spring 95 of the coil type is contained in the cylinder 92 in interposed relation between the contact member 94 and an adjusting screw 96. Screw 96 is locked, as by a lock nut 97, in a threaded opening provided in a cap screw 98 closing the end of the cylinder 92 opposite the opening 93.

Referring to Fig. 1, it will be seen that one of the devices 87 is secured to the bracket 89 on one side of the switch lever 77 and the other of the two devices 87 is secured to the bracket 89 on the opposite side of the switch lever 77.

The cylinders 92 are adjustably secured to the bracket by means of the screws 88 so that the contact members 94 just engage opposite faces of the switch lever 77. The switch lever 77 is thus yieldingly held in a normal centered position determining the normal position of the switch operating plunger 86. The tension of the loading springs 95 may be adjusted by means of the screws 96 to provide any desired resistance to

movement of the switch lever 77 out of its centered position and a corresponding force effective to restore the switch lever 77 to its centered position. When employed to control the brakes associated with car wheels, the centering springs are so adjusted as to prevent sufficient pivotal movement of switch lever 77 out of its centered position to operate switch contacts, presently described, unless the rate of acceleration or deceleration of the axle 11 exceeds a slipping rate.

The switch operating plunger 86 is slidably supported in a central boss 99 on the end cover 18 and in a cup-shaped collar 101 attached, as by screws 102, to the inner face of the end cover 18 in coaxial alignment with the axis of rotation of the axle 11. The length of the switch lever 77 is such that the forked end thereof remains in cooperating engagement with the plunger 86 as the axle 11 and spider member 27 rotate so as to be constantly effective to slidably move the plunger 86 in opposite axial directions depending upon the direction in which the switch lever 77 is pivoted on the pivot pin 83.

An annular packing or oil retainer ring 103 may be provided in the collar 101 for preventing oil from the axle journal that may possibly enter the chamber 21 within the casing 16 from traveling along the plunger 86 to the exterior of the end cover 18 and thereby contaminating the switch contacts mounted on the outer face of the end cover 18 in the manner presently to be described.

For a reason which will be presently explained, it is desirable to prevent the rotary movement of the switch plunger 86. A pin 104 fitted diametrically in the plunger 86 and engaging at its opposite ends in two spaced slots 105 formed on the collar 101 serves to prevent the rotation of the plunger 86.

The plunger 86 is provided with a rounded tip 86a, of insulating material, which tip engages a flexible contact finger 106. The flexible contact finger 106 is embedded in a suitable insulating base 107 having a securing bolt 108 embedded therein and provided with a suitable nut 109 and lock nut 110 for securing the base 107 to a projecting lug 111 on the outer face of the end cover 18 at one side of the plunger 86. The lug 111 is provided with a groove 112 having tapered sides for receiving a cooperating tongue formed on the insulating base 107 whereby to aid in fixing the position of the flexible contact member 106 while permitting axial adjustment of the position thereof. A slot 113 is provided in the lug 111 for permitting the movement of the securing bolt 108 with the base 107.

Two relatively short contact fingers 115 and 116 respectively are carried by insulating bases 107 having securing bolts 108 for attaching the contact fingers to a projecting lug 118 on the diametrically opposite side of the plunger 86 relative to the lug 111. The lug 118 is provided with a groove having tapered sides for receiving a correspondingly tapered tongue on the bases 107 of the contact fingers 115 and 116, as well as a slot 113 through which the securing bolts 108 extend. The tongue and groove relation of the lug 118 and bases 107 enables axial adjustment and alignment of the contact fingers 115 and 116 and provides support for the bases additional to the bolts 108.

The two contact fingers 115 and 116 are secured in spaced relation to each other in such manner that the tip end of the contact finger 106 is substantially midway therebetween.

The flexible contact finger 106 has an inherent

initial bias in the direction of the contact finger 116 but is flexed or bent to a normal position midway between the two contact fingers 115 and 116 in the normal position of the plunger 86.

The plunger 86 is restrained from rotation by the pin 104 in order to prevent the wear of the tip end of plunger and the flexible contact finger 106 at the point of contact thereof, which would result if the plunger were permitted to rotate.

If the plunger 86 shifts in the left-hand direction a sufficient amount in response to the pivotal movement of the switch lever 77, the tip end of the flexible contact finger 106 engages contact finger 115. If the plunger 86 is shifted axially inwardly toward the axle a sufficient amount, the inherent bias in the flexible contact finger 106 causes it to follow the plunger 86 until it engages the contact finger 116. It will thus be seen that upon movement of the plunger 86 a sufficient amount axially in either direction, the contact finger 106 engages either the contact finger 115 or the contact finger 116.

While I have shown the contact fingers 106, 115 and 116 as extending vertically, it will be apparent that they may be positioned horizontally if desired.

A cover member 121 of relatively light-weight sheet metal is attached as by screws 122 to the outer face of the end cover 18 to enclose the switch contact fingers 106, 115, and 116.

A lead wire 123 having suitable insulation is soldered or otherwise suitably secured to the base end of the flexible contact finger 106 and extends through a suitable insulated opening in the cover 121 to the exterior thereof.

The two contact fingers 115 and 116 are connected to a common wire 124 having suitable insulation and extending through the opening in the cover 121 to the exterior thereof.

The wires 123 and 124 may lead to any desired control circuit. As shown, the wires 123 and 124 constitute a part of a control circuit for a magnet valve device 125 controlling the release of fluid under pressure from a brake cylinder 126 for operating the usual brakes associated with the car wheel 12.

For simplicity, a simple brake control apparatus of the straight-air type is shown in Fig. 1 for the purpose of illustrating the manner in which the magnet valve device 125 controls the pressure of the fluid in the brake cylinder 126. It will be understood, however, that the magnet valve 125 and the fluid pressure brake control apparatus shown and presently to be described is merely illustrative of conventional equipment or any suitable brake control equipment employed.

As shown, the brake control apparatus comprises a control pipe 127 which is normally vented to atmosphere and which is charged with fluid at a different pressure from a reservoir 128 by means of a suitable brake valve 129 of the well-known self-lapping type. With the brake valve handle 129a in its brake release position, the control pipe 127 is vented to atmosphere through an exhaust port and pipe 131 at the brake valve. When the brake valve handle 129a is displaced into its application zone, the pressure established in the pipe 127 is substantially proportional to the degree of displacement of the brake valve handle 129a out of its brake release position. The brake valve 129 has, moreover, a pressure-maintaining characteristic so that if the pressure in the pipe 127 tends to reduce for any reason, such as leakage, fluid under pressure is automatically supplied to the pipe 127 to main-

tain a pressure therein corresponding to the position of the brake valve handle 129a.

The brake cylinder 126 is connected to the control pipe 127 through a branch pipe 132 in which the magnet valve 125 is interposed. The magnet valve 125 is of a standard type having a double-beat valve 133 which is normally urged to an upper seated position by a coil spring 134 and actuated to a lower seated position in response to energization of the magnet winding 135 of the magnet valve.

In its upper seated position, communication through the branch pipe 132 from the control pipe 127 to the brake cylinder 126 is established. Thus, the pressure of the fluid in the brake cylinder corresponds to the pressure in the control pipe 127 as long as the magnet winding 135 of the magnet valve remains deenergized.

In its lower seated position, the valve 133 of the magnet valve 125 closes communication through the branch pipe 132 and establishes a venting communication through which fluid under pressure is rapidly released from the brake cylinders through an exhaust port 136. Thus, when the magnet winding 135 is energized, fluid under pressure is vented from the brake cylinder 126.

A pressure operated switch 137 is connected to the control pipe 127 and is of any suitable snap-acting type responsive to variations of the pressure in the pipe and below a certain critical pressure, such as five pounds per square inch. The contacts of the switch 137 are in their open position when the pressure in the pipe 127 reduces below five pounds per square inch and are actuated to their closed position whenever and so long as the pressure in the pipe 127 exceeds five pounds per square inch.

The lead wire 124 is connected to one terminal of the magnet winding 135 of the magnet valve with the contacts of the pressure switch 137 interposed in series relation therein. The lead wire 123 is connected to the opposite terminal of the magnet winding 135 of the magnet valve with a suitable source of direct current, such as a storage battery 138, included in series relation therein. It will thus be seen that, assuming the pressure switch 137 to be closed, the engagement of the contact finger 106 with either of the contact fingers 115 or 116 completes the circuit for causing energization of the magnet winding 135 of the magnet valve 125.

Operation of embodiment shown in Figs. 1 to 7

Let it be assumed that a railway car having the wheel and axle assembly shown in Fig. 1 is traveling under power and that the operator desires to apply the brakes to bring the car to a stop. In such case, the operator first shuts off the propulsion power and then operates the brake valve handle 129a into its application zone a desired distance to cause fluid under pressure to be supplied to the brake cylinder 126, in the manner previously described, to effect application of the brakes on the wheel 12.

It will be understood that while I have shown only one wheel and axle unit and specific brake control equipment therefor, each wheel and axle assembly on the car is provided with a fluid type inertia device similar to that shown in Fig. 1 and that the operation of the brake valve 129 controls the application and release of the brakes on all of the wheel and axle assemblies of the car or the train.

Let it be further assumed that when the

brakes are applied on the wheel 12 shown in Fig. 1, the wheel begins to slip. For purposes of illustration, let it be assumed also that the axle 11 is rotating in a clockwise direction as seen in Fig. 3. It will thus be apparent that, due to the rotative deceleration of the axle 11, the mercury in the tubes 22a and 22b acts as a fluid fly wheel tending to rotate at an undiminished speed since the friction of the mercury within the tubes is relatively negligible. The momentum or the force of inertia of the annular column of mercury accordingly causes a pressure to be exerted on the diaphragm 67 secured in the casing member 24a, which pressure is effective to rock the switch lever 77 on the pivot pin 83 in a counterclockwise direction as seen in Fig. 1. In this connection it will be noted that the centrifugal forces of the mercury on the two diaphragms 67 are equal and opposite, thereby rendering the follower 71 and switch lever 77 movable without opposition by centrifugal forces.

As long as the rate of rotative deceleration of the axle is less than a certain rate, such as six miles per hour per second, the momentum force exerted by the mercury on the diaphragm 67 is insufficient to cause enough displacement of the switch lever 77 and consequent inward shifting of the switch plunger 86 to cause engagement of the flexible contact finger 106 with the contact finger 116. However, when the wheel 12 fixed to the axle 11 begins to slip, the axle rotatively decelerates at a rate far in excess of six miles per hour per second. In such case, therefore, the force of momentum exerted by the mercury in the passage 48 of casing member 24a on the diaphragm 67 causes sufficient outward flexing of the diaphragm to cause the flexible contact finger 106 to engage the contact finger 116.

The engagement of the contact fingers 106 and 116 accordingly completes the circuit for energizing the magnet winding 135 of the magnet valve 125 which accordingly operates to cause a rapid reduction of the pressure in the brake cylinder 126.

The loading springs 58 for the by-pass check valves 51 are so designed and are so adjusted by the adjusting screws 59 as to maintain the check valves seated unless the force of momentum of the mercury acting on the diaphragms 67 is sufficient to cause engagement of the contact finger 106 with the contact finger 116 (or with the contact finger 115).

Assuming that the engagement of the contact finger 106 with the contact finger 116 or 115 is effected in response to the rotative deceleration of the axle at a rate between five and six miles per hour per second, the check valves 51 are thus unseated in response to a somewhat higher rate of rotative deceleration of the wheels and axle of approximately six miles per hour per second.

Thus, substantially at the time that the contact finger 106 engages the contact finger 116, the particular one of the check valves 51 effective for the direction of rotation of the annular mercury column is unseated, thereby permitting the mercury to flow therepast into the passage 48 of the casing member 24b and thence into the tube member 22b. The degree to which the check valve 51 is unseated is substantially proportional to the pressure exerted by the mercury. Accordingly, the check valve 51 automatically regulates the flow of mercury therepast so as to regulate the rate of rotative

deceleration of the annular mercury column to a rate of approximately six miles per hour per second, this rate of rotative deceleration of the annular mercury column being sufficient to maintain adequate pressure by the mercury on the diaphragm 67 to insure the continued displacement of the diaphragm 67 and consequent engagement of the switch contact fingers 106 and 116.

The wheels and axle, it will be understood, rotatively decelerate at a rate which may attain, at times, a rate as high as one hundred (100) miles per hour per second, but due to the automatic regulation of the braking effect on the rotating annular mercury column exerted by the effective check valve 51, the annular mercury column continues to rotate at a speed higher than the rotational speed of the wheel and axle 11. When the degree of application of brakes associated with the wheel 12 and axle 11 is sufficiently reduced in response to the energization of the magnet winding of the magnet valve 125, the wheel promptly ceases to decelerate and begins to accelerate back toward a speed corresponding to car speed at an abnormally rapid rate of the same order of magnitude as the slipping rate of deceleration of the wheel. However, due to the fact that the annular mercury column is rotating at an instantaneously higher speed than the wheels and axle, although it is being decelerated at a substantially uniform rate of six miles per hour per second, the force of momentum of the mercury column on the diaphragm is maintained and consequently the switch lever 77 remains displaced so as to cause the contact fingers 106 and 116 to remain engaged not merely during deceleration of the wheel at a rate exceeding six miles per hour per second but also during the acceleration of the slipping wheel back toward a speed corresponding to car speed.

When the slipping wheel and axle are restored in speed substantially to the rotational speed of the annular mercury column, the force of momentum of the mercury acting on the diaphragm 67 and check valve 51 is reduced substantially to zero because instantaneously no braking effect is exerted on the annular mercury column.

The diaphragm follower 71 and switch lever 77 are thus restored to their normal centered position partly because of the resiliency of the diaphragms 67 and partly because of the action of the centering spring device 87 previously yieldingly compressed in response to the displacement of the switch lever 77. As previously explained, the centrifugal forces of the mercury acting on the two diaphragms 67 are balanced and therefore centrifugal force does not interfere with the restoration of the follower 71 to its normal centered position.

Due to the fact that the annular mercury column has decelerated at a higher rate (six miles per hour per second) than the normal rate of retardation of the car (maximum three miles per hour per second), the annular mercury column is instantaneously rotating at a speed less than the actual speed of rotation corresponding to the speed of the car at the time that the slipping wheel and axle are restored to the speed of the annular mercury column. If, therefore, the axle and wheel continue to accelerate at a rate exceeding approximately six miles per hour per second sufficient to cause unseating of the check valve 51 opposite to that unseated during the deceleration of the axle, such check

valve may be momentarily unseated and the switch lever correspondingly shifted in the opposite direction momentarily. This momentary displacement of the switch lever at this time may result in the momentary engagement of the contact finger 106 with the contact finger 115. However, due to the fact that the annular mercury column is almost instantaneously accelerated to the speed of the wheel and axle the switch lever 77 is promptly restored to its normal centered position.

For all practical purposes, therefore, it may be said that in its operation, my fluid type inertia device initiates operation of the switch contacts to their closed position whenever the rate of rotative deceleration of the wheel and axle exceeds a certain rate, which may be taken as a rate occurring only when the slipping of the wheel and axle occurs, and positively maintains the switch contacts in their closed positions thereafter inherently and automatically until such time as the slipping wheels and axle are restored substantially to a rotational speed corresponding to the car speed. The possible momentary operation of the switch contact to a closed position at the conclusion of the slipping cycle may for practical purposes be neglected since it occurs in a minute interval of time of the order of a tenth of a second.

The restoration of the switch lever 77 to its normal centered position in the manner previously described and the consequent disengagement of the contact finger 106 from the contact finger 116 interrupts the circuit for energizing the magnet winding of the magnet valve device 125. The reduction of the pressure in the brake cylinder 126 is thus terminated and the resupply of fluid under pressure thereto effected in response to the restoration of the magnet valve device 125 to its normal condition.

It is desirable not to reapply the brakes on a slipping wheel until it has been fully restored to a speed corresponding to car speed. This is so because if the degree of application of the brakes is increased sufficiently while a slipping wheel is rotating at a relatively low speed, the wheel may become locked and therefore slide. My fluid type inertia device accordingly functions inherently to hold off or inhibit the reapplication of the brakes on a slipping wheel until it has been restored substantially to a speed corresponding to car speed, thereby eliminating automatically the possibility of sliding of the wheels due to a premature reapplication of the brakes.

Should the wheel 12 again begin to slip upon reapplication of the brakes caused by the resupply of fluid under pressure to the brake cylinder 126, the inertia device again functions to cause operation of the magnet valve device 125 to again reduce the pressure in the brake cylinder 126, thereby causing the slipping wheel to again be restored to a speed corresponding to car speed. Thus, at no time during a brake application are the wheels permitted to become locked and slide.

When the car comes to a complete stop in response to the application of the brakes, the switch lever 77 is always restored to its normal centered position because of the complete dissipation of any inertia forces on the annular mercury column in the tubes 22a and 22b. Accordingly, the magnet winding of the magnet valve 125 is always deenergized when the car comes to a stop. It is thus possible for the operator to cause variation of the pressure in the brake

cylinder 123 to any desired degree, to hold the car on any grade encountered in service, when the car stops completely.

If the operator desires to again start the car, he may do so after first restoring the brake valve handle 129a to its brake release position, thereby causing fluid under pressure to be vented from the brake cylinder 126 and control pipe 127 to atmosphere. When the pressure in the control pipe 127 reduces below five pounds per square inch, the pressure switch 137 is restored to its open position, thereby preventing possible energization of the magnet winding 135 of the magnet valve device 125 should the wheel 12 accelerate too rapidly in response to the application of propulsion torque thereto.

While I have not indicated or shown any equipment for applying propulsion directly to the axle 11, it is assumed that such may be the case. Accordingly, if the propulsion torque applied to the axle 11 is sufficient to exceed the limit of adhesion between the wheel and the rail on which it rolls, the inertia device will respond in a manner similar to that occurring during deceleration of the axle 11.

In the case of the rotative acceleration of the axle 11, however, assuming the same direction of rotation as in the previous instance, the inertia force of the annular mercury column in the tubes 22a and 22b is now active on the diaphragm 67 in the casing member 24b because the column tends to lag behind the axle 11. In such case, therefore, the switch lever 77 is rocked on its pivot pin 83 in a clockwise direction, as seen in Fig. 1, thereby causing outward movement of the plunger 86 to cause the contact finger 106 to engage the contact finger 115.

With the pressure switch 137 in open position, however, energization of the magnet winding of the magnet valve 125 cannot be effected, thereby preventing the unnecessary consumption of current from the storage battery 138.

Let it now be assumed that the operator reverses the propulsion motors or that the car is so connected in a train that the wheel 12 and axle 11 rotate in the opposite direction to that previously assumed, that is, in a counterclockwise direction as seen in Fig. 3.

If, upon application of the brakes in such case, the wheel 12 begins to slip, it will be apparent that the momentum force of the fluid fly wheel or annular mercury column is now exerted on the diaphragm 67 in the casing member 24b, just as in the case of the acceleration of the axle 11 when rotating in clockwise direction. The switch lever 77 is accordingly shifted pivotally on its pin 83 so as to cause outward movement of the plunger 86 and engagement of the contact finger 106 with the contact finger 115. With the pressure switch 137 in its closed position, due to the fact that the pressure is established in the control pipe 127 during a brake application, the magnet winding of the magnet valve 125 is thus again energized to effect a reduction of the pressure in the brake cylinder 126.

In this case, the by-pass check valve 51 at the end of passage 48 in the casing member 24b is unseated, following the engagement of the contact finger 106 with the contact finger 115, to permit the continuous rotation or circular movement of the mercury in the tubes 22a and 22b at a speed reducing at the rate of approximately six miles per hour per second.

Switch lever 77 is accordingly maintained displaced in a clockwise direction so as to maintain

the contact finger 106 in engagement with the contact 115 until such time as the slipping wheels are restored substantially to a rotational speed corresponding to the rotational speed of the annular mercury column.

After the wheels are restored substantially to car speed, therefore, the switch lever 77 is correspondingly restored to its normal centered position, thereby causing restoration of the contact finger 106 to its centered position disengaging the contact finger 115. The magnet winding of the magnet valve 125 is thus deenergized, thereby terminating the reduction of the pressure in the brake cylinder and initiating the resupply of fluid under pressure thereto to effect the reapplication of the brakes on the wheels.

It will thus be seen that my fluid type inertia device functions automatically for either direction of rotation of the wheels and wheel axle 11.

Embodiment shown in Figures 8, 9, and 10

Referring to Figs. 8, 9, and 10, another embodiment of my invention is shown which differs somewhat from the previously described embodiment. Certain parts of the apparatus are identical, or substantially identical, to corresponding parts in the first described embodiment and a description of these parts will thus not be repeated, it being deemed sufficient to identify such parts by the same reference numerals as previously employed.

Essentially, the embodiment shown in these figures comprises a spider member 27a attached by screws 29 to the end of the axle 11 in the same manner as the spider member 27 in the first described embodiment. The spider member 27a differs from the member 27 in having—not two—but three radially extending arms 26a projecting outwardly from the central hub portion 28a, the arms being spaced substantially 120° apart, and a short radial lug or arm 170 midway between two of the arms.

The device further comprises two semi-circular tubular members 22c and 22d disposed in complementary alignment in the form of a ring. Two adjacent open ends of the tubular members 22c and 22d are welded in the opposite ends of a passage 33 in a bracket member 23a corresponding to the bracket member 23. The diametrically opposite adjacent ends of the two tubular members 22c and 22d are welded to the open ends of two "Sylphons" 145 and the opposite open ends of the "Sylphons" are welded to the opposite faces of a floating or shiftable casing member 146 in the manner more fully described presently.

The tubes 22c and 22d are further secured to the spider member 27a by means of brackets 147 surrounding the tubes and attached as by screws 148 to the arms 26a.

An expansion chamber, in the form of a "Sylphon" 34, is associated with the bracket member 23a in the same manner as in the first described embodiment.

In order to prevent failure of the "Sylphons" 145 due to the high mechanical stresses exerted thereon as a result of the centrifugal forces of the casing member 146 as well as of the mercury within the tubes 22c and 22d, the casing member 146 has a diametrically extending arm 151 attached to the inner portion thereof, as by welding, which arm is pivoted on a spindle 152 projecting from the hub portion 28a of the spider member coaxially to the axis of rotation of the axle 11. The arm 151 extends beyond the spindle 152 and carries a counter-weight 153 welded or otherwise

secured on the end thereof. The counter-weight 153 is of such a weight as to counterbalance the weight of the arm 151 and of the casing member 146, whereby to provide a substantial dynamic balance of the rotating parts without interfering with the circumferential movement of member 146.

As seen in Fig. 10, the floating casing member 146 is substantially tubular in form and has integrally formed therein two annular axially spaced rib seats 155 and 156. Seated on each annular rib seat 155 and 156 is a corresponding check valve 157 in the form of a metallic disk, a loading spring 158 acting on each valve in a direction to seat it. The annular rib seats 155 and 156 may be sharpened to a knife edge, if desired, to provide uniform opening and closing pressures therefor.

The loading force of each spring 158 is adjusted by an adjusting screw 159 screwed into the open threaded end of the casing and locked in position by a lock nut 161. Each end of the casing is provided with an external thread for receiving a cap nut 162 that has a sealing edge that seats on a corresponding contact face 163 on the casing.

The valve seats 155 and 156 are located in a transverse passage 160 in the casing having openings at opposite ends in which the "Sylphons" 145 are secured. The disposition of the check valves 157 is such that one of the check valves is unseated to permit flow of fluid from one of the tubes 22c or 22d to the other tube in one direction while the other of the check valves is unseated to permit the flow of fluid between the tubes in the opposite direction.

The loading springs 158 for the check valves 157 are so designed and are so adjusted as to prevent unseating of the check valves until the inertia or force of momentum of the mercury within the tubes 22c and 22d acting in response to rotative deceleration of the axle 11, exceeds a certain value which occurs only when the wheels slip, that is, exceed a certain rate of rotative deceleration such as six miles per hour per second. Accordingly, the casing member 146 is shifted bodily along an arc corresponding in curvature to the radius of curvature of the tubes 22c and 22d in one direction or the other direction depending upon the direction of application of the inertia force or force of momentum of the mercury in the tubes, the "Sylphons" yieldingly permitting such movement. This arcuate shifting of the casing member 146 is translated to a switch lever 77a having a forked end cooperating with the switch operating plunger 86 in the same manner as in the first described embodiment.

The switch lever 77a is pivoted on a supporting member 165 in the form of a screw attached to the short arm or lug 170 projecting radially from the hub portion 28a of the spider member 27a in diametrical relation to the one of the arms 26a to which the bracket member 23a is secured. The screw 165 extends through an arcuate slot 166 in the counter-weight arm 161 which slot permits the necessary pivotal movement of the counter-weight arm in response to the shifting of the casing member 146.

A roller 167 is rotatably mounted on the outer end of the switch lever 77a and cooperates with a shallow V-shaped notch 168 formed on one side of the counter-weight arm 151 adjacent the casing 146.

A leaf spring 169, attached at one end to the

support 165, bears against the outer end of the switch lever 77a for biasing the switch lever normally to a certain position in which the roller 167 occupies a centered position in the deepest portion of the V-shaped notch 168. In this position of the switch lever 77a, the plunger 86 is positioned in the same manner as the plunger 86 in Fig. 1, that is, so as to center the contact finger 106 controlled thereby in the normal centered position between the two contact fingers 116 and 115.

Operation of embodiment shown in Figs. 8, 9, and 10

Let it be assumed that the vehicle having the axle 11 in Figs. 8, 9, and 10 is traveling in a direction such that the axle is rotating in a clockwise direction as seen in Fig. 8 and that when the operator applies the brakes to the wheels fixed on the axle slipping of the wheels occurs. In such case, the force of momentum of the annular mercury column in the tubes 22c and 22d is exerted on the casing member 146 so as to shift it in the direction of rotation of the mercury column. The "Sylphons" 145 are respectively expanded and contracted so as to permit the arcuate bodily movement of the casing member 146 and the consequent pivotal movement of the counter-weight arm 151 on the spindle 152. This movement of the casing member 146 causes a corresponding movement of the roller 167 in the left-hand direction, as seen in Fig. 9, and a consequent pivotal movement of the switch lever 77a in a counterclockwise direction. The switch operating plunger 86 is accordingly shifted in the right-hand direction as seen in Fig. 9 and is thereby effective to permit the contact finger 106 shown in Fig. 1 to engage the contact finger 116.

Operation of the magnet valve device 125 is thus effected in the same manner as in the first described embodiment to effect a release of fluid under pressure from the brake cylinder 126 and a consequent restoration of the slipping wheel or wheels back toward a speed corresponding to car speed.

If the motion of the annular mercury column in the tubes 22c and 22d is suddenly stopped without opportunity for the mercury column to continue its rotation at a gradually diminishing speed, the momentum forces exerted on the casing 146 and effective to maintain the switch lever 77a displaced may vary in such a manner as to produce a vibratory movement of the switch lever 77a and a consequent alternate opening and closing of the switch contacts.

In order to prevent such fluttering of the switch contacts, the check valves 157 in the casing member 146 are unseated in response to the momentum force of the annular mercury column, after the casing 146 is shifted out of its normal centered position a sufficient amount to effect closure of the switch contacts to permit the continued flow or circulation of the annular mercury column through the casing member 146 in the direction of its rotation. In the assumed instance, that is with the axle rotating in a clockwise direction, it will be seen that the lower check valve 157 in Fig. 10 is unseated to permit the flow of mercury from the left-hand tube 22c to the right-hand tube 22d, the valve 157 being unseated to a degree proportional to the force of momentum of the mercury.

The resistance offered to the flow of mercury through the casing member 146 by the check

valves 157 is, moreover, effective to cause the force displacing the casing 146 out of its centered position to be maintained. Such continued displacement of casing member 146 is consequently effective to maintain the switch arm 77a in its displaced position causing engagement of the contact finger 106 with the contact finger 116.

In this connection, it will be observed that the check valves 157 serve in the same capacity as the by-pass check valves 51 of the first described embodiment, namely, to limit or regulate the rate of deceleration (or acceleration) of the annular mercury column to a value just sufficient to maintain the switch contacts closed.

It will thus be seen that in the same manner as in the first embodiment, the annular mercury column of the present embodiment continues to rotate at a speed that diminishes gradually with respect to the rotational speed of the axle at the time the slipping of the wheels occurred due to the quasi braking action on the mercury column resulting from the restriction of the check valves 157. Thus, until the slipping wheels are restored in speed sufficiently to approach the speed of rotation of the annular mercury column, the momentum force of the annular mercury column continues to be effective to unseat the check valve 157 for the corresponding direction of rotation. Accordingly when the slipping wheels are restored substantially to car speed again following the reduction in the degree of application of the brakes initiated by operation of the inertia device, the check valve 157 is resealed and the casing member 146 is restored to its normal centered position in response to the resilient action of the "Sylphons" 145.

With the casing member 146 restored to its normal centered position, the leaf spring 169 is effective to restore the switch lever 77a in a clockwise direction to its normal position wherein the switch operating plunger 86 restores the contact finger 106 to its centered position between the contacts 115 and 116. This is effective, as in the first described embodiment, to terminate further reduction of pressure in the brake cylinder and to initiate resupply of fluid under pressure thereto to cause reapplication of the brakes.

If slipping of the wheels occurs while the wheels and consequently the axle 11 are rotating in the opposite direction, that is in a counterclockwise direction as seen in Fig. 8, a similar operation occurs except that the upper check valve 157 is now unseated in response to the momentum force of the mercury column in the tubes 22c and 22d after the casing 146 is displaced in a counterclockwise direction. The switch lever 77a is, however, shifted pivotally in a counterclockwise direction just as for the opposite direction of rotation of the axle, due to the cooperative relation of the roller 167 with the V-notch 168 on the counterweight arm 151.

It will thus be seen that the device shown in Figs. 8, 9, and 10 operates automatically for either direction of rotation of the axle.

Figures 11, 12, and 13

The embodiment of my invention shown in Figs. 11, 12, and 13 is identical to that shown in Figs. 8, 9, and 10 except for the provision of a modified form of casing member 146a in place of the casing member 146.

The casing member 146a comprises two substantially parallel tubular portions 175 and 176 connected by a short neck 177 extending trans-

versely between the two tubular members portions and joining them substantially midway between the ends thereof.

The tubular portion 176 has a smooth bore 178 open at the opposite ends thereof whereby to receive a cylindrical slide valve 179 for operation therein. The slide valve 179 comprises a central imperforate abutment or piston 181 and two annular end pistons 182, one on each side of the central piston 181 and joined to the central piston by tubular stems 183.

The tubular stems 183 are provided with one or more openings 184 therein whereby to provide open communication between the opposite sides of the annular pistons 182 and thereby balance the fluid pressures, presently described, acting on the pistons.

The annular cavities 185, surrounding the tubular stems 183 between the central piston 81 and each of the end pistons 182, serve to control communication between two spaced ports 186 and 187 opening into the bore 178.

The port 186 is at one end of a curved passage 188 that has its opposite end open at one end of the tubular portion 175 of the casing. The port 187 is at one end of a curved passage 189 that has its opposite end open at the other end of the tubular portion 175 of the casing.

The tubular members 22c and 22d are connected to the open ends of the passages 188 and 189 respectively through "Sylphons" 145 which are suitably secured to the tubular members and the casing member 146a as by welding.

The cylindrical slide valve 179 is normally centered in the bore 178 by centering pins 191; and in such position of the valve the central imperforate piston 181 seals on an annular shoulder formed between the ports 186 and 187. Each centering pin 191 is slidably and loosely mounted in a corresponding adjusting screw 192 screwed into a suitably threaded hole in a collar 193 that fits closely in a counter bore 194 at the outer end of the bore 178.

A coil spring 195 concentrically surrounds each pin 191, in interposed relation between a head 196 at the inner end of each pin 191 and the inner end of the adjusting screw 192 and yieldingly urges the pin 191 into contact with the central piston 181 of the slide valve 179.

The adjusting screws 192 may be turned in either direction to vary the loading force of the springs 195 on the pins 191, a lock nut 197 being provided for locking the adjusting screw in position.

The outer end of each of the centering pins 191 has a collar 198 riveted thereon for holding the pin in assembled relation with the screw and preventing movement of the pin in response to the expanding force of the loading spring 195 beyond a certain point.

The collars 198 carrying the adjusting screws 192 are secured in the casing by means of cap nuts 199. Each cap nut 199 is provided with an inner shoulder having an annular sealing rib 201 that engages the corresponding end of the tubular portion 176 of the casing. This inner shoulder in each cap nut also engages a suitable annular compressible gasket 202 on the outer face of each of the collars 193, whereby the cap nut exerts a force holding the collar in position without interfering with the sealing contact of the rib 201 on the end of the tubular portion 176 of the casing.

The centering pin loading springs 195 on opposite sides of the central piston 181 of the slide

valve 179 are uniformly tensioned by the adjusting screws 192 so as to cause the central piston 181 of the slide valve 179 to be positioned on the annular shoulder between the ports 186 and 187. Moreover, the loading force of the springs 195 is so adjusted as to prevent the movement of the slide valve 179 in the bore, in either direction from the normal central position, except in response to a predetermined force of momentum of the mercury in the tubes 22c and 22d exerted on opposite sides of the central piston 181. Such predetermined momentum force of the mercury occurs only when the wheels rotatively decelerate at a rate exceeding a certain slipping rate, such as six miles per hour per second.

"Sylphons" 145 are so designed that the momentum force of the mercury in the tubes acting on the casing member 146a is sufficient to shift it bodily in one direction or the other only when the momentum force exceeds a certain value occurring in response to the rotative deceleration of the wheels at a rate exceeding a certain slipping rate, such as a rate between five and six miles per hour per second.

In a manner similar to the casing member 146 of the previously described embodiment, the casing member 146a is provided with a counterweight arm 151a attached, as by welding, to the tubular portion 175 of the casing and pivoted on a spindle 152 on the hub portion of a spider member 27a in the same manner as in the previous embodiment.

In a manner similar to the counterweight arm 151, the counterweight arm 151a has a shallow V-shaped notch 168a formed therein at a point adjacent the tubular portion 175 of the casing.

A roller 167 rotatably mounted on the outer end of a switch lever 77a cooperates with the notch 168a, in the same manner as in the previously described embodiment, whereby the bodily shifting of the casing member 146a in either direction from a central position rocks the switch lever in a manner to cause the engagement of the contact finger 106 with the contact finger 116 shown in Fig. 1.

The switch lever 77a of the present embodiment is pivotally mounted on a support 165 that extends through an elongated slot 166 in the counterweight arm 151a in the same manner as in the previous embodiment; and a biasing spring 169 of the leaf type attached at one end to the support 165 biases the switch lever 77a in a direction to restore the switch lever to its normal position.

In operation, the present embodiment functions similarly to the previously described embodiment having the casing member 146. Briefly, the momentum of the annular mercury column in the tubes 22c and 22d exerted on the casing member 146a when the wheels begin to slip shifts the casing member in the direction of rotation of the wheels an amount sufficient to rock the switch lever 77a to cause engagement of the contact finger 106 with the contact finger 116.

At the same time, the force of momentum of the mercury exerted on the central piston 181 of the slide valve 179 overcomes the resisting force of one of the centering pins 191 and shifts the slide valve in the bore 178 until the end piston 182 engages the collar 193 at the corresponding end of the bore. In this position of the slide valve 179 a corresponding annular cavity 185 establishes communication between the two ports 186 and 187 thereby establishing communication between the

two tubular members 22c and 22d and permitting the mercury to rotatively circulate in the tubes.

The inertia force or momentum of the mercury exerted on the central piston 181 controls the position of the valve 179 so as to regulate the rate of rotative deceleration of the annular mercury column to approximately six miles per hour. Thus the momentum force of the rotating annular mercury column is exerted on the casing member 146a continuously during deceleration and subsequent acceleration of the slipping wheel and axle until such time as the slipping wheel and axle have accelerated substantially back to a rotational speed corresponding to the rotational speed of the annular mercury column, which in turn is somewhat less than a rotational speed corresponding to car speed.

When the speed of rotation of the slipping wheels is restored to that of the annular mercury column, the inertia force of the mercury column on the casing member 146a and on the central piston 181 of the slide valve 179 is reduced to zero. Thus the centering spring 195 previously compressed is effective to restore the slide valve 179 to its normal centered position interrupting the communication between the ports 186 and 187; and at the same time the casing member 146a is restored to its normal central position due to the resilient character of the "Sylphons" 145.

The switch lever 171a is thus restored to its normal position in which the contact finger 106 is disengaged from the contact finger 116.

The engagement and disengagement of the contact fingers 106 and 116 is effective to control the magnet valve 125 in exactly the same manner as in the first described embodiment.

It will be apparent that the present embodiment functions inherently for both directions of rotation of the car wheels and car axle. This is the case because the slide valve 179 shifts in one direction from its centered position in response to a sufficient momentum force of the annular mercury column when the wheels and axle are rotating in one direction and in the opposite direction from its centered position in response to the sufficient momentum force of the annular mercury column when the wheels and axle are rotating in the opposite direction, communication between the ports 186 and 187 and consequently between the two tubular members 22c and 22d being established in either case by one or the other of the annular cavities 185 on opposite sides of the central piston 181.

Figures 14, 15, 16, and 17

In the previous two embodiments of a fluid type inertia device employing resilient "Sylphons" whereby to permit limited movement of a casing member in response to the inertia or momentum force of an annular mercury column it is important to design the "Sylphons" so as to have sufficient mechanical strength to withstand the high stresses caused by the centrifugal force of the mercury. When the rotating annular mercury column is rotated at a relatively high speed, as it is in railway service applications, it may be difficult to design the "Sylphons" so as to have sufficient mechanical strength to withstand the centrifugal forces exerted thereon and at the same time be sufficiently flexible and resilient to permit the required movement of the casing member supported between the "Sylphons" in a manner to actuate switch contacts.

In Figs. 14, 15, 16, and 17, I have accordingly disclosed another arrangement for reducing the

stresses on the "Sylphons" due to the centrifugal force of the annular mercury column.

This embodiment is based on the principle that the centrifugal forces of the annular mercury column on the "Sylphons" will be reduced if the diameter of the tubular members forming the annular passage for containing the mercury column is reduced substantially from the diameter shown in previous embodiments. With a reduction in diameter of the annular passage containing the annular mercury column, the total weight of the mercury is proportionately decreased, thereby proportionately reducing the momentum force of the mercury. It might be possible to retain the same weight of mercury for a smaller diameter annular passage as for a larger diameter annular passage if the cross-sectional area of the smaller diameter annular passage is correspondingly increased. However, I prefer to employ annular tubular members for containing the mercury, of relatively small diameter since they may be more readily formed or bent into circular form.

In order to attain the necessary weight of mercury whereby to attain the required momentum force for operating switch contacts I have provided the form of fluid type inertia device shown in Figs. 14 to 17. In this embodiment a plurality of turns of tubing are arranged in re-entrant fashion to form a continuous circulating passage in order to obtain the desired weight of mercury as a result of the increased length of the mercury column incidental to the employment of a plurality of turns instead of but a single turn of tubing. I have illustrated the manner in which two turns of tubing may be employed in connection with the "Sylphon" type of fluid inertia device shown in Figs. 8, 9, and 10, but it will be understood that the multiple-turn arrangement may be employed in connection with any of the forms of fluid type inertia device disclosed.

Referring to Figs. 14, 15, 16, and 17, it will be seen that the embodiment shown is substantially the same as that in Figs. 8, 9, and 10 except that the diameter of the annular passage formed by the tubular members 22c and 22d is much smaller in proportion to the dimensions of the axle and the journal casing than in the case of the embodiment shown in Figs. 8, 9, and 10. For simplicity, however, I have employed the same reference numerals in designating corresponding parts of the present embodiment as employed in the embodiment shown in Figs. 8, 9, and 10 notwithstanding the different sizes or dimensions of the parts in the two embodiments.

Essentially, the embodiment shown in Figs. 14 to 17 differs from that in Figs. 8, 9, and 10, aside from the different dimensions previously mentioned, in the provision of an additional turn of tubing 22x bent or formed as a ring of substantially the same diameter as that formed by the tubular members 22c and 22d and open at only one point to form two adjacent open ends. The adjacent open ends of the additional tubular member 22x are welded to a bracket member 23b, similar to the bracket member 23a, in axially spaced relation to the tubular members 22c and 22d.

Instead of a through passage connecting the tubular members 22c and 22d, the bracket member 23b has crossed non-connected passages 33a and 33b as shown in Fig. 17. The passage 33a connects one open end of the additional tubular member 22x to the end of the tube 22d whereas

the passage 330 connects the other open end of the additional tube 22x to the end of the tubular member 22c secured to the bracket member 23b.

The bracket member 23b is provided with two filling ports corresponding to the filling port 45 of the first described embodiment, a filling port being provided for each of the passages 33a and 33b so as to permit mercury to be poured directly into each of the passages and thereby readily accomplish the filling of the tubes. Screw plugs 46a and 46b are provided as shown in Fig. 17 for respectively closing the two filling openings into the passages 33a and 33b.

Brackets 147a, similar to brackets 147, are attached to arms 26a and clamped around the tubular members to provide additional support therefor.

The embodiment shown in Figs. 14 and 17 functions in exactly the same manner as does the embodiment shown in Figs. 8, 9, and 10. It is accordingly deemed unnecessary to describe the operation of this embodiment since it will be readily understood from the foregoing description of the operation of the embodiment shown in Figs. 8, 9, and 10.

Summary

Summarizing, it will be seen that I have disclosed several embodiments of my invention relating to a fluid type inertia device, all of which embodiments are based on the same operating principle, namely the utilization of the inertia force or momentum of a fluid fly wheel or rotating annular mercury column in a manner to detect or register the rate of deceleration of a rotary element.

All of the embodiments shown also have the common operating principle of permitting the annular mercury column to continue to rotate at a faster speed than the speed of rotation of the braked rotary element, with which it is associated, whereby to insure the continued closure of switch contacts during the major portion of the time the annular mercury column and the rotary element rotate at different speeds. This feature is produced by various forms of spring loaded check valves which are operative to permit the circulatory flow of the annular mercury column while exerting a braking effect thereon so as to reduce the speed thereof at a certain uniform low rate.

One embodiment dispenses entirely with flexible bellows or "Sylphons" whereas the other embodiments disclosed all employ "Sylphons". Those embodiments employing "Sylphons" are all provided with a pivoted counterweighted arm providing mechanical support for the "Sylphons" against the centrifugal forces exerted on the "Sylphons."

One of the embodiments employs a plurality of successive turns of tubular members connected in re-entrant fashion to provide a continuous circulatory passage for the mercury. This form of the invention enables a smaller and more compact device without effecting any reduction of the momentum forces of mercury attainable, because of the increased length of the mercury column.

The fluid type inertia devices disclosed herein are described in connection with the control of the brakes associated with a railway car wheel or wheels and function to release the brakes on the car wheels in response to the rotative deceleration of the car wheels at a slipping rate, such as

a rate corresponding to the retardation of the car at six miles per hour per second.

While not specifically described, it will be apparent that the fluid type inertia devices which I have disclosed herein are also suited for the detection of the rate of acceleration as well as the rate of deceleration of a rotary element. I do not intend any limitation on the scope of my invention, therefore, except as expressed by the terms of the appended claims.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, means associating the casing means and the body of liquid in a manner to cause rotational movement of the body of liquid with the casing means at the same speed, said means being operatively responsive to the inertia force of the body of liquid set up when the casing means changes its rotational speed at a rate exceeding a certain rate for permitting the body of liquid to rotatively circulate in said chamber at a speed different from that of the casing means thereby to maintain a certain predetermined inertia force of the body of liquid effective as long as the casing means and the body of liquid rotate at different speeds, and control means operatively responsive to the inertia force of the liquid in said chamber.

2. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, means associating the casing means and the body of liquid in a manner to cause rotational movement of the body of liquid with the casing means at the same speed, said means being operatively responsive to the inertia force of the body of liquid set up when the casing means changes its rotational speed at a rate exceeding a certain rate for permitting the body of liquid to rotatively circulate in said chamber at a speed different from that of the casing means thereby to maintain a certain predetermined inertia force of the body of liquid effective as long as the casing means and the body of liquid rotate at different speeds, and control means operatively responsive to the inertia force of the body of liquid in said chamber exceeding a second certain force less than said certain predetermined force.

3. A fluid type inertia device comprising casing means having an annular chamber in which body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, pressure responsive means subject to the inertia force of the body of liquid set up when the casing means changes its speed of rotation and movable in accordance with the degree of inertia force, control means operated by said pressure responsive means from a normal inactive position to an active position in response to an inertia force of the body of liquid exceeding a certain value, and means normally effective to cause said body of liquid to rotate with the casing means at the same speed and operatively responsive to an inertia force of the body of liquid exceeding a second certain value higher than the first said certain value for establishing communication permitting

said body of liquid to rotatively circulate in said annular chamber at a speed different from the speed of rotation of the casing means thereby to maintain said first certain value of inertia force of the body of liquid effective as long as the body of liquid and the casing means rotate at different speeds.

4. A fluid type inertia device for detecting the slipping condition of a vehicle wheel, said device comprising casing means having an annular tubular chamber in which a body of liquid is confined and being rotatable on an axis that intersects the center of curvature of the annular chamber at a speed corresponding to the rotational speed of the vehicle wheel, means associating the casing means and the body of liquid in a manner to permit the body of liquid to rotatively circulate in said chamber at a speed different from that of the casing member only while said wheel is slipping, thereby to maintain a predetermined inertia force of the body of liquid continuously effective in one direction during substantially the entire time the wheel is slipping, and control means operated from a normal inactive position to an active position only in response to the maintenance of an inertia force of the body of liquid exceeding said predetermined inertia force.

5. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, pressure responsive means associated with said casing and shiftable out of a normal position in response to the inertia force of the body of liquid exerted thereon when the casing means changes its speed of rotation, means effective to limit the rate of change of speed of the body of liquid to a certain rate, notwithstanding a change in the rotational speed of the casing means at a rate higher than said certain rate, to thereby cause said body of liquid to continuously exert an inertia force in one direction effective to maintain said pressure responsive means displaced out of its normal position as long as the body of liquid and the casing means rotate at different speeds, and control means operatively responsive to movement of the pressure responsive means.

6. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, pressure responsive means associated with said casing and shiftable in one direction or the opposite direction out of a normal position thereof in response to the inertia force of the body of liquid exerted thereon when the rotary member changes its speed of rotation, control means operative from a normal position to an operated position in response to a predetermined inertia force exerted on said pressure responsive means, and means effective when the casing means decelerates rotatively at a rate exceeding a certain rate for limiting the rotative deceleration of the body of liquid approximately to said certain rate to thereby cause said predetermined inertia force of the said body of liquid to be continuously effective to displace said pressure responsive means in one direction out of a normal position as long as the annular body of liquid and the casing means rotate at different speeds.

7. A fluid type inertia device for detecting the

slipping condition of a vehicle wheel, said device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber and at a speed corresponding to the rotational speed of the vehicle wheel, pressure responsive means associated with said casing and shiftable in response to the inertia force of the body of liquid exerted thereon when the vehicle wheel rotatively accelerates or decelerates, control means operative by said pressure responsive means from a normal position to an operated position when the inertia force of the body of liquid on the pressure responsive means exceeds a certain value, and means effective when the vehicle wheel decelerates at a rate exceeding a certain rate occurring only when the vehicle wheel slips for limiting the rate of rotative deceleration of the body of liquid to said certain rate to thereby cause said certain value of inertia force of said body of liquid to be continuously exerted on said pressure responsive means, whereby to maintain said control means in its operated position as long as the body of liquid and the casing means rotate at different speeds.

8. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, pressure responsive means associated with said casing means and movably responsive according to the inertia force of the body of liquid exerted thereon when the casing means changes its speed of rotation, valve means operated from a closed position to an open position in response to a predetermined inertia force of the body of liquid to provide communication permitting the rotational movement of the body of liquid relative to said casing means whereby to cause said predetermined inertia force of the body of liquid to be continuously exerted to displace said pressure responsive means in one direction out of its normal position as long as the body of liquid and the casing means rotate at different speeds, and control means operatively responsive to movement of the pressure responsive means.

9. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, pressure responsive means associated with said casing means in a manner to be movably responsive according to the inertia force of the body of liquid exerted thereon when the casing means changes its speed of rotation, normally closed valve means interposed in said annular chamber in a manner to prevent circulatory rotational movement of the body of liquid within said annular chamber and operative to an open position permitting rotational circulatory movement of body of liquid in said annular chamber relative to said casing means, resilient means biasing said valve means to its closed position and yieldable to permit the valve means to be operated to its open position in response to a predetermined inertia force of the body of liquid, and control means operatively responsive to the inertia force of the body of liquid exerted on said pressure responsive means.

10. A fluid type inertia device comprising casing means having an annular chamber in which

a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two movable abutments disposed in spaced relation along a common axis perpendicular to the plane of rotation of said casing means and parallel to the axis of rotation thereof, said movable abutments being so arranged as to be subject respectively to the oppositely directed inertia forces of the body of liquid, a follower interposed between said movable abutments, and shiftable in opposite directions in response to the inertia forces exerted on said abutments, an operating lever pivoted on said casing means and rockably moved in a plane perpendicular to the plane of rotation of the casing means in response to the movement of said follower, a member shiftable in either direction along an axis coincident with the axis of rotation of said casing means in response to the movement of said operating lever, and non-rotative control means operated in response to the movement of the last said member.

11. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two flexible diaphragms secured in said casing means in spaced relation along a common axis perpendicular to the plane of rotation of the casing means and at a certain radial distance from the axis of rotation of the casing means, said two diaphragms being subject to the inertia force of the body of liquid acting in opposite directions respectively upon a change in the rotational speed of the casing means and being of substantially the same effective pressure areas whereby the centrifugal forces of the body of liquid acting thereon are balanced, a follower interposed between said diaphragms and shiftable in opposite directions from a normal centered position by the inertia forces of the body of liquid exerted on one or the other of said diaphragms, a lever pivoted on said casing means and rockably moved to either side of a normal position, in response to movement of said follower, in a plane perpendicular to the plane of rotation of the casing means, a switch operating plunger slidably movable on an axis coincident with the axis of rotation of the casing means and associated with said lever in a manner to be shifted responsively to the movement of said lever, and non-rotative switch means operatively responsive to movement of said plunger.

12. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and terminating in two circumferentially spaced ends, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two complemental casing members separably secured together and connecting the ends of said annular chamber, a flexible diaphragm secured in each of said complemental casing members in a manner to be subject on one side thereof to the inertia force of the body of liquid confined in said annular chamber and resulting from changes in the speed of rotation of the casing means, said diaphragms being disposed in spaced relation along a common axis radially spaced from the axis of rotation of the casing means in parallel relation thereto and perpendicular to the plane of rotation of the casing means, the arrangement of said diaphragms being such that said diaphragms are acted upon respectively by

the inertia force of the body of liquid acting in opposite directions, said complemental casing members cooperating to form a bore between said diaphragms, a follower slidably supported in said bore in interposed relation between said diaphragms and shiftable in response to movement of said diaphragms, an operating lever pivoted on said casing member and cooperating with said follower in such a manner as to be shifted rockably in a plane perpendicular to the plane of rotation of the casing means in response to movement of said follower, an operating plunger shiftable on an axis coincident with the axis of rotation of the casing means and cooperating with said operating lever in such a manner as to be shifted responsively to movement of said lever, and non-rotative control means cooperating with said plunger and operatively responsive to movement thereof while said casing means is rotating.

13. A fluid type inertia device comprising casing means having an annular chamber, a body of liquid confined in said chamber, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two separately movable abutments arranged in spaced coaxial relation on an axis perpendicular to the plane of rotation of the casing means and parallel to the axis of rotation of the casing means and respectively subject to the oppositely directed inertia forces of the body of liquid in said annular chamber resulting from a change in speed of rotation of the casing means, control means operatively responsive to the movement of said diaphragms, and valve means interposed in the annular chamber of the casing means in a manner to permit circulatory rotational movement of the annular body of liquid with respect to said casing means when the casing means rotatively decelerates at a rate exceeding a certain rate, whereby the inertia force of the annular body of liquid is exerted continuously on one of said diaphragms as long as the rotational speed of the casing means is less than the rotational speed of the annular body of liquid.

14. A fluid type inertia device comprising casing means providing an annular chamber having two circumferentially spaced ends, and being rotatable on an axis that intersects the center of curvature of the annular chamber, two complemental casing members separably secured together for connecting the ends of said annular chamber, a flexible diaphragm secured in each of said complemental casing members and disposed in spaced coaxial relation on an axis perpendicular to the plane of rotation of the casing means, said diaphragms being respectively subject to oppositely directed inertia forces of the body of liquid resulting from a change in the rotational speed of the casing means, a follower slidably supported in said complemental casing members between said diaphragms and shiftable to either side of a normal centered position in response to the inertia force of the body of liquid exerted on said diaphragms, control means operatively responsive to the movement of said follower, and loaded check valve means in each of said complemental casing members respectively subject to the oppositely directed inertia forces of said annular body of liquid and effective to establish communication between the two ends of said annular chamber in response to a predetermined inertia force resulting from the rotative deceleration of the casing means at a rate exceeding a certain rate, whereby to permit the body of liquid

to rotate at a speed higher than that of the casing means so as to maintain an effective inertia force active on the corresponding diaphragm until the casing means rotates at substantially the same speed as the annular body of liquid.

15. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and being rotatable on an axis intersecting the center of curvature of the annular chamber, said casing means including a floating portion on which the inertia force of the said body of liquid resulting from changes in the rotational speed of the casing means is exerted to cause circumferential movement thereof in opposite directions out of a normal centered position depending upon the direction of application of the inertia force, a counterweight arranged to counteract the effect of centrifugal force on said floating portion of the casing means without interfering with the circumferential movement thereof, and control means operatively responsive to circumferential movement of the floating portion of the casing means.

16. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and rotatable on an axis intersecting the center of curvature of the annular chamber, said casing means including a movable portion subject to the inertia force of the body of liquid in the annular chamber and shiftable circumferentially in opposite directions out of a normal centered position depending upon the direction of application of the inertia force, a lever pivoted on said casing means on an axis coincident with the axis of rotation of the casing means, said lever being secured at one end to the movable portion of the casing and having a counterweight on the opposite end thereof for counteracting the effect of centrifugal force on said movable portion of the casing means at all times without interfering with the circumferential movement of the movable portion of the casing means, and control means operatively responsive to movement of the movable portion of the casing means.

17. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and being rotatable on an axis that intersects the center of curvature of the annular chamber, said casing means including a flexible resilient bellows portion and a movable abutment supported by said bellows in such a manner as to be subject to the oppositely directed inertia forces of the body of liquid in the annular chamber and shiftable circumferentially in response to the inertia forces according to the resilient yielding action of said bellows, a counterweight constructed and arranged so as to counteract the effect of centrifugal force on said movable abutment, and control means operatively responsive to the circumferential movement of said movable abutment.

18. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and being rotatable on an axis that intersects the center of curvature of the annular chamber, said casing means including a flexible resilient bellows portion, a casing member supported by said bellows portion in a manner to be subject to the inertia force of the body of liquid in acting in one direction or the opposite direction in response to a change in the rotational speed of the casing member, a lever pivoted on an axis coincident with the axis of rotation of said casing means, said lever being

secured at one end to the casing member and having a counterweight at the opposite end whereby to support said casing member against the centrifugal forces acting thereon and at the same time to permit movement of the casing member circumferentially in response to the inertia forces acting thereon, and control means operatively responsive to the circumferential movement of the casing member.

19. A fluid type inertia device comprising an annular tubular member rotatable on an axis intersecting the center of curvature thereof and having two circumferentially spaced ends, a casing member, resilient bellows supporting said casing member for circumferential movement between the spaced ends of the tubular member, a body of liquid confined in said tubular member and effective to exert inertia forces on the casing member to displace it circumferentially in either direction from a centered position, depending upon the direction of application of the inertia forces, when the casing means changes its rotational speed, and loaded check valve means in said casing member subject to the inertia force of the body of liquid and effective to establish communication whereby to permit the circulatory rotational flow of the body of liquid through the tubular member when the inertia force exceeds a certain value whereby to render the said certain value of inertia force continuously active in one direction on said casing member as long as the casing means and the body of liquid rotate at different speeds, and control means operatively responsive to the circumferential movement of the casing member.

20. A fluid type inertia device comprising casing means providing a plurality of coaxial spaced annular passages connected in a manner to provide a continuous endless chamber and having a body of liquid confined therein, said casing means being rotated on an axis coincident with the center of curvature of the annular passages therein, means associated with one of said annular passages in a manner to be subject to the inertia forces of the body of liquid confined in the circulatory passage resulting from a change in the rotational speed of the casing means, and control means operatively responsive to movement of the last said means.

21. A fluid type inertia device comprising a plurality of annular tubular members of substantially the same annular diameter disposed in coaxial spaced relation and connected in a manner to provide a continuous circulatory endless passage, a body of liquid confined in said passage, means in the passage formed by the tubular members effective to permit the circulatory flow of the body of liquid with respect to the tubular members only when the tubular members rotatively accelerate or decelerate at a rate exceeding a certain rate, and control means operatively responsive only to the inertia force of the body of liquid maintained while the circulatory flow of the liquid in said tubular members continues.

22. A fluid type inertia device comprising a plurality of annular tubular members of substantially the same annular diameter disposed in spaced coaxial relation and rotated on an axis intersecting the center of curvature of the annular tubular members, means interconnecting said tubular members in a manner to provide a continuous multiple-turn circulatory passage, a body of liquid confined in said passage, a floating abutment member, flexible bellows supporting said floating abutment member from one of

said tubular members in a manner to permit the circumferential movement thereof in response to the inertia forces of the body of liquid confined in the circulatory passage, counterweight means arranged in a manner to counteract the effect of centrifugal force acting on said floating abutment member without preventing the circumferential movement thereof, and control means operatively responsive to the circumferential movement of the floating abutment member.

23. A fluid type inertia device comprising a casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two movable abutments disposed in spaced relation along a common axis perpendicular to the plane of rotation of said casing means and in spaced parallel relation to the axis of rotation thereof, said movable abutments being so arranged as to be subject respectively to the oppositely directed inertia forces of the body of liquid in the annular chamber, a follower interposed between said movable abutments and shiftable in opposite directions in response to movement of said abutments, and means operatively responsive to movement of said follower.

24. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two flexible diaphragms secured in said casing means in spaced relation along a common axis perpendicular to the plane of rotation of the casing means and at a certain radial distance from the axis of rotation of the casing means, said two diaphragms being movable in response to the inertia force of the body of liquid acting in opposite directions thereon respectively upon a change in the rotational speed of the casing means and having substantially the same effective pressure areas whereby the centrifugal forces of the body of liquid acting thereon are balanced, a follower interposed between said diaphragms and shiftable in opposite directions from a normal centered position in response to movement of said diaphragms, and means operatively responsive to the position of the said follower.

25. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and terminating in two circumferentially spaced ends, said casing means being rotatable on an axis that intersects the center of curvature of the annular chamber, two complementary casing members separably secured together and connecting the said spaced ends of said annular chamber, a flexible diaphragm secured in each of said complementary casing members in a manner to be subject on one side thereof to the inertia force of the body of liquid confined in said annular chamber and resulting from changes in the speed of rotation of the casing means, said diaphragms being disposed in spaced relation along a common axis radially spaced from the axis of rotation of the

casing means in parallel relation thereto and perpendicular to the plane of rotation of the casing means, the arrangement of said diaphragms being such that said diaphragms are acted upon respectively by the inertia force of the body of liquid acting in opposite directions, said complementary casing members cooperating to form a bore between said diaphragms, a follower slidably supported in said bore in interposed relation between said diaphragms and shiftable in response to movement of said diaphragms, and means operative in response to movement of said follower.

26. A fluid type inertia device comprising casing means having an annular chamber in which a body of liquid is confined and rotatable on an axis intersecting the center of curvature of the annular chamber, said casing means including a movable portion subject to the inertia force of the body of liquid in the annular chamber and shiftable circumferentially in opposite directions out of a normal centered position depending upon the direction of application of the inertia force, a member pivoted on said casing for rotative movement on an axis coincident with the axis of rotation of the casing means and associated with said movable portion of the casing means in a manner to insure the movement thereof on a fixed arcuate path in opposition to centrifugal force, and means operatively responsive to movement of the movable portion of the casing means.

27. A fluid type inertia device comprising casing means providing a pair of coaxially spaced annular passages connected in a manner to provide a reentrant helical endless chamber, a body of liquid confined in said chamber, said casing means being rotated on an axis coincident with the center of curvature of the annular passages, means associated with one of said annular passages in a manner to be subject to the inertia forces of the body of liquid confined in the chamber and resulting from a change in the rotational speed of the casing means, and means responsive to movement of the last said means.

28. A fluid type inertia device comprising a plurality of annular tubular members of substantially the same annular diameter disposed in spaced coaxial relation and rotated on an axis intersecting the center of curvature of the annular tubular members, means interconnecting said tubular members in a manner to provide a reentrant helical circulatory passage, a body of liquid confined in said passage, a floating abutment member, flexible bellows supporting said abutment member from one of said tubular members in a manner to permit the circumferential movement thereof in response to the inertia forces of the body of liquid in the circulatory passage exerted on the abutment member, means supporting said abutment member for movement in an arcuate path for resisting displacement thereof in response to centrifugal force, and means operatively responsive to the circumferential movement of the abutment member.

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