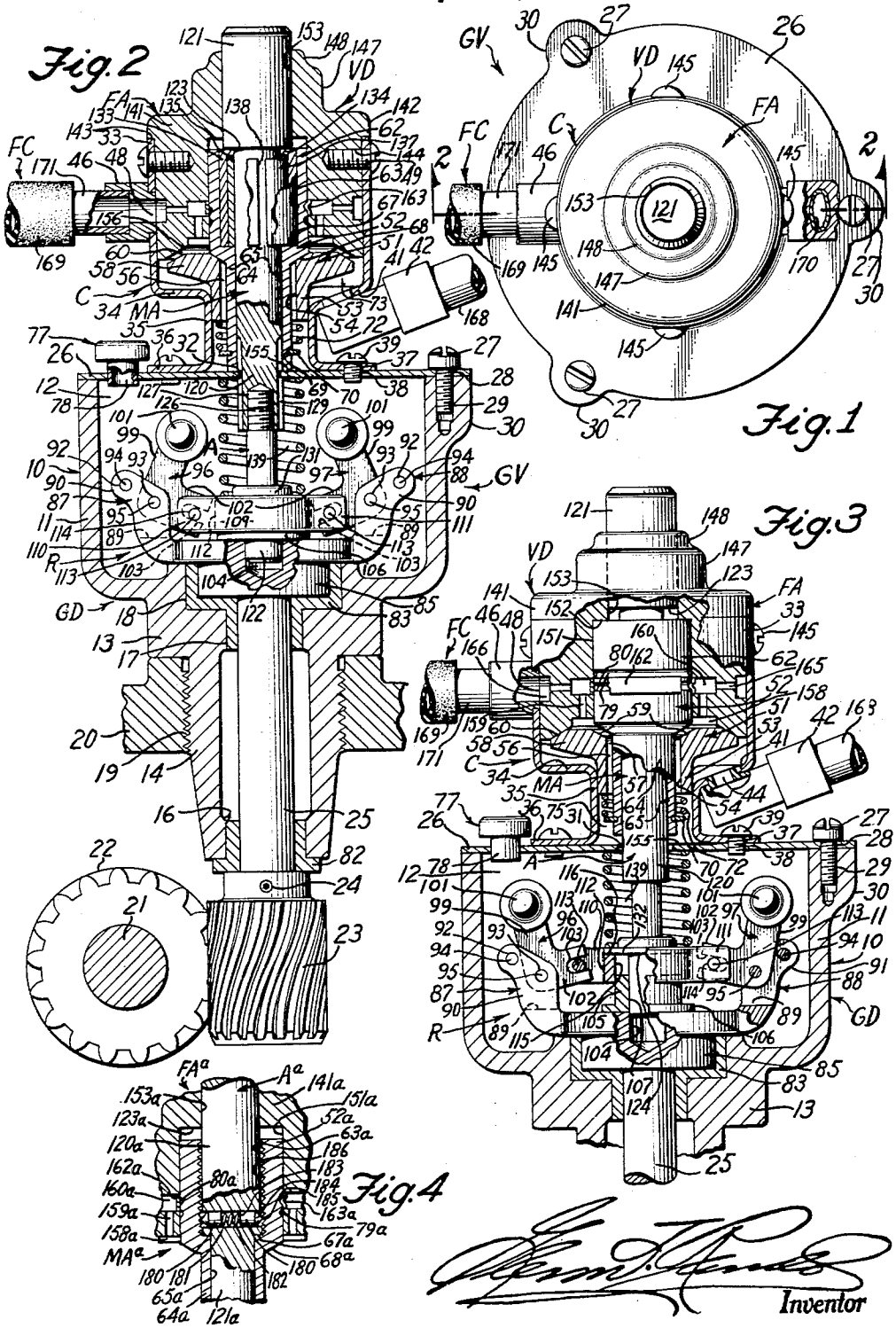
April 5, 1960 G. T. RANDOL 2,931,374

SPEED-RESPONSIVE VALVE MECHANISM

Filed April 22, 1957



United States Patent Office

2,931,374

Patented Apr. 5, 1960

2,931,374

SPEED-RESPONSIVE VALVE MECHANISM

Glenn T. Randol, Mountain Lake Park, Md.

Application April 22, 1957, Serial No. 654,379

16 Claims. (Cl. 137—54)

The present invention relates to a new and novel speed-responsive valve device actuated by centrifugal force generated by a rotatable element movable relatively toward and away from its axis of rotation as a function of its speed of rotation, said device being designed for controlling an associated fluid circuit at a plurality of selective points within a predetermined operating range thereof.

In a broader sense, my invention concerns a novel speed-sensitive valve mechanism for selectively controlling a fluid circuit adapted to control the operation of a fluid pressure energizable apparatus such as, for example, a hydraulic master cylinder for automotive hydraulic braking systems, automotive clutch operating servomotors and the like, said power device being situated approximately or remotely to said mechanism, and wherein such apparatus may be energized or de-energized at a plurality of selective stations defining the full operating stroke of an element reciprocably actuated in response to variations in the speed of said rotatable element whereby, for example, said actuatable element is operable to cause energization of the apparatus at all stations during speed increase and to cause de-energization thereof substantially at all such stations in response to decrease in the speed of the centrifugally-operated parts and vice versa. Therefore, the present invention contemplates the control of fluid energizable power apparatus through the full operating range of the speed-sensitive control valve whereby minute change in the speed of the rotating element at all points along the operating range thereof is effective to open and close the control circuit responsive to increase and decrease of speed respectively at a selected point, with continuous increase or decrease in speed being effective to maintain the control valve in its initially selected operating position until the opposite direction of actuation occurs.

More specifically, my invention is directed to the provision of novel valve mechanism operable in response to minute reciprocable movements of an element to two operating positions along the full operating stroke thereof defined by a governor, preferably of the centrifugal-type, operable through a predetermined speed range, said valve mechanism and governor forming a unitary assembly.

The primary objects of the invention therefore, are the provision of a compact and simple speed-sensitive valve mechanism responsive to minute reciprocable movements of an actuatable element, for selectively controlling a fluid circuit at any point along the full operating stroke of said element; the provision of means for operating said mechanism at speeds proportional to the speed of a rotating element; the provision of means incorporated in said mechanism for accommodating incremental movements of the actuatable element without affecting the then existent relative disposition of the fluid circuit controlling elements; and the provision of means for stabilizing the valve mechanism in its different operating positions despite relative movement of the centrifugally-operated parts in the same direction following establishment of a given operating position.

A further and important object of the invention related to the series of primary objects immediately preceding, is the provision of means to accommodate a full operating stroke of the centrifugally-operated means relative to either of said operating positions which in the present disclosure, by way of example, correspond to open and closed positions of an included movable valve assembly, and wherein said movable valve assembly is operatable to said open and closed positions with respect to a fixed valve seat substantially at all points along the full stroke of the centrifugal means responsive to minute reciprocable movements thereof within the operating stroke aforesaid to thus produce, in effect, a follow-up control of the energization and de-energization of a fluid power device controlled by the associated fluid circuit.

Another object relative to that immediately above, is the provision of novel means to enable continued movement of the centrifugally urged parts in the same direction after the movable valve assembly has been withdrawn from the fixed valve seat to open the valve mechanism, without affecting the then existent open disposition of the assembly; to enable continued movement of the centrifugally urged parts in the opposite direction after the movable valve assembly has been moved to seated relationship with respect to each other and the fixed seat and thus open the valve mechanism; and to enable arrested disposition of the centrifugally urged parts during the full operating stroke thereof in either direction without affecting the then obtaining disposition of said movable assembly.

The present invention contemplates utilization of either a friction-type clutch mechanism between the actuatable element and movable valve assembly for imparting limited reciprocable movement to the latter at selected points along the full operating stroke of said element, or a modified structure comprising a spring-loaded movable detent assembly carried by the actuatable element for engaging a series of suitable cooperating recesses formed in one of the members comprising said movable assembly. In a more specific sense, a pair of detents are provided with conically formed ends with the apexes thereof releasably engageable with a series of parallelly disposed V-shaped circular channels formed in the cylindrical surface of coaxial bore in the movable member aforesaid.

In the more comprehensive and detailed description to follow, features and advantages not specifically recited hereinbefore will be apparent or noted, reference being had also to the accompanying drawing in which:

Figure 1 is a plan view of a speed-sensitive valve mechanism constructed in accordance with the principles of the present invention;

Figure 2 is a longitudinal sectional view on an enlarged scale taken along the line 2—2 of Figure 1, illustrating the control elements of the mechanism in an operated (open) condition, and the gear-drive for imparting rotational movement to the control elements thereof;

Figure 3 is a fragmentary sectional view of Figure 2, illustrating the control elements in a different operated (closed) condition; and

Figure 4 illustrates a modified form of the invention incorporating a yieldable detent clutch drive operably disposed between the centrifugally influenced actuator and one of the movable valve elements.

Like characters of reference designate like parts in the several views with corresponding parts in the Figure 4 modification distinguished, however, by the addition of the letter "*a*" to each.

The speed-responsive valve mechanism comprising the

present invention is designated in its entirety by letters "GV," and its incorporation in a fluid circuit, generally designated "FC," has been resorted to for illustrating and explaining, by way of example, the novel construction and operation thereof.

Referring to the drawing in detail and first to Figure 1–3 inclusive, wherein my new and improved speed-responsive valve is shown as being employed to control the opening and closing of a valve device generally designated "VD" in a single fluid circuit. The governor device is generally designated "GD" and the valve device to be controlled thereby is particularly constructed and arranged for actuation from one operating (open) position to another operative (closed) position in response to speed, or other actuating force, variations.

The governor device GD is of substantially conventional construction of the commonly known "fly-ball" type, and therefore, only such features of construction will be described as will insure a complete understanding of the new and novel valve mechanism VD and its novel utilization of the centrifugal action of the governor for its operation. The governor GD includes a hollow casing **10** provided with an upper, generally cylindrical cup-like casing **11** defining an open-topped inner chamber **12** overlying a lower mounting extension **13** having an exteriorly threaded shank **14** provided with an axial bore **16**. The bore at its upper end terminates in a radially enlarged bore **17** defining an open-topped counterbore **18** in continuous communication with the chamber **12**. The casing shank portion **14** is threadedly received by a mating threaded aperture **19** formed in a support structure **20**, which may conveniently be a bracket member secured to the block of a motor vehicle engine. An output shaft **21**, or other source of control speed, carries for rotation therewith a gear or similar toothed member **22**, which member **22** meshes with a worm gear or other matingly toothed member **23**. The member **23** is pinned as at **24** or otherwise co-rotatably secured to a driven shaft **25** which serves to actuate the control elements of the governor, as will be hereinafter described in greater detail.

The open-topped chamber **12** of the casing is closed by a cap or cover **26** of circular configuration and which carries on its upper exterior side in coaxial disposition with respect to the driven shaft **25**, the valve device VD as seen to best advantage in Figures 2 and 3; said device including as principal components a cup-shaped valve casing or body generally designated "C," a movable valve assembly generally designated "MA"; and a fixed valve assembly generally designated "FA."

The cover **26** is detachably secured to the casing **11** by suitable means, as by cap screws **27** projecting through holes **28** in the peripheral margin of the cover into threaded engagement with threaded holes **29** provided in registering side embossments **30** integral with the exterior of the casing **11** adjacent the open end thereof. Centrally disposed in the cover is a circular aperture **31** formed with a pair of diametrically opposed inwardly projecting tabs **32** for an important purpose as will appear.

The cup-shaped casing C includes a cylindrical body portion **33**; an end wall **34**; an externally projecting reduced tubular bearing portion or collar **35** integral with the latter and terminating in a circular outturned flange **36** having a plurality of circumferentially spaced holes **37** registering with threaded holes **38** formed in registering disposition with those in the cover **26** for reception of fasteners **39** such as the illustrated cap screws (Figures 2 and 3) to rigidly secure the valve device VD to the cover of the governor device GD thus forming the mechanism GV; an angular embossment **41** extruded outwardly from the end wall **34** between the body and tubular portions; an angularly disposed hollow fitting **42** closed at one end and attached exteriorly of said embossment; a fluid passageway **44** through a side wall of said fitting communicating with the interior of the casing and fitting; a cup-shaped fitting **46** secured to the exterior of the cylindrical portion of the casing medially thereof; a fluid passageway **48** through the end wall of the latter fitting establishing fluid communication with the interior of the casing; and a plurality of circumferentially spaced holes **49** through the cylindrical portion adjacent the open end thereof.

The movable assembly MA includes a pair of telescopically related relatively movable poppet-type valve elements **51**, **52**, the outer element **51** comprising a tubular extension **53** having a longitudinal bore **54** therethrough and a plurality of coextensive longitudinal atmospheric channels **56** communicating with an internal annular space **57** at the inner end formed in the cylindrical surface of the bore **54**; an annular external flange head **58** forming the inner end of extension **53**; inner and outer concentric angular ring seats **59**, **60** formed in the end surface of the flange **58**. The inner element **52** comprises an inner terminating tubular body portion **62** having a longitudinal bore **63** and a tubular reduced diameter extension **64** projecting from the other end through the bore **54** and having a correspondingly reduced longitudinal bore **65** coaxially disposed with respect to the bore **63** and collar **35**; an internal annular shoulder **67** formed at the point of mergence of the bores **63**, **65**; and an angular ring-type seat **68** forming the external annular shoulder between the exterior surfaces of the tubular portion **62** and extension **64**; an external annular channel **69** formed in the exterior cylindrical surface of the extension **64** adjacent the end thereof and normally spaced from the end of the extension **53**; a split-type retainer ring **70** adapted to engage said channel; a helically formed compression spring **72** encircling the portion of the extension **64** projecting beyond the extension **53** with the opposite ends thereof reacting on the end of the extension **53** and retainer ring **70** to bias the outer and inner elements **51**, **52** toward each other to intimately engage the concentric valve seats **59**, **68**, in fluid-tight sealing relationship best demonstrated in Figure 2; an annular fluid chamber **73** in continuous communication with passageway **44** and formed between the end wall **34** and confronting face of the valve flange **58**; an annular atmospheric chamber **75** formed between the ends of the extensions **53**, **64**, confronting portion of cover **26**, cylindrical wall of the tubular casing extension **35** and spring encircled portion of the extension **53** and having continuous communication with the atmosphere aperture **31** in the cover **26**, chamber **12**, and an inverted cup-shaped breather or venting cap **77** pressfitted or otherwise attached to the exterior of the cover by means of a short tube **78**, said tube having a plurality of radial holes through its wall adjacent the end connected to the underside of the cap end wall to divert the direction of air flow across the open end of the cap into the governor chamber **12** thereby enabling the cap to act as a baffle to filter out foreign matter from entering the chambers **12** and **75** and also to silence the ingress of air through the aperture **31**. Formed in the exterior cylindrical surface of the inner valve tubular portion **62** are a pair of longitudinally spaced annular grooves **79**, **80** which serve an important function to be later fully described.

The shaft **25** is journalled for rotation within plain or sleeve-type bearings, one bearing **82** being pressfitted within the bore **16** at the lower extremity thereof and the other bearing **83** being seated in the counterbore **18** against the shoulder **17** above-described. The shaft **25** carries at its upper end an enlarged circular boss **85** either formed integrally therewith or detachably secured thereto for co-rotation, and the boss **85** forms part of the rotor indicated generally at "R." The rotor is generally cylindrical in shape (Figure 2), and is provided with a pair of diametrically opposed upstanding peripheral brackets **87**, **88** slotted at **89** to form each with a pair of legs **90**, **91** respectively having angularly dis-

posed cross bores 92, 93 with said bores being equipped with pressfitted cross pins 94, 95 respectively for a purpose to later appear.

The cross pins 95 pivotally support reversed L-shaped arms 96, 97 fitted into slots 89 with the upwardly projecting free arm 99 thereof terminating in a centrifugal weight or member 101 and the lower arm 102 normal to the free arm is slotted at 103, arms 99 being adapted to engage the cross pins 94 to limit the outward throw of the weights 101. The circular boss 85 forming the upper end of the shaft 25 has an axial bore 104. Coaxially disposed with respect to bore 104 is a sleeve 105 with its lower end terminating in an external annular flange 106 adapted to have continuous contact with the upper surface of the circular boss, said sleeve being centrally bored at 107 in axial alignment with the axial bore 104. Normally superimposed on the flange 106 is a circular disc member 109 having diametrically opposed ears 110, 111 each slotted at 112 and having a cross pin 113 pressfitted through cross bores 114, said disc having an axial bore 115 terminating at its upper end to form an internal annular shoulder 116 with a counterbore 117 forming the upper terminus thereof, the sleeve 105 being adapted to have a sliding fit within the axial bore 115 with the upper end of the sleeve 106 being in circular alignment with the shoulder 116 in the normal at rest disposition of the governor GD (see Figure 2).

Slots 112 receive the slotted ends 103 of the centrifugal arms 101 in engagement with the cross pins 113 to form a pivotal connection between the centrifugal members 101 and disc 109 whereby said disc is reciprocably movable in response to centrifugal action imparted to the arms 96, 97 by rotational movement of the rotor assembly R. A spool-type actuator or riser rod generally designated "A" is coaxially disposed with respect to shaft 25 and comprises a medial reduced diameter portion 120 terminating at each end with enlarged diameter portions 121, 122 respectively, the point of mergence between the enlarged portions forming with the portion 120 external annular shoulders 123, 124 respectively. The medial portion operably projects from the chamber 12 through the cover aperture 31 and tubular portion 35 into operative engagement with the inner valve member 52 as will appear. This lower enlarged portion 122 terminates at its upper end in a shouldered threaded stem 126 having threaded engagement with a threaded hole 127 in the portion 120 to facilitate assembly through the hole 31, and carries a pair of elongated longitudinal channels 129 diametrically disposed in the outer cylindrical surface thereof, said channels being engaged by the tabs 32 whereby the actuator is prevented from rotating, and therefore, provided with sliding movement only with respect to the fixed cover 26. As the disclosure clearly portrays, the lower diameter portion 122 projects through the bore 107 of the sleeve 105 into piloted relation with the shaft bore 104. A collar 131 terminating at its lower end into a right angle external annular flange 132, is pressfitted onto the portion 122 into engagement with the shoulder 124 whereby the collar and actuator A move together, the flange 132 being disposed movement within the counterbore 117 in engagement with the shoulder 116 when the governor GD is substantially at rest best demonstrated in Figure 2. A cylindrical sleeve-type bushing 133 is formed at its upper end adjacent the shoulder 123 with an internal right angle annular flange 134, said bushing being of substantially the same length as the bore 62 and having a pressfit therein to form an internal annular channel or space 135 between the flange 134 and internal annular shoulder 67 for reception of a contractible friction sleeve 137 made of springy material and longitudinally split at 138 to enable inward radial deformation in pre-installed status to provide a frictional coefficient between the sleeve 137 and rod portion 120 of such magnitude as to impart limited movement to the inner valve element 52 as will appear.

A normally preloaded helically formed compression spring 139 encircles the rod portion 120 operating within the chamber 12 with its upper end bearing on the marginal undersurface adjacent the cover aperture 31 and the lower end thereof continuously reacting on the collar flange 132 whereby the collar 131 and pivotally connected centrifuges 101 are biased to their respective positions shown in Figure 2 wherein the governor GD is substantially at rest. Therefore, when the governor is operating, the centrifugal force resulting is continuously opposed by the action of spring 139 and variations of such force cause in cooperation with the action of this spring the reciprocable movement of the riser A to elevate and lower the movable valve assembly MA a corresponding amount defined by the stroke of the latter shorter than the predetermined operating stroke of the actuator A, the latter being responsive to the full inward and outward throw of the weights 101 substantially best demonstrated in Figures 2 and 3 respectively.

Accordingly, the rotational movement of the rotor R is effective to raise and lower the actuator A responsive to centrifugal force generated by the outward movement of the flyweights 101, such force being transmitted from the weights through the L-shaped arms 96, 97 pivotally connected to the circular boss 85, thence through the lower arms 102, pivotal connection 103, 113 to the inner valve member 52 frictionally connected to said actuator A, it being noted that the rotational movement of the member 109 is not imparted to the actuator A and attached collar 131 due to the lower end 122 of the rod being piloted in the bore 104 and loosely projecting upwardly through the bore 107. However, any tendency for the actuator to rotate due to frictional engagement with the rotating parts is prevented by the engagement of the cover tabs 32 and cooperating channels 129.

The fixed valve assembly FA comprises a cylindrical body portion 141 having an external diameter of substantially the same internal diameter as the cylindrical portion of the casing C to accommodate telescopic assembly thereof to form the valve mechanism VD; an external flange 142 terminates the outer end of the cylindrical portion 141 and forms therewith an external annular shoulder 143 engaged by the open end of the casing C; a corresponding number of circumferentially spaced threaded holes 144 are provided in the cylindrical portion 141 adjacent the shoulder 143 for receiving in threaded engagement, for example, cap screws 145 which project through the holes 49 in the casing cylindrical wall whereby the casing C and assembly FA are secured in a unitary assembly; the outer end of the portion 141 is coaxially formed with an annular embossment 147 terminating in an offset reduced concentric embossment 148; a longitudinal bore 151 extends partially through the body portion 141 in which the tubular portion 62 of the inner valve member 52 slidably moves and forms an internal annular shoulder 152 with a coaxial reduced diameter bore 153 extending to the embossment exterior of the body portion 141 as shown in Figures 1 and 2, the upper end 121 of the actuator rod A projecting through the bore 153 as a bearing support therefor. Annular shoulders 124, 152 are normally longitudinally spaced as portrayed in Figure 2 when the valve device VD is open so that the shoulder 152 is engageable by the bushing flange 134 when the inner valve element 52 is moved to its other operating position shown in Figure 3 wherein the shoulder 124 on the actuator rod A has moved relatively with respect to upper end of the inner valve member 52 induced by the upper end of the valve element 52 engaging the shoulder 152 causing the friction sleeve 137 to release the actuator rod for such relative movement in the same direction which caused the Figure 3 disposition of the valve member 52. Accordingly, the shoulder 152 serves as a stop for establishing the valve member 52 in closed position (see Figure 3)

thereby limiting the upward movement of the movable valve assembly MA, and the opposite end of the extension 64 normally engages the confronting marginal upper face portion 155 of the cover 26, as shown in Figure 2, to limit the downward movement of the movable valve assembly MA thus establishing the open position thereof. In this manner, the outer face portion of the cover 26 adjacent the aperture 31 and the shoulder 152 define the limit of reciprocable movement of the movable valve assembly MA for opening and closing the valve mechanism VD while the actuating rod A is provided with a predetermined operating stroke of greater length than the minute reciprocation of the movable assembly MA, in accordance, for example, with the operating range of movement of the actuator A whereby the frictional engagement between the inner valve element 52 and actuating rod A enables limited reciprocations of the movable assembly MA at selected points along the full operating stroke of the actuator within the extremes thereof for novel purposes as will hereinafter appear.

The inner end of the valve body portion 141 is formed with an annular valve seat 156 in confronting relation with respect to the outer seat 60 on the outer valve element 51 and normally slightly spaced apart as depicted in Figure 2, said seat 156 merging at its inner marginal edge with an annular fluid chamber or space 158 in continuous communication with a plurality of longitudinal passageways 159 communicating with an annular internal passageway 160 formed in the cylindrical surface of the longitudinal bore 151 spaced above the annular chamber 158, said annular passageway 160 being fitted with a resilient split-type metallic ring 162 of springy material with one end formed with an inwardly extruded detent portion 163 adapted to cooperate with the grooves 79, 80 for selective engagement therein to stabilize the valve members 51, 52 in their two operating positions respectively. When the valve parts assume the positions shown in Figure 2, the detent portion 163 engages the groove 79, and when the Figure 3 disposition is effective, the groove 80 is engaged by the detent to thus releasably stabilize the inner valve element 52 in its open and closed position respectively. The tension inherent in the metallic ring 162 is of such magnitude as to require a very light actuating force from the flyweights 101 or spring 139 to slidably disengage the detent from the active groove and the move the inner valve member 52 to its other position for the other groove to be automatically engaged by the detent. And, as will be observed from the disclosure, this metallic ring in no way interferes with the free flow of air through the passageway 160, and its circular contour does not clamp the body portion 62 but provides an easy sliding fit therebetween so that the tension of the ring 162 is effective only to control the detent portion 163 whereby delicate engagement thereof with the grooves 79, 80 may be made according to the operating characteristics of the governor device GD. The annular space 160 is connected by a plurality of radial passageways 165 which in turn are connected to an external annular passageway 166 in circular alignment with the passageway 160, this latter passageway having continuous communication with the fitting passageway 48, and preferably flexible fluid conduits 168, 169 connected respectively to the fittings 42, 46 as by short tubes 170, 171 respectively are utilized to convey the fluid actuating pressure from its source via the valve VD to the apparatus to be controlled thereby.

A modified form of the invention is presented in Figure 4 by substituting for the friction ring connection a pair of diametrically opposed detents 180 movable radially toward and away from each other in a cross bore 181 provided in the actuator A^a normally adjacent the shoulder 68*a*, said movement being effected and accommodated respectively by an interposed preloaded compression spring 182. These detents are each preferably formed with a cylindrical base portion 183 terminating at their outer ends in a conical or tapered portion 184. The apex 185 being adapted to releasably engage a series of parallelly disposed closely generated circular V-shaped grooves or channels 186 formed in the bore 63*a* of the inner member 52*a* whereby limited reciprocal movement of the actuator A^a is transmitted to the inner valve member to operate in unison therewith and accommodate relative movement of the actuator in the same direction with respect to the movable valve assembly MA^a in response to increase in speed of the rotor R^a without disturbing the established operating condition of the valve device VD^a. However, upon decrease in speed of the rotor, the centrifugal weights 101*a* correspondingly withdraw the actuator to move the movable valve assembly MA^a via the detent connection in unison therewith to its other operating position, and thereafter, further decrease in speed of the rotor R^a retracts the actuator relatively to the assembly MA^a without disturbing its other position setting as a consequence of the detents ratcheting past the circular channels aforesaid until the governor GD^a establishes its normal at rest disposition as portrayed in Figure 2. In this at rest position the valve mechanism VD^a is conditioned for valve closing and opening cycles at different points along the full operating stroke of the actuator A^a in response to the governor device GD^a operating at increasing and decreasing speeds respectively.

The relative disposition of the modified movable assembly MA^a corresponds to open condition of the valve device VD^a, and it may be assumed that otherwise the components correspond to those of the embodiment first disclosed (Figures 1–3 incl.).

Accordingly, operation of the governor GD^a actuates the weights 101*a* to raise and lower the riser A^a in accordance with the centrifugal force generated by said weights above that necessary to counterbalance the reaction of spring 139*a*, and in so doing the movable valve assembly MA is operated out of and into engagement with each other and the fixed seat to close and open the valve device VD^a as should be clearly understood.

The primary function of the friction ring connection 120, 137 of Figures 1–3 inclusive or the modified detent connection of Figure 4, between the riser A and movable valve assembly MA is to impart minute reciprocable movements to the movable assembly to operate the valve device VD as described above responsive to variations in the speed of the rotating member 25, said minute reciprocations of the movable valve assembly being shorter than the full predetermined operating stroke of the riser A which enables an opening and closing position of the valve device VD at closely selected points along the full predetermined operating stroke of the centrifugally influenced riser A whereby, for example, a fluid operated motor may be energized under control of valve device VD to operate during speed decrease of the governor device GD whereat fluid communication between conduits 168, 169 is effective and for other uses as will appear. These conduits may be isolated from each other to de-energize said motor at substantially the same operating speed of the governor device GD which established such communication between them, in response to minute increase of governor speed from the factor prevailing at the selected open position of said valve device or vice versa.

Operation

As hereinbefore noted, the governor valve GV of the present invention is illustrated, for explanatory purposes, as incorporated in a fluid control circuit FC utilizing vacuum to produce a differential pressure for operating a fluid motor and the like.

With the parts in the positions shown in Figure 2, as a result of the biasing effect of the spring 139 on the flyweights 101, it will be noted that valve seats 59, 68 are firmly engaging each other in air-tight sealing relationship, while the valve seat 60 is slightly separated

from its mating seat 156 on the fixed body portion 141. Accordingly, a subatmospheric condition is present in both conduits 168, 169 via fitting passageway 42, the chamber 73, fluid chamber 158, passageways 159, 160, 165, 166, and fitting passageway 48 to energize the fluid motor connected to conduit 169. While the parts are in the positions explained above to energize the vacuum servomotor, it should be importantly noted that the biasing force of the spring 139 must be overcome by the centrifugal action of the weights 101 to place the inner valve element 52 in its other (closed) operating position portrayed in Figure 3 and, in the Figure 2 depiction the actuator shoulder 123 is acting on the bushing flange 134 thereby establishing the movable valve assembly MA in its open position defined by the lower end of the extension 64 on the valve element 52 in engagement with the confronting face portion 155 on the cover plate 26.

With the valve parts in the positions just described wherein the valve device VD is open, air is vented into chamber 75 and connected channels 56 and annular space 57 via the breather cap 77, governor chamber 12, and cover aperture 31, but cannot pass between the air controlling seats 59, 68 which are engaged, thus the annular atmospheric space 57 is isolated from the vacuum charged chamber 73 thereby establishing the valve mechanism in open condition.

Closure of the valve mechanism VD is accomplished by reversal of the operations noted above for opening it. Reference is now made to Figure 3 wherein the valve parts are shown in their respective position for establishing closed condition thereof which isolates the conduit 169 from the vacuum charged chamber 73, and places said conduit in communication with the atmosphere via fitting passageway 48, passageways 166, 165, 160, 159, fluid chamber 158, separated seats 59, 68, channels 56, annular space 57, cover aperture 31, governor chamber 12, and breather cap 77 to the atmosphere whereby the servomotor power chamber is vented to atmosphere to equalize the pressure on opposite sides of the movable power member thereof. This closing operation of the present valving mechanism may be accomplished at a plurality of closely selected positions within the extremes of the full operating stroke of the actuator A, and it should be importantly observed that the friction sleeve 137 has released the actuator sufficiently to enable the action of the weights 101 to raise the actuator to the position shown in Figure 3 wherein the shoulder 124 thereon is spaced from the upper end of the inner valve element 52 a greater distance than required for the movement of the valve members 51, 52 to their closed positions defined by the engagement of the valve element 52 with the shoulder 152. With the valve parts so positioned and slight decrease in the speed of the governor GD occurs, the valve members 51, 52 will be returned to their Figure 2 positions in unison with the actuator A and thereafter relative slipping release of the actuator will occur upon further decrease in governor speed to return the actuator to its normal fully retracted position shown in Figure 2 responsive to the action of the spring 139, and without disturbing the previously established open position of the valving, and in a similar manner the closed position of the valving after having been established will not be disturbed during relative movement of the actuator A in the direction previously causing such closed condition.

For a better comprehension of the operation of the present invention, let it be assumed that the rotary shaft 25 is driven, for example, from the fan belt of an engine in an automotive vehicle or the tailshaft of an included change-speed transmission, so that rotational speed of the shaft 25 is directly proportional to the speed of the engine or the tailshaft as the case may be. Further, let it be assumed that the fluid circuit FC forms part of the control circuit for a power-controlled friction clutch or automatic drive which is automatically operated in response to the flow of fluid pressure through the conduits 168, 169.

When the valve elements are open, as when the movable elements 51, 52 have their seats 68, 59, respectively engaged the fixed seat 156, fluid flow, for example, through the conduit 168 to conduit 169, energizes a motor or other fluid operated apparatus (not shown), the latter being connected to operate the clutch or drive as the case may be. As a result of the opening of the valve elements, fluid flow is established through the assumed control circuit. When the elements are closed, as in Figure 3, fluid flow is interrupted between the conduits 168, 169. Thus, it will be appreciated that the present invention provides means for controlling fluid flow through the conduits 168, 169 and an assumed control circuit FC associated therewith.

When the shaft 25 is rotating at a speed sufficient to generate a substantial centrifugal force sufficient to throw the weights 101 radially outwardly against the compression spring 139, the weights will assume the relative positions shown in Figure 3, and the movable valve elements 51, 52 will be separated, and the fixed element or seat 68 engaged. Thus no fluid flow through the assemblies MA and FA is possible. The cross pins 94 will serve to limit the outward throw of the weights best demonstrated in Figure 3 and the outward centrifugal force-responsive movement will serve to additionally compress the spring 139.

As the rotative speed of the shaft 25 decreases, the ratio of the spring compressive force to the outward centrifugal force will increase until such time as these two forces become substantially counterbalanced. After this counterbalancing point is reached, further decrease in speed produces a differential counteraction between the centrifugal and spring forces whereby the weights 101 will be moved inwardly until the spring 139 retracts the actuator A sufficiently to bring the movable valve elements 51, 52 into engagement with each other and the element 51 separated from seat 68 thereby opening the valve device VD as shown in Figure 2. Obviously, the exact point of valve element engagement and separation as aforesaid may be primarily controlled by the compressive strength of the spring 139 in relation to the weight of the centrifuges 101 at a given rotative speed of the latter. In this way, governor GD construction is contemplated to utilize selectively weighted springs 139 having a working rate from a predetermined installed tension such that opening and closure of the valve device VD may occur at relatively low rotating speeds of the shaft 25 or at higher relative speeds according to the control function desired.

Referring now to Figures 2 and 3, it will be observed that the closing of the valve device VD is accomplished by the outward action of the weights 101 and this movement represents only an increment of the full outward throw of the weights from the position of Figure 2 to the position wherein the outer edges of the L-shaped arms 96, 97 engage the cross pins 94. This incremental movement of the riser A in response to centrifugal force effects interruption of the seating engagement between the circular valve seats 59, 68 and engages seats 60, 156, such movement being exaggerated in Figure 3 for clarity in illustrating the separation of said valve elements, and for the same reason the space between the upper end of the valve element 51 and confronting shoulder 152 is correspondingly abnormal as shown in Figure 2. In Figure 3 this incremental or minute elevation of the movable assembly MA by the action of the centrifugal member 101 through the intermediary of the friction sleeve 137 engaging the cylindrical surface of the actuator portion 120. The frictional engagement of the spring 137 is sufficient and continuously acts on the actuator A to move the inner valve element 52 simultaneously therewith to the limits of said incremental movement thereof

defined by the shoulder 152 and cover 26. Accordingly, the spring 137 is effective to induce simultaneous movement of the valve member 52 with the riser A to elevate and lower the movable valve assembly MA to place the valve device VD in closed and open conditions respectively. A special novel feature of the present valve mechanism will now be described with reference to Figure 3. In this figure the valve members 51, 52 have been closed responsive to the incremental outward throw of the centrifuges 101 and the upper end of the valve member 52 moved into engagement with the shoulder 152 thereby establishing the limit of the elevating (closing) movement of the movable valve assembly MA. However, despite this stopped condition of the movable valve assembly, the increase in speed of the shaft 25 of the governor GD following such valve closing operation has caused the weights 101 to move further outwardly radially and the spring 139 additionally compressed. This latter operation is accommodated by the friction clutch mechanism 137 releasing the riser A from the valve member 52 responsive to the slipping engagement between the rod portion 120 and said valve member, to thus enable the riser A and connected centrifugal member 101 to move relatively to the valve member in the same direction as the prior incremental movement requisite to closing the valve device. Accordingly, as Figure 3 clearly demonstrates, the actuator rod A is positioned upwardly from the position utilized in establishing the incremental valve closing movement of the valve VD. In fact, the weights 101 may be rotated at such speed as to place their respective L-shaped arms 96, 97 in contact with the stop pins 94 which establishes the limit of the outward throw of said weights and the relative upward movement of the riser shaft A with respect to the valve member 52 stationed at the limit of its upward movement. With the parts in their respective relative disposition as shown in Figure 3, if the speed of the shaft 25 is decreased, it is obvious that the sleeve connection between the riser shaft A and valve member 52 will lower theim simultaneously to the position shown in Figure 2 wherein the lower end of the valve member 52 is in engagement with the cover 26 to establish the limit of the downward movement of the valve member 52 and connected valve element 51 and further decrease in the speed of the shaft 25 after said valve VD has been opened, results in the riser shaft A moving relatively to the valve member 52 as shown in Figure 2 responsive to the biasing action of the spring 139 made effective to lower the riser shaft A and weights correspondingly operated to their respective innermost positions through loss of centrifugal force. It is thus seen that the present novel valve mechanism GV provides for rapid intermittent openings and closings of the control circuit FC at any selected intermediate point of the riser shaft A along its full predetermined operating stroke in response to minute reciprocations of said shaft induced by centrifugal-spring forces acting thereon. It should be further manifest that at low rotating speeds of shaft 25 or at substantially stalled condition of the governor device GD, the valve mechanism VD reverts to the Figure 2 disposition, and that subsequent closing and opening of the valve VD may be effected at any selected point along the full operating stroke of the riser shaft A, responsive to minute reciprocable movements imparted to said shaft in accordance with slight variations in the speed of the drive shaft 25 to establish a higher and a lower speed with respect to a predetermined speed factor.

It should be importantly observed that the resilient detent ring 162 carried in the annular channel 160 in encircling relation with respect to the tubular valve portion 62, is effective to releasably engage the detent 163 in the two grooves 79, 80 to stabilize the movable valve assembly MA in its two extreme positions whereby the assembly requires some degree of actuating force for its movement from either extreme position in response to the centrifugal action of the flyweights 101 and counteracting spring 139. Upon establishing the movable assembly MA in either of its extreme positions (open and closed positions), the yieldable detent 163 insures that such position will be maintained notwithstanding relative movement of the riser rod A may ensue due to increase in speed of the governor device GD. Stated differently, stabilization of the movable valve assembly MA is necessary in its two operating positions depicted in Figures 2 and 3 so that operation of the governor device GD will not tend to produce a "hunting" or fortuitous vibratory effect on the valve position until a change of valve position is desired, for example, as by lowering the actuator rod A from the position of Figure 3 to the position of Figure 2 causing smooth transition of the valving from closed to open position at a higher speed condition of the governor than the speed actuation which effected the previously existent closed position.

Reverting now to exemplary illustrations of using the present valve device to control shifting of change-speed transmissions and the engaging and disengaging of an automotive power-operated clutch disposed in the drive line of the vehicle between the engine and a change-speed gearbox, this valve mechanism finds special use in the automotive field, particularly in the control of master and transmission friction clutches of the well known single plate and multiple disc types including servo-controlled clutch bands as in the case of planetary gearing.

Assuming the shaft 25 of the present governor device GV is driven from the transmission tailshaft at speeds proportional thereto. A shift-control valve would be provided for controlling energization of the servos and clutches. One end of this valve would be acted on by pressure flow through the present governor valve while the other end would be influenced by the engine accelerator via an interposed preloaded compression spring opposing governor pressure actuation thereof. With the vehicle standing the transmission will be assumed to be in low speed operative condition. Pressure on the accelerator will cause the vehicle to be driven forwardly in low gear, and at such predetermined speed of the vehicle and accelerator position, the governor will change the valve mechanism VD to another operating position wherein a higher speed is established in the transmission. Following this point of speed change to the higher gear, the centrifugal members 101 of the governor GD continue to be under the influence of increase in vehicular speed and therefore, move the riser A of the governor connected to the centrifugal members, relatively to the movable valve assembly MA without disturbing the new operating position of the latter causing the higher speed to be effective. With the engine throttle opened as required to negotiate a hill and torque of the engine insufficient to maintain speed of the vehicle which drops rapidly even though the throttle is maintained open in an engine accelerating direction. With such vehicular speed reduction with the throttle open, the present governor valve moves to its lower gear position causing the transmission to operate to establish such lower gear ratio and thus enable the engine to drive the vehicle under the load and road conditions involved without any tendency of the engine stalling. It is to be noted that the downshift just described occurred at a higher speed range of the vehicle, than the upshift, and without appreciable loss of vehicular speed from the point where maximum engine torque was utilized. Accordingly, the present valve mechanism finds special use in automatic transmission construction for automotive vehicles and the like by enabling normal upshifting operations to occur within a predetermined speed control range thereof for utilization of maximum engine torque as in ascending a steep grade, but at the point of reduction in vehicular speed where maximum torque is insufficient, a downshift to a lower gear ratio is automatically accomplished responsive substantially to the existent throttle position and such in-

cremental decrease in vehicular speed without requiring reduction in speed to the same factor which rendered said lower speed effective prior to the upshift.

Another example of a practical application of the present invention in the automotive field is for controlling the engine clutch for power transmission, starting the vehicle, and facilitating change in speed within the associated gearbox will now be described:

In vacuum-power operated friction clutches for automotive vehicles which utilize vacuum to withdraw the clutch when the vehicle approaches a complete stop to prevent stalling of the engine, especially when it is desired to bring the vehicle to a complete stop as at a traffic light, the power device of the clutch would be activated when the valve VD is opened to cause the vacuum-power to withdraw the clutch and when closed accommodates closure or engagement of the clutch as by spring means. The present valve device under such circumstances would include auxiliary valve means for slowly venting atmosphere into the power device to produce smooth engagement of the clutch as when starting the vehicle.

Under these conditions, the present novel speed-responsive device or governor, when the vehicle is slowed to a stop, completes the fluid circuit to the power device and thereby operates the power device to open the clutch. Upon depressing the accelerator, the car starts since the governor is driven from the engine as by the fan belt which when speeded up causes the valve elements 51, 52 to close and thus de-energize the power device with consequent admission of atmosphere into the power cylinder for the clutch. If the operator continues to press the accelerator the clutch will smoothly engage and the car gotten underway, but should he dwell on the accelerator and consequently fail to depress the pedal sufficiently to give the engine sufficient power to move the load, this will cause engine speed to drop and possibly, if the driver fails to further manipulate the accelerator in an engine accelerating direction, it may stall. Here is where my novel governor comes into action. With such slight decrease in engine speed, the governor operates to immediately open the valve device VD and thus open the clutch possibly only slightly enough to enable the engine to operate without loss of speed at the given throttle position and load. The driver now realizing the situation depresses the accelerator further to speed up the engine with consequent clutch engagement and the car is underway.

The main cause of engine stall where a car is equipped with power-controlled friction clutches, is the failure to give the engine sufficient throttle, and when the engine starts to stall at low speeds as in starting the vehicle, it can quickly come to a fully stopped condition before the driver senses that he should either further depress the accelerator, or take his foot off the accelerator, the latter usually requiring too much time with resultant engine-stall.

Note that the governor of the present invention is able to cause the clutch to open at any point along the full operating range thereof, not just at substantially stalled condition of the vehicle, responsive to the driver slightly releasing the accelerator pedal. In this way he maintains throttle on the engine, which is quite necessary in cold weather drive and starting, and by merely alternating the accelerator position fore and aft, the clutch can be closed and opened automatically, respectively, to simulate a "follow-up" control action for feathering the clutch members into smooth engagement.

If this governor is used to control the change of gear ratios in a step-gear transmission, the very same conditions obtain. Here with low speed engaged, the shift is made to second speed with the governor GV having two open (operating positions) instead of the closed and open operating positions illustrated. Should second speed cause decrease in engine speed to a point of possibly stalling the same due to load and road conditions encountered by the vehicle, this slight incremental decrease in engine speed is instantly transmitted to the governor GV to change the valve opening of the governor for low speed operation with resultant shift to low speed.

In starting the car, the slightest release of the accelerator pedal from any given engine accelerating position prevents engine-stall, full release of the accelerator not being required as in conventional power-operated clutches. According, the present invention in effect simulates the operation of a centrifugally-operated friction clutch, where the governor is associated with a clutch control as explained above. However, a centrifugal clutch has the one disadvantage of opening in opposition to the centrifugal action. Special provisions must be incorporated to enable a shift in the transmission by relief of torque where a centrifugal clutch is involved. The governor of the instant invention provides clutch withdrawal irrespective of engine speed which is translated into car speed according to the effective gear ratios of the transmission.

In addition to the close control of valve closing and opening at selected intermediate points between the extremes of the full operating movement of the governor device GD, "hunting" of the movable elements 51, 52 is reduced to a minimum as a result of the stabilizing effect of the contractible friction sleeve on the actuator A thus preventing the movable valve assembly MR from fortuitous vibratory movements independently of the actual actuating movement imparted thereto by the action of the governor riser A.

The releasable connection between the valve member 52 and riser shaft A may comprise the continuous frictional connection of Figures 1–3, or the ratcheting connection of Figure 4, the former tending to impart a smoother operating relationship from the riser A to the valve member 52 thereby enabling more sensitive operating characteristics of the governor device GD.

Referring to the terminology used in the foregoing description and in the appended claims, the identifying expressions and/or terms employed are intended to convey meanings which include the range of reasonable equivalents in the patent sense. For example, the expressions, "governor," "governor device," "speed-responsive valve mechanism," "valve device," "speed-sensitive valve device," are intended to include any structure utilizing centrifugal members for its operation, whether such members are pivotally mounted on the rotating member, or differently mounted to serve the same purpose. The terms "upper," "lower," "top," "bottom," "downwardly," "upwardly," "depending," and other directional words and characters are intended to have only relative connotation for convenience in describing the structure as it appears in the drawings, and are not intended to be interpreted as establishing any particular orientation with respect to related structure or position in which the present disclosure is mounted for operation.

The preferred and modified embodiments of the invention have been illustrated and described. It is to be understood, however, that the invention contemplates any and all modifications, substitutions and/or arrangements thereof that may fall within the purview of the claims hereunto appended.

Having thus described my invention, I claim:

1. In a speed-responsive valve mechanism having a fixed valve seat and a pair of cooperating valve seats movable relatively with respect to each other and to said fixed seat to establish two operating positions thereof for controlling the condition of an associated fluid circuit one of said operating positions being attained when the two cooperating seats are in engagement, and the other of said operating positions being attained when one of said two seats engages said fixed seat; a rotatable shaft adapted to be rotated at varying speeds; a rotor rotatable with said shaft; a pair of diametrically opposed

centrifugal elements coaxially disposed with respect to said rotor; means for pivotally connecting said centrifugal elements and rotor to accommodate movement of the former toward and away from their axis of rotation as a function of their speed of rotation; means biasing said centrifugal elements toward their axis of rotation; an element operably connected to said centrifugal elements for reciprocable movement thereby; normally preloaded spring means for biasing said pair of valve seats into seated relationship in one direction and accommodating unseating thereof in the opposite direction; releasable means for interconnecting the reciprocable element with the other one of said pair of valve seats whereby pivotal movement of the centrifugal elements is imparted to said other of said pair of seats selectively to engage the pair of valve seats with one another and to engage said one seat with said fixed seat, said pair of seats being actuated to their respective two operating positions in response to minute reciprocations of the reciprocable element at any selected position thereof intermediate the limits defining the full operating stroke thereof for controlling the condition of said fluid circuit; a pair of fixed abutments disposed in spaced confronting relation for selective engagement by said one of the pair of valve elements to establish said two operating positions; and means for rotating said shaft at varying speeds.

2. In a speed-responsive device: a rotary shaft; a pair of cooperating valve members relatively movable to establish two operating positions with respect to a fixed valve member, said pair of valve members cooperating with one another in one such position and with the fixed valve member in the other position; a rotary member fixed on said shaft; a centrifugal member connected to said rotary member for movement between outer and inner positions in a plane disposed substantially at right angles to the axis of rotation of said shaft; normally preloaded spring means for biasing said pair of valve members into seated relationship and accommodating unseating thereof in the opposite direction; normally preloaded spring means for biasing said centrifugal member toward its inner position; a movable member connected to the centrifugal member for unison movement therewith through a predetermined operating stroke; clutch means having a movable element operably incorporated between the movable member and one of said pair of valve members to move said member to and from a cooperative relation with the other of said pair of valve members whereby minute reciprocations of the movable member in response to variations in the speed of said rotary shaft reciprocate said one of said pair of valve members to selected positions intermediate the limits of the operating stroke of the movable member to relatively move the pair of valve members to their respective two operating positions; a pair of fixed abutments disposed in spaced confronting relation for selective engagement by said one of the pair of valve elements to establish said two operating positions; and means for rotating said shaft at varying speeds.

3. In a speed-responsive device: a rotary shaft; a rotary member fixed on said shaft; a centrifugal member pivoted to said rotary member for oscillation between outer and inner positions in a plane disposed substantially at right angles to the axis of rotation of said shaft; normally preloaded spring means for biasing the centrifugal member toward its inner position; a movable member connected to the centrifugal member for conjoint movement therewith through a predetermined operating stroke; a valve device comprising a pair of cooperating valve seats movable relatively with respect to each other in response to limited operating strokes of less extent than said predetermined stroke for controlling an associated fluid circuit; normally preloaded spring means for biasing said pair of valve seats into seated relationship and accommodating relative unseating movement thereof; means for establishing the limited stroke of said pair of valve seats; clutch means having a relatively movable element operably incorporated between the movable member and one of said pair of valve seats whereby minute reciprocations of the movable member in response to variations in the speed of the rotary shaft at any selected position intermediate the extremes of the predetermined operating stroke thereof correspondingly reciprocate said one of said pair of valve seats to control said fluid circuit; means limiting movement of the other of said pair of valve seats in one direction to less than the extent of reciprocation of said one of said pair of valve seats; a pair of fixed abutments disposed in spaced confronting relation for selective engagement by said one of the pair of valve elements to establish said two operating positions; and means for rotating said shaft at varying speeds.

4. The speed-responsive device according to claim 3 in which the movable element of the clutch means comprises: a contractible split-type ring carried by the one of said pair of valve seats for continuous frictional engagement with a cooperating cylindrical surface on the movable member, the frictional engagement being effective to sequentially move the pair of valve seats in unison with the movable member and relatively thereto to control said fluid circuit and accommodate relative movement of said movable member in the same direction to the end of its predetermined operating stroke without disturbing the established controlling position of the pair of valve seats with respect to each other.

5. The speed responsive device according to claim 3 in which the movable element of the clutch means comprises: a spring-loaded movable detent carried by the movable member and adapted to cooperate with a series of closely generated substantially V-shaped circular parallel shoulders formed on the one of said pair of valve seats to sequentially move the pair of valve seats in unison with the movable member and relatively thereto to control said fluid circuit and accommodate relative movement of said movable member in the same direction to the end of its predetermined operating stroke without disturbing the established controlling position of the pair of valve seats with respect to each other.

6. In a speed-responsive valve mechanism comprising: a rotatable shaft adapted to be rotated at varying speeds; a rotor rotatable with said shaft; a pair of diametrically opposed centrifugal elements coaxially disposed with respect to said rotor; means for pivotally connecting said centrifugal elements to said rotor to accommodate movement of the former toward and away from their axis of rotation as a function of their speed of rotation; means biasing said centrifugal elements toward their axis of rotation; a double-ended casing and a pair of relatively movable telescopically related elements therein having cooperating seats normally engaged, a concentric seat on one of said elements; a fixed cooperating seat normally spaced from said concentric seat in fully retracted position and when engaged establishing an operating position, a fluid chamber formed between the pairs of cooperating seats aforesaid, a port establishing continuous communication between the chamber and exterior of the casing, another fluid chamber formed between the one element and casing, a port establishing continuous communication between the exterior of the casing and the last-mentioned chamber, a normally preloaded compression spring operably disposed between said pair of valve elements urging them into seated relationship with respect to each other, a passageway communicating with the first-mentioned cooperating seats, a port for establishing continuous constant communication between the exterior of the casing and said passageway, a longitudinal bore in the other element coaxially disposed with respect to said elements, a counterbore merging with said longitudinal bore, axially aligned circular openings in the ends of the valve casing, an actuator rod operably connected to the centrifugal elements for reciprocable movement

therewith and projecting from one end of the exterior of the casing through the openings and bores aforesaid to the exterior of the casing at the opposite end, a radially contractible split-type sleeve encircling said rod in continuous frictional engagement therewith and disposed in circular alignment with the surface of the counterbore, an internal annular shoulder formed at the point of mergence between the bores aforesaid to engage one end of the split sleeve, an internal shoulder forming the outer terminus of the counterbore adjacent the other end of the split sleeve to thus prevent axial displacement of the split sleeve with respect to the other valve element, an enlarged diameter portion on the rod forming an annular shoulder therewith adapted to effect limited retracting movement of said rod and valve elements toward their respective fully retracted positions wherein the pair of elements are in seated relation and the one element spaced from its fixed seat, a pair of abutments fixed on said casing and disposed in spaced confronting relation for engagement by opposite ends of the other valve element to establish said valve elements in their two operating positions, and means for rotating said shaft at varying speeds.

7. The speed-responsive valve mechanism according to claim 6 in which the counterbore is press-fitted with a cylindrical sleeve terminating at its outer end with an internal annular shoulder to form an internal annular space with the opposite end of the counterbore confronting said annular shoulder, said annular space receiving said contractible sleeve for radial movement only relatively thereto between said spaced annular shoulders.

8. The speed-responsive valve mechanism according to claim 7 including an internal annular channel formed in the cylindrical surface of the casing opening through which the enlarged diameter portion of the actuator projects to the exterior thereof, a split-type ring having inherent resiliency carried in said channel and enabling yieldable outward radial deflection of one end of the ring, said ring encircling the enlarged diameter portion of the actuator rod in light engagement therewith, an inwardly extruded detent ridge adjacent one end of the split ring, and a pair of longitudinally spaced annular grooves of substantially corresponding configuration to the detent ridge in the cylindrical surface of said enlarged diameter portion for selective engagement by said detent ridge to releasably establish the actuator rod and connected movable valve seats in the two operating positions aforesaid.

9. The speed-responsive valve mechanism according to claim 8 including a longitudinal counterbore in the fixed valve seat in coaxial disposition with respect to the axis thereof and circular openings aforesaid for slidably supporting a portion of the other valve element; an internal annular shoulder formed at the point of mergence of said last-mentioned counterbore and circular opening for the enlarged diameter portion of the actuator rod for engagement by the confronting end of the other valve element when moved to establish said operating position thereof; an annular hollow reduced diameter projection formed on the opposite end of the valve casing in coaxial disposition therewith; an inturned annular flange forming the terminus of said projection and marginal edge of the opening through which the actuator rod projects for engagement by the opposite end of the other valve element when fully retracted whereby the reciprocable movement of the pair of valve elements is limited.

10. In a speed-sensitive valve mechanism comprising: a rotatable shaft adapted to be rotated at varying speeds; a rotor rotatable with said shaft; a pair of diametrically opposed centrifugal elements coaxially disposed with respect to the rotor; means for pivotally connecting said centrifugal elements to said rotor to accommodate movement of the former toward and away from their axis of rotation as a function of their speed of rotation; a hollow valve body; a valve seat fixed within said body; a pair of telescopically-related valve elements movable relatively with respect to each other and together; inner and outer concentric valve seats carried on one of said valve elements, said outer seat cooperating with said fixed seat; a valve seat carried by the other valve element cooperating with the inner seat aforesaid; a pair of fluid chambers formed on opposite sides of the one valve element with one of said chambers disposed between the valve elements; a port establishing continuous communication between one of said chambers and the exterior of the valve body; another port establishing continuous communication between the other chamber and the exterior of the valve body; a third fluid chamber formed between the one valve element and one end of the valve body; a port establishing continuous communication between the exterior of the valve body and said third chamber; a passageway establishing continuous communication between the third chamber and cooperating seats on said pair of valve elements; a normally preloaded compression spring carried by the other valve element for biasing the one valve element into seated relation with the other valve element; another normally preloaded compression spring for biasing said centrifugal elements toward their axis of rotation and both valve elements into normal released position wherein the outer concentric seat is spaced from its fixed seat placing the pair of chambers in communication with each other, and the cooperating seats between the valve elements in seated relation to isolate the pair of chambers from the third chambers; reciprocable means operably connected to the centrifugal elements for movement together and coaxially disposed with respect to said valve elements; friction means operably incorporated between said reciprocable means and said other valve element for transmitting limited reciprocable movements to said valve elements at any selected position intermediate the limits of the full operating stroke of said reciprocable means to establish and disestablish fluid communication between the first and second mentioned ports; a pair of abutments fixed on said valve body and disposed in spaced confronting relation for engagement by opposite ends of said other valve element to limit the reciprocable movement of said valve elements; and means for rotating said shaft at varying speeds.

11. In a speed-sensitive valve mechanism for controlling a fluid circuit including a rotatable shaft adapted to be rotated at varying speeds; a rotor rotatable with said shaft; a pair of diametrically opposed centrifugal elements coaxially disposed with respect to the rotor; means for pivotally connecting the centrifgal elements to the rotor to accommodate movement of the former toward and away from their axis of rotation as a function of their speed of rotation; means biasing the centrifugal elements toward their axis of rotation: a valve body having a fixed annular seat therein; a pair of telescopically-related valve elements movable relatively with respect to each other and together; inner and outer concentric valve seats carried on opposite sides of one of said valve elements, said outer seat cooperating with said fixed seat; an annular concentric valve seat carried by the other valve element cooperating with the inner confronting concentric seat on the one valve element; means for normally biasing said pair of valve elements into seated relationship with respect to each other and the one valve element spaced from the fixed seat; a fluid chamber formed between the one valve element and fixed seat in continuous communication with a passageway leading to the exterior of the casing; a second fluid chamber formed between the pair of valve elements and confronting valve seats thereof in continuous communication with a passageway leading to the exterior of the casing; a third fluid chamber formed between the pair of valve elements and one end of the

casing in continuous communication with a passageway leading to the exterior of the casing; reciprocable means operably connected to the centrifugal elements for moving said pair of valve elements out of engagement with respect to each other to establish their confronting seats in spaced relationship and into engagement with the fixed seat to isolate the first-mentioned chamber from the third chamber and to connect the latter chamber with the second chamber; means responsive to minute reciprocations of the reciprocable means at any selected position intermediate the limits of the full operating stroke thereof for alternately moving said pair of valve elements into and out of engagement with respect to the fixed seat and the confronting seats thereof to open and close said fluid circuit respectively; a pair of abutments fixed on said valve body and disposed in spaced confronting relation for engagement by opposite ends of said other valve element to establish said valve elements in their open and closed positions; and means for rotating said shaft at varying speeds.

12. In a speed-responsive valve mechanism for controlling a fluid circuit including a rotatable shaft adapted to be rotated at varying speeds; a rotor rotatable with said shaft; a pair of diametrically opposed centrifugal elements coaxially disposed with respect to the rotor; means for pivotally connecting the centrifugal elements to the rotor to accommodate movement of the former toward and away from their axis of rotation as a function of their speed of rotation; means biasing the centrifugal elements toward their axis of rotation: a valve body having opposed end walls and a pair of ports leading from the hollow of the valve body in continuous communication with the exterior of the valve body; a reciprocable valve assembly movable within the hollow of the valve body relatively to said pair of ports for controlling the latter; means for continuously biasing the valve assembly toward connecting said ports; a longitudinal bore through the valve assembly having an intermediate annular space of larger diameter forming an internal annular shoulder at each end thereof; a pair of axially aligned openings formed in the end walls of the valve body and concentrically disposed with respect to said longitudinal bore; a reciprocable element operably connected to the centrifugal elements and projecting through the wall openings of the valve body and said longitudinal bore in the valve assembly; a contractible longitudinally split friction sleeve confined between said pair of internal annular shoulders for axial movement with the valve assembly and encircling said reciprocable element in continuous frictional engagement therewith for imparting limited reciprocations to the valve assembly at any selected position intermediate the limits of the full operating stroke of the reciprocable element for alternately moving the valve assembly to connect and disconnect said pair of ports resulting in the associated fluid circuit being opened and closed respectively; and means for rotating said shaft at varying speeds.

13. The speed-responsive valve mechanism according to claim 12 including an internal annular channel in the surface of the valve body hollow spaced from the valve assembly in normal port connecting disposition; a fixed shoulder for engagement by the confronting end of the valve assembly when moved by said last-mentioned means; and an inturned annular flange formed on the marginal portion of the opening through the opposite end wall of the valve body for engagement by the opposite end of the valve assembly when in normal port connecting disposition whereby the reciprocable movement of the valve assembly is limited.

14. The speed-responsive valve mechanism according to claim 13 including a series of ports through the wall of said inturned flange for maintaining communication between a portion of the interior of the valve body and the exterior thereof; and a venting cap mounted on said opposite end wall of the valve body and spaced from said series of ports for preventing foreign particles from entering said interior of the valve body.

15. The speed-responsive valve mechanism according to claim 14 in which the free end of the reciprocable element is formed with a larger diameter to produce an external annular shoulder with the normal smaller diameter thereof, said larger diameter projecting through the opening in the end wall of the valve body correspondingly enlarged to accommodate the same, and said shoulder normally engaging the confronting end of the valve assembly to releasably maintain the latter in port connecting disposition wherein the opposite end of the valve assembly is engaged with the inturned flange of the opposite end wall of the valve body.

16. The speed-responsive valve mechanism according to claim 1 including yieldable stabilizing means for the movable valve seats, said means being operatively incorporated between the fixed valve seat and reciprocable element for releasably stabilizing the movable valve seats in either of their two operating positions aforesaid.

References Cited in the file of this patent

UNITED STATES PATENTS

2,650,815 Feilden ---------- Sept. 1, 1953
2,762,384 Rosenberger ---------- Sept. 11, 1956

UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,931,374 April 5, 1960

Glenn T. Randol

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 29, for "open" read -- close --; line 47, after "of" insert -- a --; column 5, line 61, strike out "movement"; line 62, after "116" and before "when" insert -- and thereby accommodates relative rotational movement of the member 109 --; line 64, after "Figure 2" and before the period insert -- or operating --; column 7, line 46, for "the move" read -- then move --; column 9, line 31, for "position" read -- positions --; column 11, line 39, for "theim" read -- them --; column 14, line 11, for "According" read -- Accordingly --; line 28, for "MR" read -- MA --.

Signed and sealed this 4th day of July 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents