United States Patent

Biechl et al.

[15] **3,672,343**

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[54] **CENTRIFUGAL REGULATOR SYSTEM FOR FUEL-INJECTION COMBUSTION ENGINES**

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[52] **U.S. Cl.** ....**123/140 MC**, 123/140 R

[51] **Int. Cl.** **F02d 1/04**

[58] **Field of Search** ....123/140 R, 140.3

[56] **References Cited**

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2,818,053	12/1957	Shallenberg	123/140 R
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1,124,340	10/1956	France	123/140 R
1,011,223	6/1958	Germany	123/140 R
1,080,814	10/1960	Germany	123/140 R

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[57] **ABSTRACT**

A centrifugal regulator for an internal combustion engine having a fuel injector controllable by actuation of a control rod. Movement of the governor sleeve upon a variation in rpm is transferred to a spring-biased rocker arm, which is pivoted on an intermediate lever between a fixed pivot thereof and a link connecting it with the control rod. Various types of relationship between fuel injection rate and rpm are obtained by means of differently placed adjustable or resilient stops provided on a spring-urged support arm and on which the rocker arm may swing when transferring sleeve movement to the intermediate lever and the control rod.

5 Claims, 5 Drawing Figures

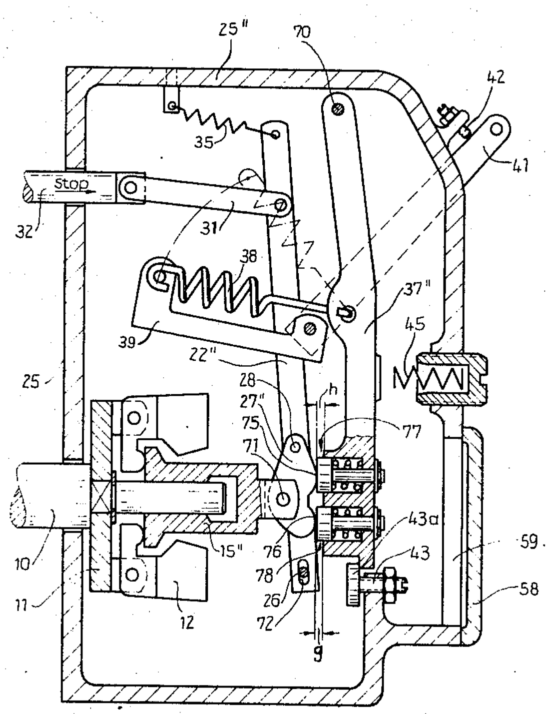

Fig. 1

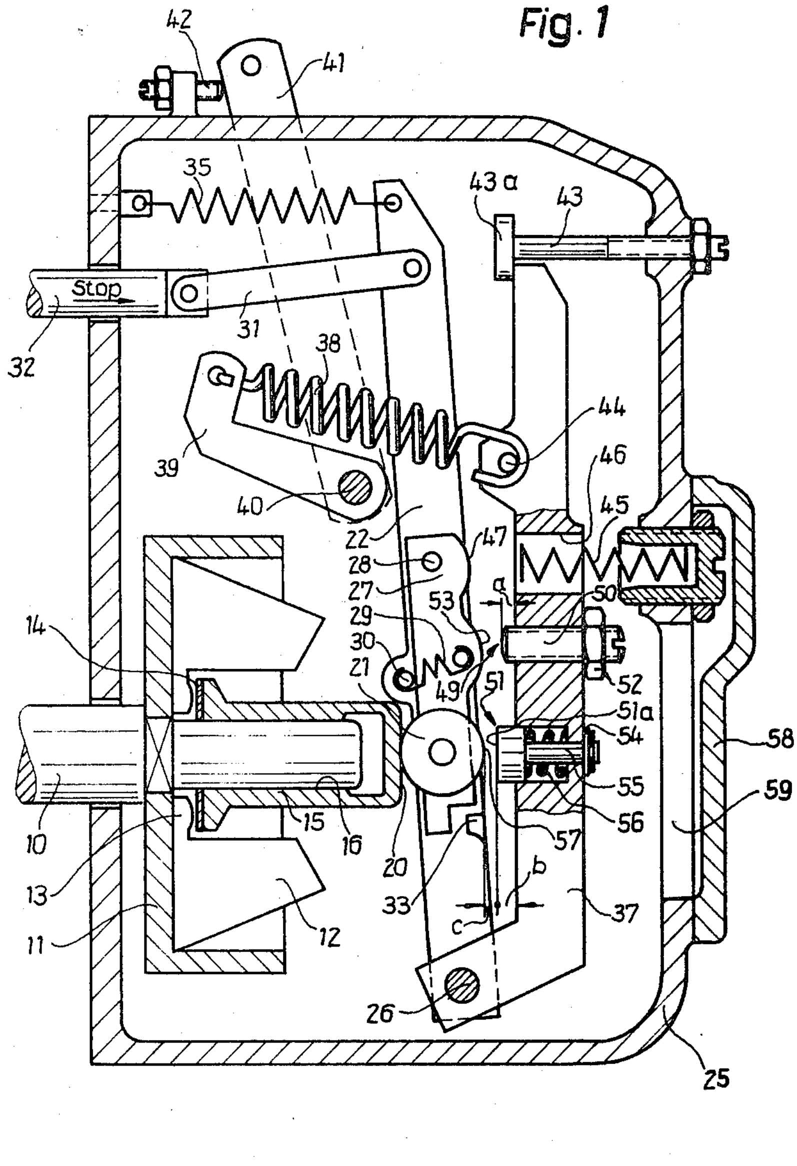

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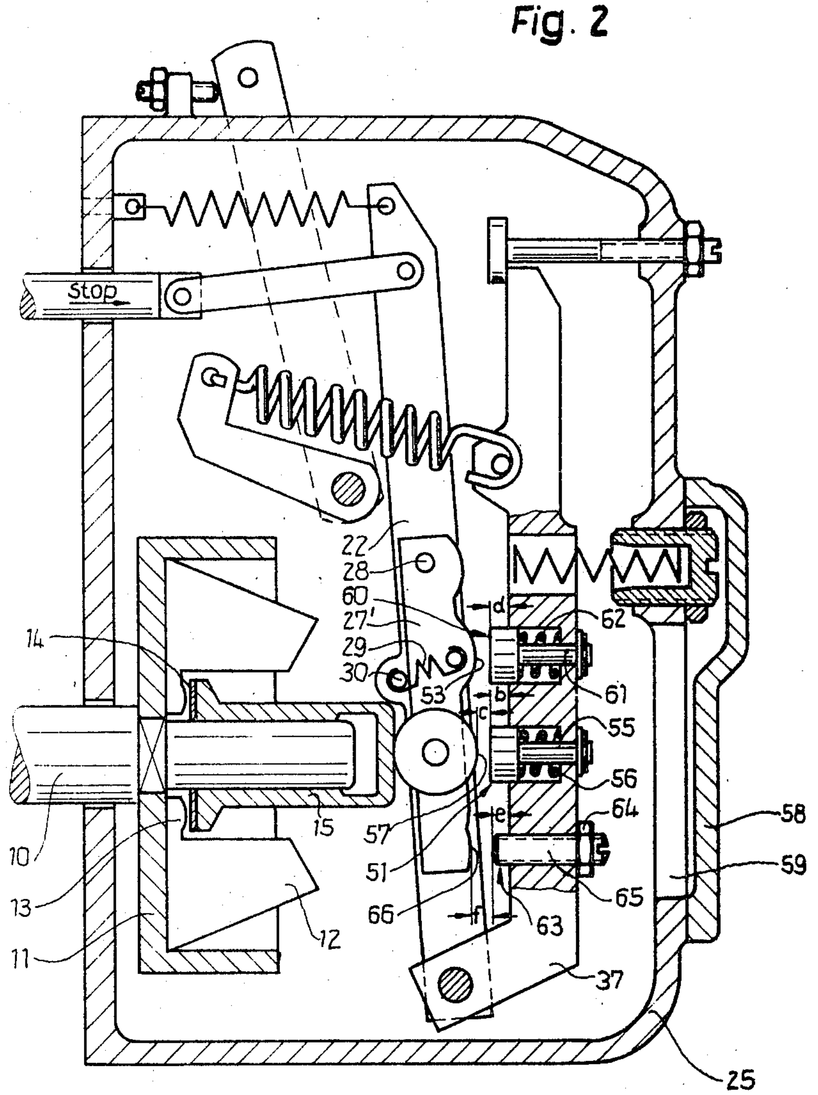
Fig. 2


Stop
22
28
60
27'
29
30
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14
d
62
b
61
c
55
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64
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66
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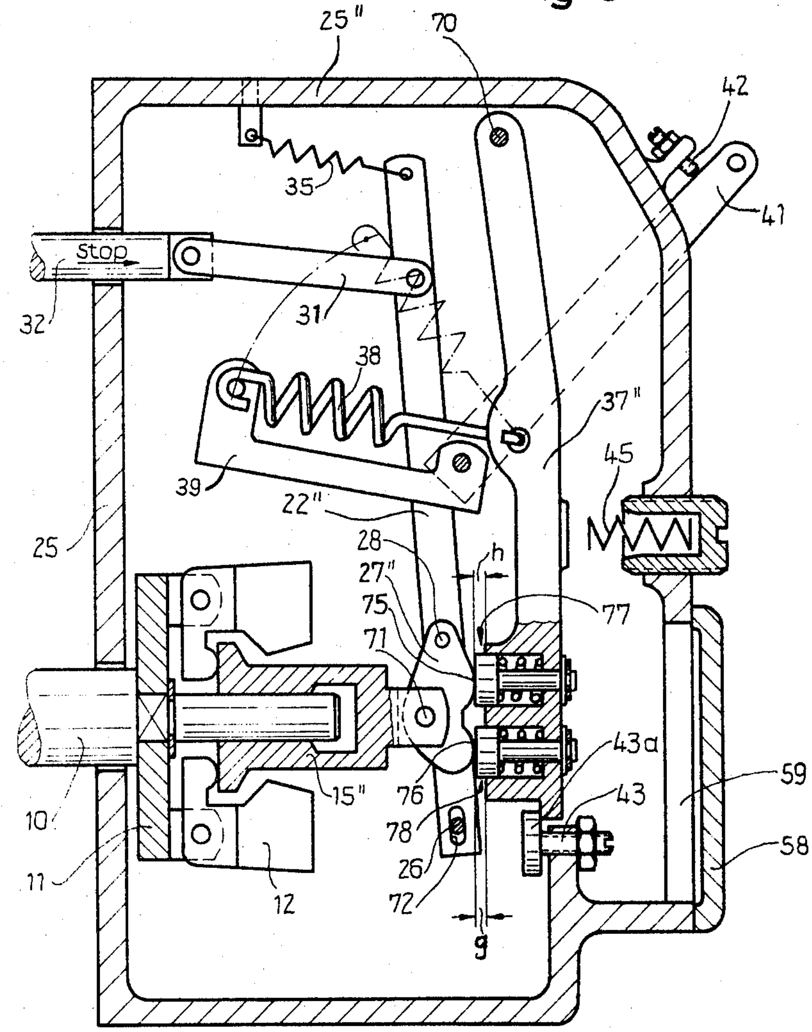
Fig. 3


25"
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Stop
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Fig. 4

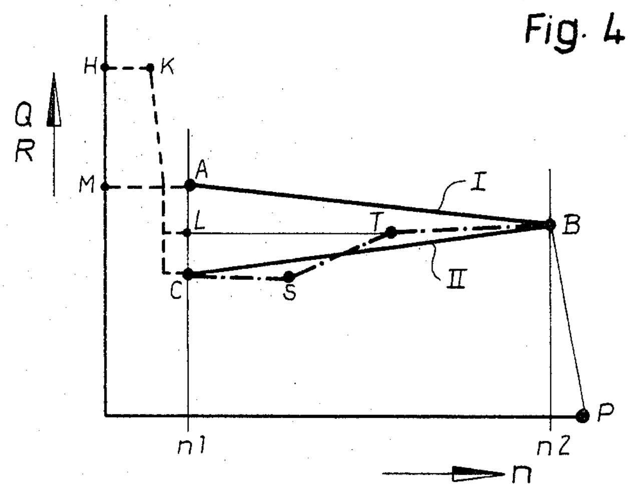
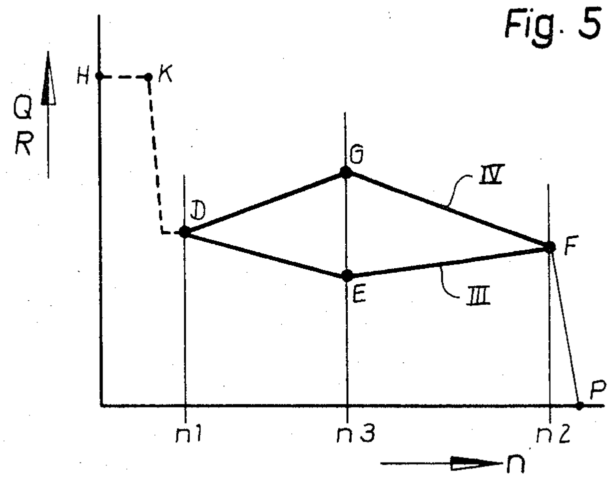


Fig. 5



CENTRIFUGAL REGULATOR SYSTEM FOR FUEL-INJECTION COMBUSTION ENGINES

FIELD OF THE INVENTION

The invention relates to a centrifugal regulator for fuel-injection internal combustion engines having a governor sleeve movable in response to the rpm of the engine.

BACKGROUND OF THE INVENTION

It is known to transfer movements of the governor sleeve of a centrifugal regulator to an intermediate lever which is movable about a fixed pivot and coupled to a movable control member of the injection pump for controlling the rate of fuel supply, a counterforce means being provided for subjecting the governor sleeve to a counteracting spring force.

Fuel-injection engines, particularly those of motor vehicles, operate in a wide range of rpm's. The injector pumps are often provided with regulators serving not only to control the rpm but also to vary the maximum full-load rate of fuel supply within as large a range of rpm's as possible in accordance with what is required by the engine for smokeless combustion or for a predetermined type of variation or adaptation of the rate of supply according to particular operating conditions.

Known centrifugal regulators of the above-indicated type, such as are described in German Pat. Nos. 1,011,223 and 1,080,814, provide adaptation of the amount of fuel supplied by the injector pump to the full-load operating characteristic of the engine, by means of an adaptor comprising a spring device inserted between the counterforce means and the governor sleeve. In operation, upon an increase in rpm, the spring displaces the control rod of the fuel-injector pump in the direction towards "stop" according to the bias and the stiffness thereof. This reduces the rate of supply by a predetermined amount.

This arrangement has the disadvantage that the maximum rate of supply in response to an increase in rpm can only be controlled downwards, whereas a rising or a composite type of variation, i.e. where the rate of supply first increases and then decreases, or vice versa, cannot be realized with the known arrangement.

Arrangements are known per se in other types of regulators than the one referred to for obtaining an arbitrary type of variation of a rate of supply, for instance, by means of a cam (U.S. Pat. No. 2,259,693 and German Pat. No. 1,010,321). However, these arrangements are not applicable to the type of regulators initially referred to.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide in a centrifugal regulator of the type initially referred to an arrangement which enables a control of the variation of the rate of supply of the injector pump, by which for varying rpm's the maximum rate of supply can be variable within a predetermined range of rpm's by a desired amount in either sense, the sense of the variation being reversible at least once within the range of rpm's.

The essential features of the invention comprise a rocker arm coupled between the governor sleeve and the intermediate lever and having at least two stop surfaces cooperating with corresponding stops on the counterforce means, at least one of the stops being resilient, and either one thereof serving as a pivot point for rocking movements of the rocker arm, the rocker arm being pivoted at one end to the intermediate.

In an embodiment of the invention, the rocker arm is pivoted to the intermediate lever between its point of coupling with the control rod and the fixed pivot.

In a further embodiment, a resilient stop is positioned in the prolongation of the axis of the governor sleeve and a second fixed stop is provided above the first one and is adjustable by means of a screw to a desired level. With this arrangement, it is possible to control the full-load rate of supply to cause it to increase or decrease with an increase in rpm, or to first decrease and then increase again within a higher range of rpm's.

However, if it is desired to control the full-load rate of supply in response to an increase in rpm so as to first increase and then decrease, according to a further embodiment, a first resilient stop is provided in the prolongation of the axis of the governor sleeve and a second resilient stop is arranged above the first one between the axis of the control member and the pivoted end of the rocker arm, a third, adjustable fixed stop being provided below the first one.

In a still further embodiment of the invention, the rocker arm has a pair of stop surfaces provided above and below the axis of the governor sleeve and cooperating with correspondingly positioned stops. With this arrangement, any desired type of adaptation of the variation of the rate of supply to different engine operating characteristics can be realized.

The invention will be described in detail with reference to the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1, 2 and 3 are schematic representations of three embodiments of the centrifugal regulator system of the invention; and

FIGS. 4 and 5 are diagrams illustrating the operation of the invention.

DESCRIPTION OF EMBODIMENTS

In the FIG. 1 embodiment, **10** designates the cam shaft of the fuel injection pump (not shown) of an internal combustion engine having a carrier member **11**, on which centrifugal weights **12** are pivotally mounted in a manner known per se. Arms **13** on the weights engage the contact surface **14** of a governor member or sleeve **15** slidable on shaft **10** with its boring **16**. The other end face **20** of sleeve **15** engages a roller **21** mounted indirectly on an intermediate lever **22**, which is pivoted on a pin **26** affixed to the housing **15** of the regulator. Roller **21** is directly mounted on a rocker arm **27**, which is pivotally mounted on lever **22** by means of a pin **28** and is urged in its inoperative position into engagement with a stop pin **30** on lever **22** by a spring **29**. Lever **22** is coupled via link **31** with a fuel supply control member in the form of a control rod **32** of the fuel injector pump. A tension spring **35** is attached at one end to lever **22** and serves to eliminate play and also urges rod **32** towards higher fuel supply, thereby serving as a starting spring.

Pivoting movement of arm **27** away from the inoperative position takes place against the return force of a spring **29** and is limited by a stop **33** on lever **22**, which prevents the engine from racing if spring **29** breaks off. In fact, in the absence of spring **29**, starting spring **35** would pull lever **22** to increase the supply rate. Stop **33** is positioned so as to permit arm **27** to turn as much as is necessary for adjusting the rate of supply. The function of this angular deflection is described in more detail below.

Pivotally mounted on pin **26** is also counterforce means in the form of a support arm **37**, which transmits to governor sleeve **15** a counteracting spring force of a speed control spring **38**. Spring **38** is a tension spring having one end thereof attached to lever **37** and the other end to a rocking lever **39**, which is fixedly mounted on a shaft **40** journaled in housing **25**. Lever **39** is coupled by shaft **40** to a handle **41** placed outside the housing and shown in its terminal position, which is defined by a screw **42** and serves to determine the maximum rpm obtained by the regulator. The position of support arm **37** in response to the bias of spring **38** is determined by an adjusting screw **43**. This determines the point of attachment **44** of spring **38** and also, as will be explained below, the full-load initial position of control rod **32**.

An additional adjustable idling control spring **45** provided in housing **25** extends through a recess **46** in support arm **37** and influences the movements of intermediate lever **22** in the idling control range by engagement with a surface **47** on rocker arm **27**.

Support arm **37** has a pair of stops **49, 51** adjusted to project therefrom by amounts *a* and *b* , respectively. Stop **49** is provided by a screw **50** with a lock nut **52** thereon and cooperates with a stop surface **53** of arm **27**. Stop **51** is located in the prolongation of cam shaft **10** and comprises a bolt **55** and a spring **56** providing a resilient stop **51** cooperating with a stop surface **57** formed by the periphery of roller **21**.

The projection distances *a* and *b* and the biasing force of stop **51**, as well as the operating range of idling control spring **45**, can be adjusted through an opening **59** in housing **25**, having a lid **58** provided therefor.

The distance *a* is adjusted by turning of screw **50** and locking the same with nut **52**. The distance *b* can be adjusted by interposing a disc **54** of suitable thickness. As an alternative, stop **51** could be mounted in a manner known per se, not shown, in a threaded sleeve which would be adjustable in support arm **37** and be locked in adjusted position by a lock nut.

FIG. **2** shows the second embodiment, which is substantially similar to that of FIG. **1**, as indicated by identical reference numerals, the differences relative to FIG. **1** being as follows: Support arm **37**, besides resilient stop **51**, has instead of the fixed stop **49** of the first embodiment, a second resilient stop **60** similar to stop **51** and comprising a stop bolt **61** and a spring **62**. Below the axis of cam shaft **10** and stop **51**, a third, fixed stop **63** is provided by a screw **65** locked by means of a nut **64**. Stop **63** cooperates with a stop surface **66** on rocker arm **27'**. Stops **51, 60** and **63** are adjusted to project by distances *b*, *d* and *e* , respectively.

FIG. **3** shows the third embodiment, which differs in the following respects from the foregoing ones: Support arm **37''** is mounted on a separate pin **70** in the upper part of housing **25''**, whereas intermediate lever **22''**, similarly to lever **22** of FIGS. **1** and **2**, is pivoted on pivot **26** in the lower part of the housing. A further difference relative to FIGS. **1** and **2** is that rocker arm **27''** is linked not only to intermediate lever **22''** but also through a bolt **71** to governor sleeve **15''**. A slot **72** in the lower end of lever **22''** in engagement with pin **26** makes it possible for lever **22''** to perform small vertical movements, for instance, when rocker arm **27''** rocks on bolt **71**. Arm **27''** has a pair of contact surfaces **75, 76**, one above and the other below the axis of cam shaft **10**. Opposed to contact surfaces **75** and **76** are stops **77** and **78**, respectively, of arm **22''**.

DESCRIPTION OF OPERATION

The three embodiments according to FIGS. **1, 2** and **3** make it possible to adapt the full-load fuel supply of the injector pump in response to rpm to the maximum fuel supply rate required for smokeless combustion or for some other operating condition of the engine.

For adapting the full-load rate of supply, by way of example, the following control processes can be realized by the regulator:

I. The rate of supply decreases with increasing rpm, i.e., the control rod is displaced towards "stop" by a predetermined amount within a certain range of rpm,

II. The rate of supply increases with increasing rpm,

III. The rate of supply first decreases and then increases with increasing rpm, and

IV. The rate of supply first increases and then decreases with increasing rpm.

These four possible control processes are illustrated in the diagrams of FIGS. 4 and 5, in which the abscissa is the rpm designated *n* and the ordinate is the rate of supply Q or the position coordinate R of the control rod. It is assumed that the coordinate R is a measure of the rate of supply Q of the injector pump. If this is true, the corresponding graphs show the rate of supply as a function of the rpm. Process I is represented in FIG. 4 by the heavy line A–B, process II by C–D, process III in FIG. 5 by D–E–F and process IV by D–G–F. The dash lines H–K–D and H–K–A, H–K–L or H–K–C show the variation of the control rod coordinate in the lower range of rpm, when the regulator controls an excess fuel amount required for starting. When no excess starting fuel is needed, the control rod follows, for instance, line M–A (FIG. 4).

The measure of section H–K is determined by the bias of starting spring **35**.

If the regulator does not perform any adapting process, the variation takes place, for instance, along the line H–K–L–B of FIG. 4. The downward control curve for limiting the maximum rpm is designated in FIGS. 4 and 5 by B–P and F–P, respectively.

The operation of the regulator will be described with particular emphasis on the adapting function provided by the cooperation of rocker arm **27, 27', 27''** and stops **49, 51, 60, 63, 77** and **78**.

In FIG. **1**, weights **12** are shown in the inoperative position, handle **41** rests on stop **42**, and control spring **38** is biased for limiting the maximum rpm via rocking lever **39**. The force of spring **38** holds support arm **37** in position against the head **43a** of adjustment screw **43**. Starting spring **35**, by means of intermediate lever **22** and link **31**, holds control rod **32** into the position in which the injector pump supplies the maximum amount of fuel required for starting the engine (H in FIGS. **4** and **5**). If the engine starts running at n1 rpm, weights **12** push sleeve **15** and roller **21** to the position in which the latter engages end surface **51***a* of stop **51**. Sleeve **15** and roller **21** have then been displaced by an amount *c* and control rod **32** is, for instance, at the point C of FIG. **4**. Since roller **21** and rocker arm **27** are coupled by spring **29** and stop **30** with intermediate lever **22**, any movement of roller **21** in response to governor sleeve **15** is transferred in a measure corresponding to the lever arm ratio to control rod **32**.

If the regulator is to realize the control process II (increasing rate of supply), stop **49** is adjusted to such a value of distance *a* that it just touches stop surface **53** of rocker arm **27** when the distance *c* has been traversed. If the rpm rises beyond *n***1**, the sleeve force overcomes the bias of spring **56** of stop **51**, stop bolt **55** is displaced to the right and the distance *b* is reduced. Simultaneously the increasing sleeve force also overcomes the force of spring **29** and rocker arm **27** rocks about the momentary pivoting point formed by stop surface **53** and fixed stop **50**. Since rocker arm **27** is hinged by pin **28** to lever **22** at a higher level than contact surfaces **53, 57**, pin **28** will move towards the left and control rod **32** will be displaced in a direction corresponding to an increased rate of supply (graphs C–B of FIG. **4**).

By using a softer spring **56** with a stronger bias it is also possible with the arrangement of the stop just described to realize a control process according to C–S–T–B in FIG. **4**.

If a control process according to I (decreasing rate of supply) is to be realized, stop **49** is removed or is set back in an inoperative position. After this, only stop surface **57** and stop **51** are active and the sleeve force can compress stop **51** by an amount corresponding to the distance *b* . Rocker arm **27** then remains relative to intermediate lever **22** in the position shown, lever **22** participates in the movement of roller **27** and the rate of supply decreases according to the graph A–B of FIG. **4**.

To realize the process III (first decreasing, then increasing), the distance *a* of stop **49** is adjusted so as to cause first a portion of the distance *b* to be traversed until surface **53** hits stop **49**, after which the rest of distance *b* is covered simultaneously with the rocking movement by rocker arm **27** about its point of contact with stop **49**. This process is in accordance with line D–E–F of FIG. **5**.

The process IV (see line D–G–F in FIG. **5**) is achieved with the regulator according to FIG. **2**. The projection distances *b* and *d* of stops **51** and **60** are adjusted in such a way that when the excess fuel quantity for starting has been used up (K–D in FIG. **5**) or at the end of the distance *c*, stop surfaces **53** and **57** simultaneously engage stops **51** and **60**. Between fixed stop **63** and stop surface **66**, however, there remains a spacing corresponding to the difference between distance *f* and that corresponding to the traversed length *c*. Furthermore, the bias of spring **56** is weaker than that of spring **62**. If the rpm surpasses the value *n***1**, spring **56** will first give way, stop **60** will operate as a fixed stop, rocker arm **27'** rocks on the momentary pivot point formed by stop **60**, and the rate of supply is increased

(D–G). When the maximum allowable full-load quantity is reached at point G in FIG. 5, corresponding to an rpm of $n3$, rocker arm **27'** has traversed the distance f and stop surface **66** strikes against stop **63**. Upon a further increase in rpm, sleeve **15** works against both of the resilient stops **51** and **60** and rocker arm **27'** now rocks on stop **63**, after which the rate of supply decreases. At the terminal value $n2$ (point F in FIG. 5), the adapting process is completed.

With the embodiment of FIG. 3, it is possible to realize all of the processes I–IV.

In a process according to A–B of FIG. 4 (process I), the upper stop **77** recedes resiliently (spring displacement h) and the lower stop **78** is a fixed pivot point. In this case it may have a very strong bias and be blocked or be replaced by a fixed bolt.

A process according to C–B of FIG. 4 (process II) can be realized if the stop **78** recedes (spring displacement g) and the stop **77** operates as a fixed pivot point.

The regulator realizes a process according to the broken graph D–E–F of FIG. 5 (process III) if, between the rpm values $n1$ and $n3$, first stop **77** recedes by an amount h and then, between $n3$ and $n2$, stop **78** by an amount g.

A variation of the rate of supply according to the kinked graph D–G–F of FIG. 5 (process IV) is realized if the resilient stops **77** and **78** operate in the opposite order to the one just described, stop **78** receding first and then stop **77**.

Through the use of two springs instead of each one of springs **56**, **62** in resilient stops **51**, **60**, **77**, **78**, it is possible to further adapt the control process.

The regulator, in all cases described above, effects a downward control upon reaching the final rpm value $n2$, when the sleeve force surpasses the bias of control spring **38** and support arm **37**, **37''** moves away from screw head **43***a*. This receding movement is followed by intermediate lever **22**, **22''**, which is driven by rocker arm **27**, **27'**, **27''**, as the latter is held in engagement with support arm **37**, and intermediate lever **22**, **22''** pulls control rod **32** into the "stop" position (line B–P of FIG. 4 or F–P of FIG. 5).

That which is claimed is:

1. A centrifugal rpm regulator system for internal combustion engines operating on injected fuel, said system being of the known type that has (a) a governor member movable as a function of the engine rpm, (b) a fuel injection pump having

a movable control member for controlling the rate of fuel supply, (c) an intermediate lever movable about a fixed pivot for transferring the displacements of said governor member to said control member, (d) at least one counteracting spring and (e) a force transmitting member subjecting said governor member to the force of said counteracting spring, the improvement comprising,

A. a rocker arm in engagement with said governor member and pivotally attached at one of its ends to said intermediate lever at a location remote from said fixed pivot, said rocker arm constituting the sole means to transfer the motions of said governor member to said intermediate lever,

B. at least two stop surfaces provided on said rocker arm remote from said pivotally attached end thereof, and

C. at least two stops provided on said force transmitting member for cooperating, upon movement of said governor member, with corresponding stop surfaces provided on said rocker arm, at least one of said stops yielding resiliently and another of said stops being stationary to serve as a fixed point for said rocker arm during pivotal motions thereof.

2. An improvement to claim **1**, in which said rocker arm is pivoted to said intermediate lever between the point of coupling thereof to said control member and said fixed pivot.

3. An improvement according to claim **1**, in which said governor member is axially movable, said resilient stop is positioned in the prolongation of the axis of said governor member and a second one of said stops is adjustable to an arbitrary fixed level.

4. An improvement according to claim **1**, in which said governor member is axially movable, said stops include a first resilient stop positioned in the prolongation of the axis of said governor member, a second resilient stop between said axis and said pivoted end of said rocker member, and a third stop adjustable at an arbitrary fixed level and positioned at the opposite side of said second resilient stop relative to said first resilient stop.

5. An improvement according to claim **1**, in which said governor member is axially movable, said stop surfaces are two in number and are positioned at opposite sides of the axis of said governor member for cooperation with correspondingly positioned stops.

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