

March 4, 1969

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3,430,614

DESMODROMIC DRIVE ARRANGEMENT

Filed July 7, 1967

Sheet 1 of 3

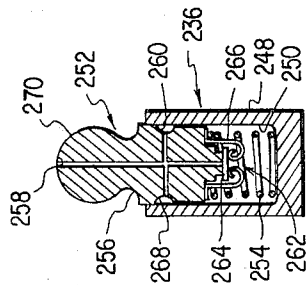


FIG. 8

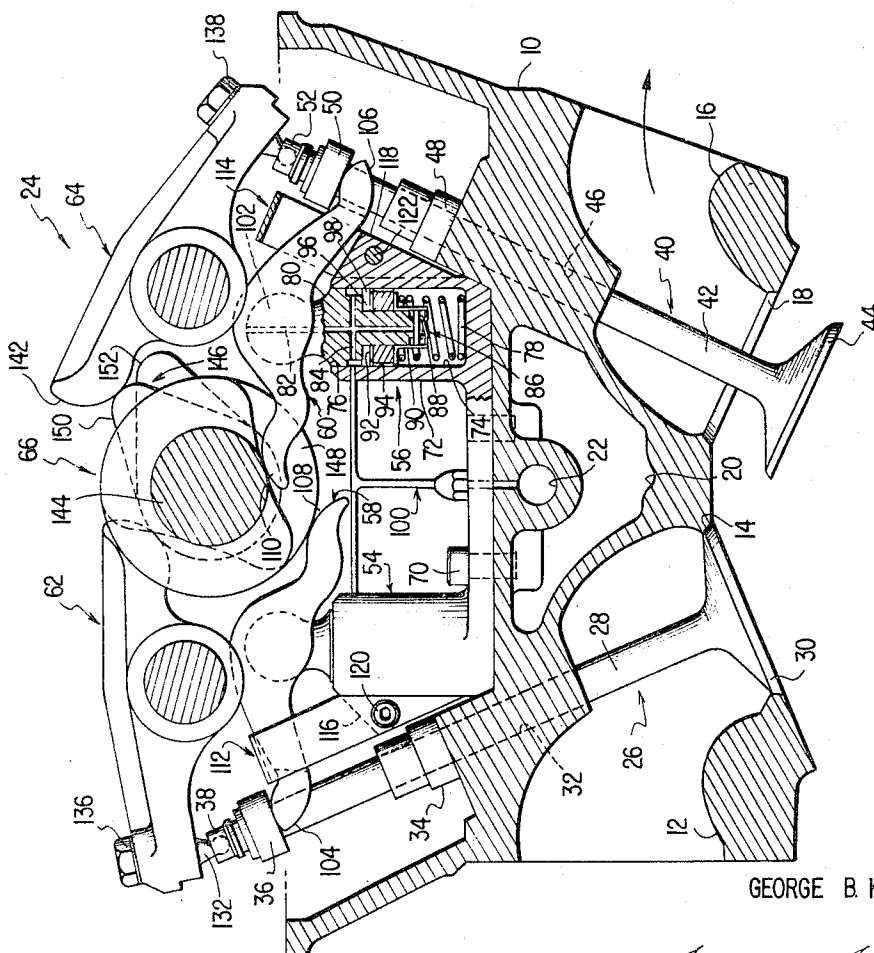


FIG. 1

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FIG. 6

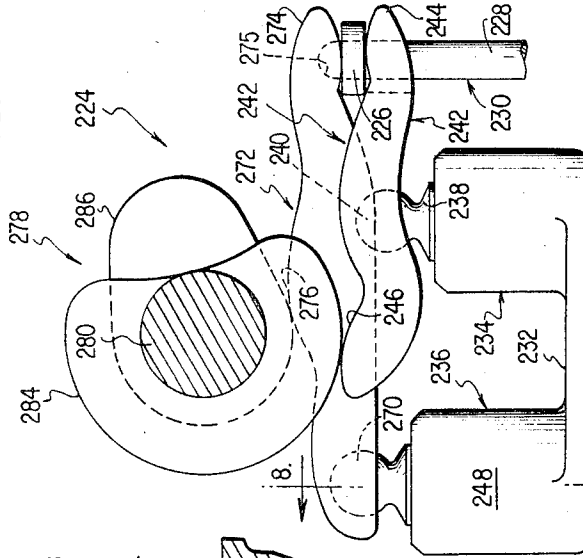
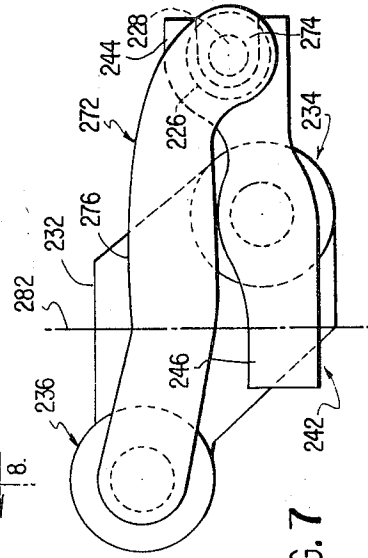


FIG. 7

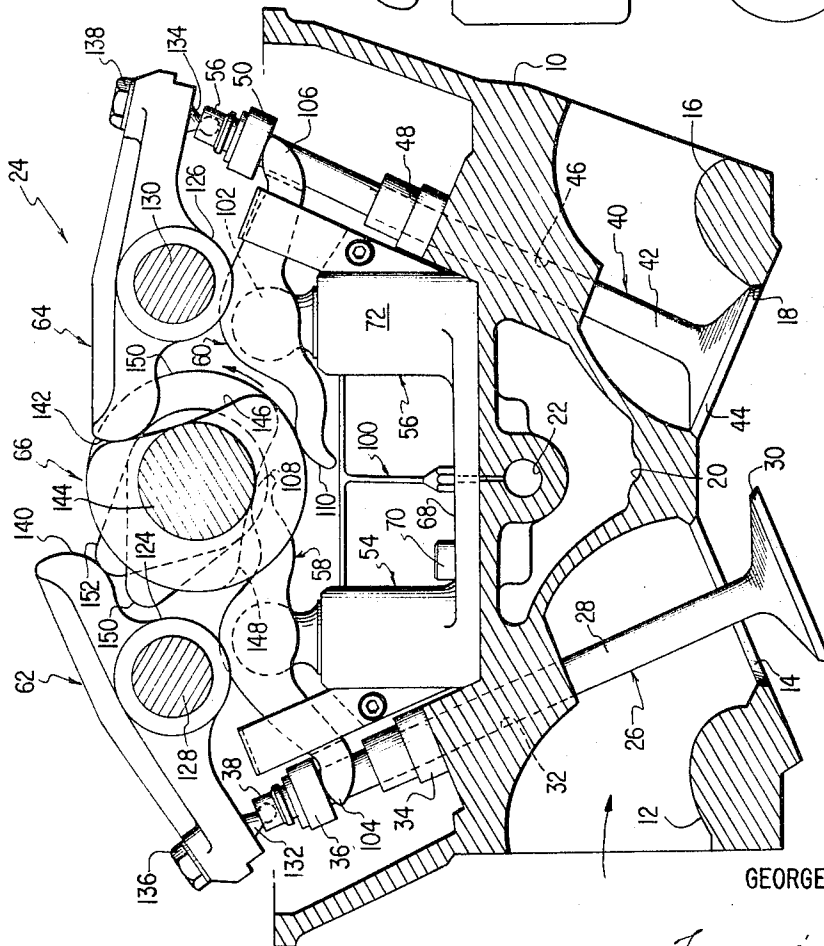


FIG. 2

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FIG. 3

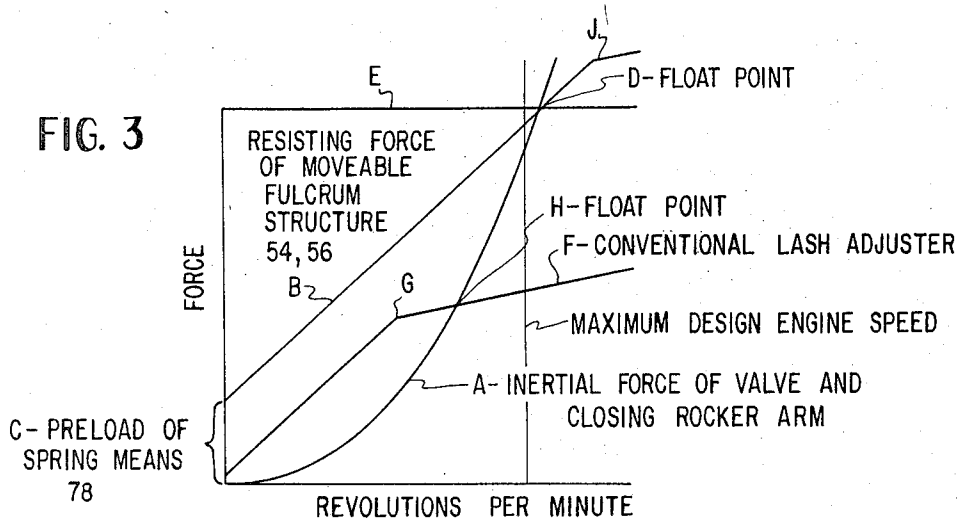


FIG. 4

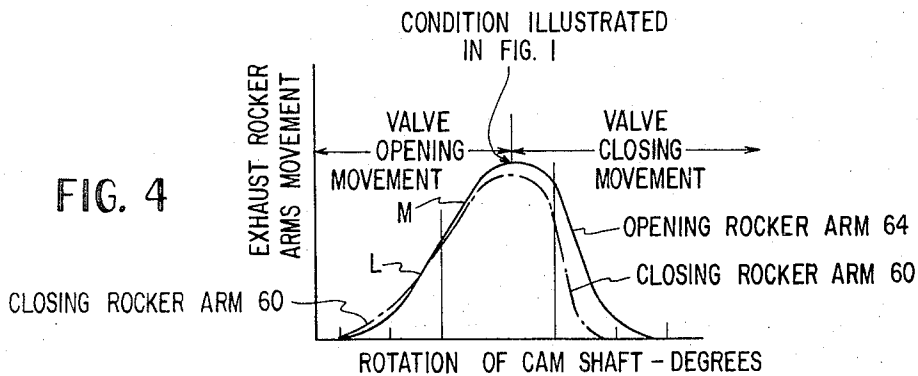
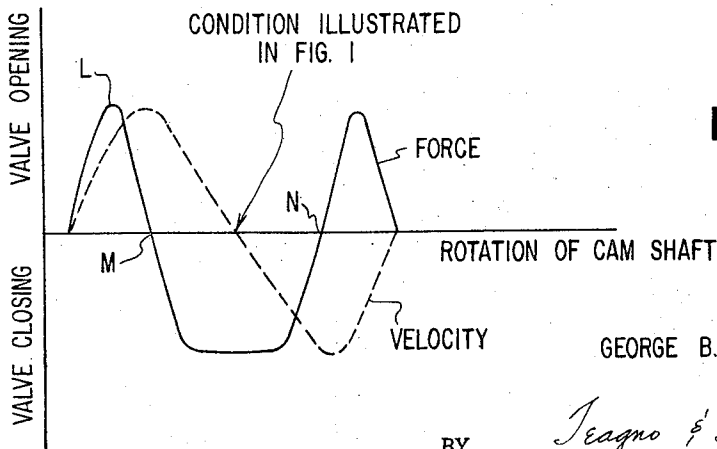


FIG. 5



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DESMODROMIC DRIVE ARRANGEMENT

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U.S. Cl. 123-90

29 Claims

Int. Cl. F011 1/30, 1/18

ABSTRACT OF THE DISCLOSURE

This invention relates to an engine valve arrangement in which the valve is positively opened and positively closed. The mechanism for closing the valve comprises a rocker arm, a movable fulcrum structure arranged to bias the rocker arm toward a camming mechanism in order to bind the camming mechanism, rocker arm and valve together to operate as a unit. The multiple fulcrum structure comprises spring means and dashpot apparatus arranged to produce a resistance to movement away from the camming mechanism that is proportional to engine speed.

Background of the invention

This invention pertains to desmodromic drive arrangements for engine valves. By definition, a desmodromic valve arrangement is one that positively opens and positively closes a valve. This is in contrast to the normal drive valve arrangement in which the valve is positively opened and spring-biased closed.

One of the problems with desmodromic drive valve arrangements is sensitivity to change in size of the components of the drive system. The components of the drive system become enlarged at elevated temperatures because of a normal thermal expansion of the metallic components. In use, the components of the drive system will wear thereby decreasing the size of the components. Because an engine is normally operated for a period of time and is then quiescent for a period of time, the increase in size because of thermal expansion is cyclic but decrease in size due to wear is normally in one direction only. From this discussion it will be apparent that one of the major difficulties of prior art desmodromic valve arrangements is the critical and accurate adjustment of various working components to ensure that the components operate together as a unit.

Several attempts to overcome the change in size of the components are evidenced in the prior art. Exemplary U.S. patents illustrating such attempts are Nos. 1,541,081, 2,401,480, and 3,098,472. Each of these patents discloses a spring of one type or another that is arranged to bias the cam, rocker arm and valve together to operate as a unit. While such approaches allow for thermal expansion and wear of the drive components, the primary difficulty is that the spring must be of sufficient strength to overcome the inertial forces produced by the moving valve and rocker arm. This is necessary since the moment the inertial forces of the valve and rocker arm exceed the spring produced forces, the valve, rocker arm and cam no longer operate as a unit. Accordingly, maximum engine speed is obtained at the speed at which the inertial forces of the valve and rocker arm equals the forces produced by the spring. One disadvantage of such spring devices is that large contact forces are imposed on the cam and rocker arm throughout the range of engine speed operation rather than imposing large contact forces only at high engine speeds. This disadvantage of prior art devices results in premature failure of the cam and rocker arm.

Even though the spring devices of the prior art produces a resilient support for the rocker arm assembly, the

disadvantage of critical adjustment remains. This is aggravated since the adjustment of the tolerances between the operating elements effects the preload of the spring. It will accordingly be seen that the adjustment of desmodromic valve arrangements presents considerably different problems from those apparent in the adjustment of ordinary valve drives.

It is known in the prior art to provide lash adjustors of various types for ordinary valve drive arrangement. One type of lash adjustor known in the prior art comprises a dashpot structure and spring element. As will be pointed out more fully hereinafter, such conventional lash adjustors are not suitable for use in desmodromic arrangements even though a speed responsive resistance force is produced. The primary reason that these types of conventional lash adjustors are not usable in desmodromic valve arrangements is that the rate of increase of the resistance force produced decreases significantly at higher engine speeds.

Summary of the invention

This invention comprises a desmodromic valve drive arrangement for engine valves in which at least a closing rocker arm is mounted on a movable fulcrum in which the fulcrum is arranged to force the cam, rocker arm and valve together as a unit. The fulcrum structure is also arranged to produce a resistance to movement of the rocker arm away from the cam. The resistance produced by the fulcrum structure is speed dependent and increases with engine speed. The rate of increase of the resistance produced by the fulcrum structure increases at a generally constant rate throughout long ranges of engine operation.

The desmodromic drive arrangement of this invention obviates the requirement for critical and accurate adjustment of the tolerances between the various working components and also obviates the requirement for critical and accurate adjustment of the spring preload designed into the fulcrum structure. The desmodromic drive arrangement of this invention is designed to produce relatively small forces resisting movement of the rocker arm away from the cam at low engine speeds. This feature minimizes contact forces between the cam and rocker arm at low speeds thereby prolonging the effective life of the drive arrangement. Since the resistance forces increase with engine speed, the resistance to movement of the fulcrum increases thereby resulting in higher obtainable engine speeds. Accordingly, the use of the desmodromic drive arrangement of this invention allows the construction of a high performance engine capable of satisfactory performance at low engine speeds.

It is accordingly a primary object of the instant invention to provide a desmodromic drive arrangement for engine valves wherein the drive arrangement comprises a biased movable fulcrum structure wherein the requirement for critical and accurate adjustments of a spring preload are obviated.

Another object of this invention is to provide a desmodromic drive arrangement of the type having a movable fulcrum for a closing rocker arm wherein the forces binding a cam, rocker arm and valve together increase with engine speed.

Still another object of this invention is to provide a desmodromic drive arrangement enabling the construction of a high performance engine capable of satisfactory performance at low engine speeds.

A further object of this invention is to provide a desmodromic drive arrangement of the type described that produces high engine speeds with a minimum of maintenance and adjustment.

A still further object of this invention is to provide a desmodromic drive system wherein the forces binding a

cam, rocker arm and valve together for operation as a unit increase with engine speed.

Another object of this invention is to provide a high performance engine equipped with a desmodromic drive arrangement wherein the engine is capable of satisfactory low speed performance.

Other objects and important features of the invention will become apparent from a study of the specification following taken with the drawing which together show, illustrate, describe and disclose preferred embodiments or modifications of the invention and what is considered to be the best mode of practicing the principles thereof.

Other embodiments or modifications may be suggested to those having the benefit of the teachings herein, and such other modifications and embodiments are intended to be reserved especially as they fall within the scope or spirit of the subjoined claims.

Brief description of the drawing

In the drawing:

FIGURE 1 is a cross-sectional view of a head casting equipped with a desmodromic drive arrangement constructed in accordance with the principles of this invention, illustrating an intake valve in a closed position and an exhaust valve in an open position;

FIGURE 2 is a view similar to FIGURE 1 and illustrates the position of the operative element when the intake valve is in the open position and the exhaust valve is in the closed position;

FIGURE 3 is a graph illustrating the operating characteristics of a movable fulcrum structure of the desmodromic valve drive arrangement of this invention;

FIGURE 4 is a chart illustrating the operative relationship between the movement of the opening and the closing rocker arms and the extent of cam rotation;

FIGURE 5 is a chart depicting the relationship between the force imparted to the valve; the velocity of the valve and the extent of cam rotation;

FIGURE 6 is a simplified view of another embodiment of the desmodromic drive arrangement of this invention;

FIGURE 7 is a top-view of the embodiment of FIGURE 6, the cam structure being illustrated as a broken line for clarity of illustration; and

FIGURE 8 is a vertical cross-sectional view taken substantially on line 8—8 of FIGURE 6 and illustrating a movable fulcrum structure used with the rocker arm that causes valve opening.

Description of the preferred embodiments

Attention is now directed to FIGURES 1 and 2 wherein a conventional head casting 10 is provided with an intake port 12 having a valve seat 14 and an exhaust port 16 having a valve seat 18. A suitable coolant passageway 20 is formed in the head casting 10 to provide for cooling thereof in a conventional manner. A suitable oil galley 22 is formed in the head casting 10 for delivering lubricating fluid to a desmodromic valve arrangement 24 as well as to other lubrication sites.

An intake valve 26 comprises a stem 28 and a valve face 30 arranged to engage the valve seat 14 as shown in FIGURE 1. The valve stem 28 extends through a bore 32 formed in the head casting 10 and is constrained to linear movement by a valve guide 34. The upper end portion of the valve stem 28 carries a valve stem tip 36 and an elephant's foot 38. Between fifteen and twenty-five thousandths clearance is preferably provided between the valve stem tip 36 and the elephant's foot 38.

Also provided is an exhaust valve 40 having a valve stem 42 and a valve face 44 arranged to engage the valve seat 18 as shown in FIGURE 2. The stem 42 extends through a bore 46 in the head casting 10 and is constrained to linear movement by a valve guide 48. A stem tip 50 is positioned on the upper end portion of the valve stem 42 adjacent an elephant's foot 52. Between fifteen and

twenty-five thousandths clearance is preferably provided between the stem tip 50 and the elephant's foot 52.

The major components of the desmodromic valve arrangement 24 comprise movable fulcrum structures 54, 56 respectively associated with the intake and exhaust valves 26, 40, closing rocker arm means 58, 60 respectively carried by fulcrum structures 54, 56, opening rocker arm means 62, 64 respectively associated with the intake and exhaust valves 26, 40 and cam means 86. As will be explained more fully hereinafter, the rotation of the cam means 66 manipulates the rocker arm means 58, 60, 62, 64, in timed relation to deliver a combustible material through the inlet port 12 into a cylinder (not shown) and to remove combustion products through the exhaust port 16.

The fulcrum structures 54, 56 are illustrated as mounted on a plate 68 secured to the head casting 10 by suitable fasteners 70. Since the disclosed movable fulcrum structures 54, 56 are substantially the same, only one will be described for purposes of brevity. Although the disclosed fulcrum structures 54, 56 are described as substantially identical, it should be understood that they may be of diverse types insofar they meet the operational requirements of this invention. Fulcrum structure 56 comprises a housing 72 having a blind opening 74 therein slidably receiving a dashpot plunger 76. Spring means 78 is mounted in the opening 74 and biases the plunger 76 upwardly for purposes more fully explained hereinafter. In the embodiment disclosed, the spring 78 is a seventy-five to one-hundred pound spring although this may vary in accordance with the characteristics of the remainder of the desmodromic valve arrangement 24 and in accordance with the performance desired.

The plunger 76 comprises a body 80 having a vertical passageway 82 and a connecting transverse passageway 84. The lower end of the vertical passageway 82 is closed by a check valve arrangement 86 comprised of a valve member 88 and a plurality of spring arms 90 affixed to a disc 92 rigid with the plunger body 80. The disc 92 provides one or more passageways 94 thereacross, which may be formed by flattening one or more sides of the generally circular disc 92. As shown in FIGURE 1, the plunger body 80 and disc 92 cooperate with the interior surface of the housing 72 to form a cavity 96 in communication with the transverse passageway 84. A thermal responsive sealing ring 98 is positioned about the interior of the blind opening 74 adjacent the disc 92 to control the effective flowpath through the passageways 94 in response to the temperature of the fluid within the adjustable fulcrum structure 54. The sealing ring 98 is preferably made of a material that expands with increasing temperature to make the effective flow paths through the passageways 94 smaller to compensate for the decreased viscosity of the fluid at higher temperatures to make the operation of the adjustable fulcrum 56 substantially independent of temperature.

Providing fluid to the interior of the adjustable fulcrum structures 54, 56 is an oil line 100 in communication with the oil galley 22 and leading to each of the adjustable fulcrums 54, 56. It will accordingly be seen that the upper end portion 102 of the plunger body 80 is lubricated by oil passing through the oil line 100, the cavity 96, the transverse passageway 84, and the vertical passageway 82. As will be explained more fully hereinafter, the closing rocker arm 60 is mounted for pivotal movement on the upper end portion 102 of the plunger body 80 of the movable fulcrum structure 56.

It will be evident that the spring means 78 biases the plunger 76 upwardly and thereby tends to induce plunger movement in the direction of the closing rocker arm 60. When the rocker arm 60 is capable of being moved by the spring 78, oil delivered from the galley 22 flows through the oil line 100, the cavity 96, the transverse passageway 84, and the vertical passageway 82 against closing movement of the check valve 86 to replenish fluid

in the blind opening 74 thereby maintaining the blind opening 74 substantially filled with oil.

When forces produced by the actuation of the desmodromic valve arrangement 24 tend to depress the plunger 76, the check valve 86 prevents fluid flow through the vertical passageway 82 thereby propelling the entrapped oil from the blind opening 74 through the passageways 94 into the cavity 96 and into the oil line 100. It will therefore be apparent that the movable fulcrum structure 56 comprises a dashpot or fluid retarder in which the blind opening 74 constitutes a dashpot cavity while the plunger 76 constitutes a piston allowing fluid flow more readily in one direction than in the other. The significance of the adjustable fulcrum structure 56 will be more fully explained hereinafter.

The closing rocker arms 58, 60 are of generally conventional configuration and respectively comprise bifurcated ends 104, 105 surrounding the valve stems 28, 42 and abutting the retainers 36, 50. The opposite ends 108, 110 of the respective rocker arms 58, 60 are configured to engage the cam means 66 as more fully discussed hereinafter. Suitable guide structure 112, 114 is provided for each of the rocker arm means 58, 60 to constrain them for movement in a generally up and down fashion. Guide structure 112, 114 is illustrated as a generally U-shaped element and is fixed to a web 116, 118 integral with the respective fulcrum structure 54, 56 by a bolt 120, 122.

The opening rocker arm means 62, 64 are of generally conventional configuration and comprise a sleeve or member 124, 126 mounted for movement on a rocker shaft 128, 130 each of which is fixed at suitable locations (not shown). Mounted on one end portion of each of the rocker arm means 62, 64 is a ball connection 132, 134 positioned in operative engagement with the elephant foot 38, 52 of the inlet and exhaust valves 26, 40. An adjusting screw 136, 138 is respectively associated with each of the ball connections 132, 134 for adjusting the relation between the rocker arm means 62, 64 and the valves 26, 40. Each of the rocker arm means 62, 64 comprises a cam engaging portion 140, 142 as will be explained more fully hereinafter.

The cam means 66 includes a shaft portion 144 mounted for rotation and driven in timed relation with respect to an engine crankshaft (not shown) in any suitable manner. A first cam 146 is rigidly mounted on the shaft portion 144 and juxtaposed to the cam engaging end portion 110 of the exhaust closing rocker arm means 60. Immediately behind the first cam 146 is a second cam 148 juxtaposed to the cam engaging end portion 108 of the closing rocker arm means 58. A third cam 150 is positioned behind the first and second cams 146, 148 and is juxtaposed to the opening rocker arm means 64. Although the opening rocker arm means 62, 64 may be arranged for operation by the third cam means 150, it is preferred that a fourth cam 152 be provided on the shaft portion 144 behind the third cam 150 for operation of the opening rocker arm means 62.

Referring more particularly to the showing of FIGURE 1, it will be seen that the intake valve 26 is closed while the exhaust valve 40 is open. Accordingly, the third cam 150 is illustrated as cooperating with the cam engaging portion 142 of the exhaust opening rocker arm means 64 to depress the ball connection 134 and thereby depress the exhaust valve 40. The first cam 146 is configured to allow relative upward movement of the cam engaging end portion 110 of the exhaust closing rocker arm means 60 during downward movement of the exhaust valve 40. With the cam means 66 rotating in a counterclockwise direction as shown by the arrow in FIGURES 1 and 2, the outwardly extending lobe of the third cam 150 moves out of abutting engagement with the exhaust opening rocker arm means 64 thereby enabling the exhaust closing rocker arm means 60 to close the exhaust valve 40. Contemporaneously with the disengagement of the third cam 150 and the exhaust opening

rocker arm means 64, the first cam 146 depresses the cam engaging end portion 110 of the exhaust closing rocker arm means 60. Accordingly, the bifurcated end 106 of the rocker arm means 60 acts against the retainer 50 to seat the exhaust valve 40 as shown in FIGURE 2.

Continued rotation of the cam means 66, in the direction indicated by the arrow, positions the outwardly extending lobe of the fourth cam 152 in abutting relation with the cam engaging portion 140 of the opening rocker arm means 62 as shown in FIGURE 2. Accordingly, the rocker arm means 62 is moved about the axis of the shaft 128 to depress the ball connection 132 and thereby open the inlet valve 26.

An important feature of the desmodromic valve arrangement of this invention is graphically illustrated in FIGURE 3 wherein there is shown the relationship between various forces generated and the speed of the engine with which the arrangement is associated. The rapidly increasing trace A designates the inertial forces generated by movement of one of the valve and closing rocker arm units. The trace B designates the resisting force produced by the movable fulcrum structure associated with the valve and closing rocker arm unit. The bracketed area C designates the preload force produced by the spring means 78. The increasing resistance force illustrated by the upwardly inclined trace B results from the dashpot nature of the movable fulcrum structures 54, 56. The intersection D of the traces A and B represents the engine speed at which the inertial forces of the valve and closing rocker arm unit equals the resisting force produced by the movable fulcrum structures 54, 56. The intersection D also represents the engine speed at which the rocker arm and the valve are no longer bound together by the force produced by the movable fulcrum. At engine speeds above the intersection D, the closing rocker arm and valve will no longer operate as a unit and therefore marks the maximum obtainable engine speed. The vertical distance between the traces A and B is representative of the force tending to bind the cam, rocker arm and valve together as a unit.

The primary function of the movable fulcrum of this invention and of the movable fulcrums shown in the prior art desmodromic valve arrangements is to accommodate for thermal expansion of the cam, rocker arm and valve and also to accommodate for wear thereof. These functions are accomplished in both the device of this invention and in prior art desmodromic valve arrangements having movable fulcrums by binding together the cam, rocker arm and valve to operate as a unit.

Although the primary functions of accommodating thermal expansion and wear had been achieved by the movable fulcrums of the prior art desmodromic valve arrangements, several disadvantages have accrued therefrom. Exemplary of prior art movable fulcrums illustrating a spring binding together the cam, rocker arm, and valve is U.S. Patent No. 1,541,081. It is axiomatic that the force produced by such a spring must exceed the inertial forces of the rocker arm and valve in order to bind the cam, rocker arm, and valve together, as a unit. As shown in FIGURE 3 the line E illustrates a spring load of a device such as is shown in Patent 1,541,081 necessary to produce a float point equivalent to the float point D of the device of this invention. It will accordingly be apparent that this spring would be of great strength thereby necessitating large contact forces between the cam and rocker arm at all speeds. As compared to the resisting force illustrated as trace B it will be seen that the prior art movable fulcrum desmodromic valve arrangement results in premature cam and rocker arm failure. In contrast, the desmodromic valve arrangement of this invention results in cam forces proportional to engine speed and accordingly minimizes cam and rocker arm wear during all ranges of engine speed operation.

Referring again to FIGURE 3, trace F represents the relationship between forces produced by a conventional

spring-dashpot lash adjuster when used to support the movable fulcrum of a desmodromic valve arrangement. It will be noted that there is a discontinuity G between the two segments of the trace F. The discontinuity G represents the speed at which the spring of the conventional lash adjuster no longer effectively operates. This phenomenon occurs because the spring is being flexed so rapidly that the spring has no time to rebound and return the dashpot plunger, pivot structure and the rocker arm means associated therewith before the next impartation of force thereon. The intersection H between the trace F and the trace A designates the engine speed at which inertial forces of the valve and closing rocker arm equals the resisting force produced by a conventional spring-dashpot lash adjuster.

The vertical separation of the trace F and the trace A is representative of the force tending to bind the cam, rocker arm and valve together to operate as a unit. At engine speeds greater than the intersection or float point H, the cam, rocker arm and valve no longer operate as a unit. Accordingly, the use of a conventional spring-dashpot lash adjuster as a support for a movable fulcrum, the maximum engine speed is designated at point H. It is accordingly apparent that the use of a conventional spring-dashpot lash adjuster in a desmodromic valve arrangement is such that the discontinuity G occurs at lower engine speeds than the float point H. It will accordingly be seen that the maximum engine speed that is obtainable is seriously limited.

The shape of the trace F should be compared to the shape of the trace B wherein the discontinuity J occurs at a higher engine speed than the float point D. Accordingly, with the movable fulcrum structure of this invention, the resistance forces produced continue to increase without substantial diminution in the rate of increase during all ranges of engine operation.

Referring now to FIGURE 4, the relationship between exhaust rocker arm movement and the rotation of the cam means 66 is graphically illustrated. It should be noted that the trace of movement of the opening rocker arm means 64 is not identical with the trace of movement of the closing rocker arm means 60. This is a reflection of the shape of cams 146, 150 and illustrates the fact that these cams are not perfectly conjugate. It will be noted that during initial exhaust valve opening movement, the closing rocker arm means 60 leads the opening rocker arm means 64 thereby allowing the opening rocker arm means 64 to control movement of the exhaust valve 40. It may be said, therefore, that during initial movement of the exhaust valve 40 toward the opening position, forces imparted by the cam 146 on the rocker arm means 60 are relaxed. In the event the rocker arm means 60 is stressed below a predetermined amount, for example, one hundred pounds, the plunger 76 of the fulcrum structure 56 is biased upwardly by the spring means 78 with fluid from the oil line 100 passing through the check valve 86 into the dashpot cavity 74. It will therefore be seen that the spring means 78 maintains the cam means 66, rocker arm means 60 and valve 40 in operative relation. Assisting in this operation is oil pressure from the oil supply line 100 which operates on the bottom of the plunger 76 to propel the plunger 76 upwardly.

It will be seen that the force imparted to the valve 40 during initial cam rotation increases rapidly to a maximum value at point L in FIGURE 5 which corresponds to point L in FIGURE 4. The decreasing force applied to the valve 40 after point L is the result of the closing rocker arm means 60 bearing against the retainer 50. When the opposite forces transmitted to the valve 40 by the rocker arm means 60, 64 are equal (point M in FIGURE 5) the valve 40 is approaching the half opened position, as graphically depicted at point M in FIGURE 4. During the negative valve acceleration region (M to N in FIGURE 5), the opening lobe 150 and the closing lobe 148 diverge from each other in the manner

shown in FIGURE 4, forcing down the dashpot plunger 76. The force resisting this motion is proportional to the speed, and serves to overcome the inertial forces tending to separate the parts.

It will be noted that the resultant force imparted to the valve 40 by the rocker arm means 60, 64 in the condition illustrated at M in FIGURES 4 and 5 is substantially zero. If the forces imparted to the rocker arm means 60 are less than about one-hundred pounds, the spring means 78 of the movable fulcrum structure 56 forces the plunger 76 upwardly to increase the forces binding the cam, rocker arm and valve together as a unit.

Continued rotation of the cam means 66 results in increased closing forces imparted to the rocker arm means 60 to force the exhaust valve 40 toward the closed position. When the valve face 44 mates with the valve seat 18 at an insufficient sealing force, for example, less than one-hundred pounds, the spring means 78 pushes the dashpot plunger 76 upwardly to seat the valve 40 securely. Whenever the plunger 76 is forced upwardly by the spring 78, oil from the oil line 100 flows into the dashpot cavity 74 thereby preventing easy downward movement. The movable fulcrum structure 56 therefore acts much like a one-way actuator to take up slack quickly and to relax slowly. It should be noted at this time that the fulcrum structure 56 appears relatively rigid to high dynamic forces, for example, in the order of eight hundred to one-thousand pounds, but appears resilient to slow dimensional forces such as those produced by thermal expansion or wear. As pointed out in the discussion of FIGURE 3, the forces produced by the movable fulcrum structure 56 are speed dependent such that at low engine speeds, the forces developed are small while at high engine speeds, the forces are larger in order to bind the cam, rocker arm, and valve together as a unit.

Attention is now directed to FIGURES 6 to 8, wherein there is shown another desmodromic valve arrangement 224 arranged to work against a stem tip 226 on a stem 228 of a valve 230. The desmodromic valve arrangement 224 comprises a supporting plate 232 on which is mounted a first movable fulcrum structure 234 and a second movable fulcrum structure 236. The first fulcrum structure 234 may be substantially identical to the fulcrum structure 56 disclosed in the embodiment of FIGURES 1 and 2, and in any event should have operative characteristics similar thereto.

The first fulcrum structure 234 has a dashpot plunger 238 having a generally spherical upper end portion 240 carrying closing rocker arm means 242. The closing rocker arm means 242 is configured similarly to the rocker arm means 58, 60 and comprises a bifurcated end portion 244 disposed beneath the stem tip 226 in operative relation thereto. The closing rocker arm 242 also provides a camming surface 246 to work against a suitable cam structure as will be pointed out hereinafter.

The second movable fulcrum structure 236 comprises a housing 248 forming a blind opening or dashpot cavity 250 therein in which is slidably mounted a dashpot plunger 252. Biasing the dashpot plunger 252 in an upwardly direction is a spring means 254 which differs from the spring means of fulcrum structures 54, 56, 234 in that the spring means 254 is a much weaker spring and preferably is on the order of about ten pounds to fifteen pounds.

The dashpot plunger 252 comprises a body 256 having a longitudinal passageway 258 extending therethrough and intercepting a transverse passageway 260. The lower end of the longitudinal passageway 258 is closed by a check valve arrangement 262 having a valve member 264 biased against the plunger body 256 by a plurality of spring arms 266. The plunger body 256 forms a circumferential groove 268 providing a means of ensuring continued connection of the passageways 258, 260 to a source of

pressurized fluid (not shown) such as the oil line 100 of the embodiment of FIGURES 1 and 2.

The plunger body 256 forms a generally spherical upper end portion 270 on which is fulcrumed an opening rocker arm means 272 having an opposite end portion 274 disposed above the stem tip 226. The underside of the end portion 274 provides a recess 275 cooperating with the upper end portion of the valve stem 228 for transmitting forces from the end portion 274 to the valve stem 228. The opening rocker arm means 272 provides a camming surface 276 for cooperation with the cam means 278.

The cam means 278 comprises a shaft 280 journaled at suitable locations for rotation about an axis 282 and carries a closing cam 284 and an opening cam 286. The opening and closing cams 284, 286 may be configured in the same manner as the cams 146, 148, 150.

The operation of the desmodromic valve arrangement 224 is substantially the same as the operation of the desmodromic valve arrangement 24. It should be noted, however, that the second movable fulcrum structure 236 allows for thermal expansion and wear of the opening rocker arm 272 and the opening cam 286.

While the invention has been described, disclosed, illustrated and shown in terms of preferred embodiments, the scope of the invention should not be deemed to be limited by the precise modifications herein shown, described, illustrated and disclosed such other modifications, embodiments, procedures or equivalents are intended to be reserved especially as they fall within the scope of the claims here appended.

What is claimed is:

1. An engine comprising:

a head casting having inlet and outlet ports;
an intake valve disposed in the inlet port for sealing the inlet port and for opening the inlet port to allow fluid flow therethrough, the intake valve having a valve stem;

structure on the valve stem defining spaced surfaces on which separate rocker arms may work;

an opening rocker arm shaft;

an opening rocker arm rotatable on the shaft and arranged to abut one of the surfaces defined by the structure on the valve stem for depressing the valve stem;

a closing rocker arm arranged to abut another of the surfaces defined by the structure on the valve stem for retracting the valve stem;

structure providing a movable fulcrum supporting the closing rocker arm, the movable fulcrum structure comprising:

dashpot means having a housing carried by the head casting and having a passage therein;

a plunger slidably mounted in the passage and forming a dashpot cavity in conjunction with the housing, the plunger having first and second passageways therethrough leading to the dashpot cavity;

a check valve arranged to allow fluid flow through the first passageway toward the dashpot cavity and to prevent reverse flow therethrough;

oil supply means in communication with the first and second passageways;

spring means in the dashpot cavity arranged to bear against the dashpot plunger to force the plunger toward the closing rocker arm;

the spring means and the dashpot means being arranged to produce a force resisting movement of the plunger into the dashpot cavity proportional to engine speed and having a discontinuity therein at a higher engine speed than that value where the inertial force of the valve and the rocker arm equals the opposing force produced by the biasing means; and

cam means for actuating the rocker arms comprising:

a rotatable shaft;

opening cam structure on the cam shaft for rotation therewith and arranged to abut the opening rocker arm;

closing cam structure on the cam shaft for rotation therewith and arranged to abut the closing rocker arm;

said cam structures being arranged to effect leading of the closing rocker arm during initial valve opening and lagging of the closing rocker arms during the remainder of valve movement.

2. The engine of claim 1 further comprising:

an exhaust valve disposed in the exhaust port for sealing the exhaust port and for opening the exhaust port to allow fluid flow therethrough, the exhaust valve having:

a valve stem;

structure on the exhaust valve stem defining spaced surfaces on which separate rocker arms may work;

an exhaust valve rocker arm shaft;

an exhaust valve opening rocker arm rotatable on the exhaust valve rocker arm shaft, the exhaust valve opening rocker arm being arranged to abut one of the surfaces defined by the structure on the exhaust valve stem for depressing the valve stem;

an exhaust closing rocker arm arranged to abut one of the surfaces provided by the structure on the exhaust valve stem for retracting the exhaust valve stem;

structure providing a movable fulcrum supporting the exhaust closing rocker arm, the movable structure comprising:

dashpot means having a housing carried by the head casting and having a passage therein;

a plunger slidably mounted in the passage and forming a dashpot cavity in conjunction with the housing, the plunger having third and fourth passageways therethrough leading to the dashpot cavity;

a check valve arranged to allow fluid flow through the third passageway toward the dashpot cavity and to prevent reverse flow therethrough;

a conduit leading from the oil supply means providing communication between the oil supply means and the third and fourth passageways;

spring means in the dashpot cavity arranged to bear against the dashpot plunger and force it toward the exhaust closing rocker arm;

the spring means and the dashpot means being arranged to produce a force resisting movement of the plunger into the dashpot cavity proportional to engine speed and having a discontinuity therein at a higher engine speed than that value where the inertial force of the valve and rocker arm equals the opposing force produced by the biasing means; and

means for actuating the exhaust rocker arms comprising:

exhaust opening cam structure on the cam shaft for rotation therewith and arranged to abut the exhaust opening rocker arm;

exhaust closing cam structure on the cam shaft for rotation therewith and arranged to abut the closing rocker arm;

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said cam structures being arranged to effect leading of the exhaust closing rocker arm during initial valve opening movement and lagging of the exhaust closing rocker arm during the remainder of exhaust valve movement.

3. The engine of claim 2 wherein the spring means of both the fulcrum structures comprises:

a seventy-five to one-hundred pound compression spring.

4. In an engine of the type having a valve, means for positively opening the valve and means having a rocker arm for positively closing the valve, the improvement comprising:

structure providing a movable fulcrum for the rocker arm,

said structure having biasing means forcing the rocker arm toward the closed position,

said biasing means being arranged to produce an opposite force resisting movement of the fulcrum proportional to engine speed and having a discontinuity at a higher engine speed than that value where the inertial force of the valve and rocker arm equals the opposing force produced by the biasing means.

5. The engine of claim 4 wherein the biasing means comprises:

spring means and dashpot means.

6. The engine of claim 4 wherein the engine further comprises:

cam means having opening cam structure for actuating the positive opening means and closing cam structure for actuating the positive closing means, the cam structures being arranged to effect leading of the rocker arm during initial valve opening and lagging of the rocker arm during the remainder of valve opening.

7. The engine of claim 6 wherein the cam means is further arranged to effect lagging of the rocker arm during the remainder of valve movement.

8. The engine of claim 4 wherein the movable fulcrum structure comprises a dashpot having at least one fluid transmitting passage therethrough and a thermal expansive element disposed adjacent the passage, the thermal expansive element being responsive to increases in temperature to expand and thereby restrict the effective size of the fluid transmitting passage.

9. In an engine of the type having a valve, means for positively opening the valve and means having a rocker arm for positively closing the valve, the improvement comprising:

structure defining a movable fulcrum for the rocker arm for forcing the rocker arm toward the closed position and arranged to produce force resisting movement of the fulcrum in the opposite direction proportional to engine speed.

10. The engine of claim 9 wherein the structure defining the movable fulcrum structure comprises spring means and dashpot means.

11. The engine of claim 9 wherein the structure defining the movable fulcrum comprises spring means and dashpot means arranged to develop the engine speed proportional force, the engine speed proportional force having a discontinuity therein at engine speeds above that value where the inertial force of the valve and rocker arm equals the opposing force produced by the spring and dashpot means.

12. The engine of claim 11 wherein the dashpot means comprises:

a housing having a passage therein;

a plunger slidably mounted in the passage and forming a dashpot cavity in conjunction with the plunger, the plunger having

first and second passageways therethrough leading to the dashpot cavity;

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a fulcrum thereon receiving the rocker arm;

a check valve arranged to allow fluid flow through the first passageway toward the dashpot cavity and to prevent reverse flow therethrough; and

oil supply means in communication with the first and second passageways.

13. The engine of claim 12 wherein the spring means comprises a seventy-five to one-hundred pound compression spring in the dashpot cavity bearing against the plunger.

14. The engine of claim 12 further comprising a thermal expansive element disposed adjacent the second passageway, the thermal expansive element being responsive to increases in temperature to expand and thereby restrict the effective size of the second passageway to compensate for changes in fluid viscosity with temperature.

15. A desmodromic drive arrangement for positively opening and positively closing valves comprising:

a support;

first and second fulcrum structures carried by the support;

an intake valve closing rocker arm carried by the first fulcrum structure;

an exhaust valve closing rocker arm carried by the second fulcrum structure;

first and second opening rocker arm shafts disposed generally above each of the closing rocker arms;

an intake valve opening rocker arm carried by the first rocker arm shaft;

an exhaust valve opening rocker arm carried by the second rocker arm shaft; and

cam means comprising:

a cam shaft disposed between the first and second rocker arm shafts;

first cam structure on the cam shaft disposed to abut the intake valve closing rocker arm;

second cam structure on the cam shaft disposed to abut the intake valve opening rocker arm;

third cam structure on the cam shaft disposed to abut the exhaust valve closing rocker arm;

fourth cam structure on the cam shaft disposed to abut exhaust valve opening rocker arm.

16. The desmodromic drive arrangement of claim 15 wherein the cam structures are arranged to effect leading of the closing rocker arms during initial valve opening movement and to effect lagging of the closing rocker arms during the remainder of valve opening.

17. The desmodromic drive arrangement of claim 15 wherein each of the fulcrum structures comprises:

a movable plunger carrying the closing rocker arms;

spring means arranged to force the closing rocker arms toward the cam means; and

dashpot means operatively arranged with the plunger to develop a force resisting movement of the plunger away from the cam means proportional to engine speed.

18. In an engine of the type having a valve, first means having an opening rocker arm for opening the valve; second means having a closing rocker arm for closing the valve; and cam means for actuating the first and second means; the improvement comprising:

first movable fulcrum structure providing support for the opening rocker arm, the first movable fulcrum structure having first means forcing the opening rocker arm toward the cam means; and

second movable fulcrum structure providing support for the closing rocker arm, the second movable fulcrum structure having second means forcing the closing rocker arm toward the cam means.

19. The arrangement of claim 18 wherein the second means is stronger than the first means.

20. The arrangement of claim 18 wherein the second movable fulcrum structure comprises dashpot means arranged to allow relatively easy movement of the ful-

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crum toward the cam means and to impede movement in the opposite direction.

21. The arrangement of claim 20 wherein the second means is stronger than the first means.

22. The arrangement of claim 18 wherein the second movable fulcrum structure comprises spring means and dashpot means arranged to produce a force resisting movement of the closing rocker arm away from the cam means proportional to engine speed.

23. The arrangement of claim 18 wherein the second movable fulcrum structure comprises spring means and dashpot means arranged to produce a force resisting movement of the closing rocker arm away from the cam means, the force being proportional to engine speed and having a discontinuity at higher engine speed than that value where the inertial force of the valve and rocker arm equals the opposing force produced by the biasing means.

24. The arrangement of claim 18 wherein:
the first movable fulcrum structure comprises first dash-
pot means arranged to allow relatively easy move-
ment of the fulcrum toward the cam means and to
impede movement in the opposite direction; and
the second movable fulcrum structure comprises
second dashpot means arranged to allow relatively
easy movement of the fulcrum toward the cam
means and to impede movement of the opposite
direction;
the second means and the second dashpot means being
stiffer than the first means and the first dashpot
means.

25. A desmodromic valve arrangement comprising:
a valve having a stem;
an opening rocker arm operatively connected with the
valve stem to depress the valve;
a closing rocker arm operatively connected with the
valve stem to retract the valve;
first movable fulcrum structure supporting the opening
rocker arm at a point spaced from the valve stem,
the first movable fulcrum structure comprising:
first dashpot means comprising:

- a first housing having a passage therein;
- a first plunger slidably mounted in the passage
and forming a dashpot cavity in conjunc-
tion with the first housing, the plunger hav-
ing first and second passageways there-
through leading to the dashpot cavity;
- a first check valve arranged to allow fluid
flow through the first passageway toward
the dashpot cavity and to prevent reverse
flow therethrough;

first oil supply means in communication with
the first and second passageways; and

first biasing means in the dashpot cavity arranged
to bear against the force the dashpot plunger
toward the opening rocker arm;

second movable fulcrum structure supporting the clos-
ing rocker arm at a point spaced from the valve stem
and intermediate location on the closing rocker arm,
the second movable fulcrum structure comprising:

- second dashpot means comprising:
a second housing having a passage therein;
- a second plunger slidably mounted in the
passage and forming a dashpot cavity in
conjunction with the second housing, the
plunger having third and fourth passage-
ways therethrough leading to the dashpot
cavity;

a second check valve arranged to allow fluid
flow through the third passageway toward
the dashpot cavity and to prevent reverse
flow therethrough;

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second oil supply means in communication
with the third and fourth passageways;

second biasing means in the dashpot cavity ar-
ranged to bear against and force the second
plunger toward the closing rocker arm, the
second biasing means being stronger than the
first biasing means; and

cam means comprising:

a shaft;
opening cam structure on the shaft disposed
to engage the opening rocker arm between
intermediate the fulcrum and the valve
stem; and

closing cam structure on the shaft disposed
to engage the closing rocker arm on an-
other portion away from the fulcrum from
the valve stem.

26. A desmodromic valve arrangement comprising:

a valve;
an opening rocker arm in operative relation with the
valve for depressing the valve;
means for supporting the opening rocker arm;
a closing rocker arm in operative relation with the valve
for retracting the valve;
movable fulcrum structure supporting the closing
rocker arm for generally up and down movement;
and
cam means for actuating the rocker arms in timed re-
lation to each other;

the movable fulcrum structure comprising:

- a movable element carrying the closing rocker
arm;
- spring means forcing the rocker arm toward the
cam means;
- dashpot means arranged to resist movement of the
movable element away from the cam means,
the resistance of the dashpot means being pro-
portional to the cyclic rate of movement of the
valve.

27. The desmodromic valve arrangement of claim 26
wherein the resistance of the dashpot means has a dis-
continuity at cyclic rates of speed higher than that value
where the inertial force of the valve and rocker arm
equals the resistance of the dashpot means.

28. The desmodromic valve arrangement of claim 26
wherein the cam means is arranged to produce leading of
the closing rocker arm during initial valve opening and
lagging of the closing rocker arm during the remainder
of valve opening.

29. The desmodromic valve arrangement of claim 26
wherein the cam means is arranged to produce leading of
the closing rocker arm during initial valve opening and
lagging of the closing rocker arm during the remainder
of valve movement.

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