

[54] **FUEL INJECTION REGULATOR FOR INTERNAL COMBUSTION ENGINES**
[75] Inventor: **Karl-Heinz Adler**, Leonberg, Germany
[73] Assignee: **Robert Bosch GmbH**, Stuttgart, Germany
[22] Filed: **Oct. 15, 1969**
[21] Appl. No.: **866,521**
[52] U.S. Cl.**123/32 EA, 123/119 R, 123/32 R**
[51] Int. Cl.**F02b 3/00, F02b 33/00**
[58] Field of Search**123/32 CL; 60/39.29**

[56] **References Cited**

UNITED STATES PATENTS			
2,886,015	5/1959	Steinke.....	123/32
2,910,054	10/1959	Schutte	123/32
2,971,337	2/1961	Wintrode	60/39.28
3,045,426	7/1962	Brahm.....	60/39.28
3,064,422	11/1962	Neher.....	60/39.28
3,124,932	3/1964	Nelson	60/39.28
3,407,793	10/1968	Lang	123/32
3,425,401	2/1969	Lang	123/32
3,526,212	9/1970	Bassot	123/32
3,028,526	4/1962	Wintrode	60/39.28
3,548,792	12/1970	Palmer	123/32 CL

FOREIGN PATENTS OR APPLICATIONS

884,305	12/1961	Great Britain.....	123/32
884,462	12/1961	Great Britain.....	123/32
1,191,641	5/1970	Great Britain.....	123/32
1,191,642	5/1970	Great Britain.....	123/32
1,206,540	2/1960	France	123/32
1,184,152	12/1964	Germany.....	123/32

Primary Examiner—Laurence M. Goodridge
Attorney—Michael S. Striker

[57] **ABSTRACT**
A regulating arrangement for internal combustion engines, particularly of the diesel-engine type. The fuel injection pump is set and displaced through an amplifier having one signal input derived from a speed sensor coupled to the crank shaft of the engine. The input of amplifier may also be fed with a signal derived from the accelerating pedal of the engine. A hydraulic displacement device between the output of the amplifier and the fuel injection pump converts the electrical signal from the amplifier into a corresponding setting of the pump. The feedback network of the amplifier is such that the amplification of the amplifier is substantially high at idling speeds of the engine.

19 Claims, 6 Drawing Figures

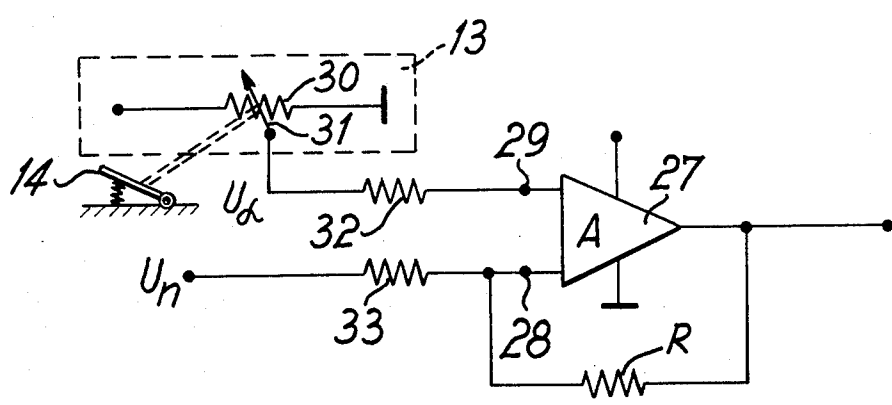


FIG. 1

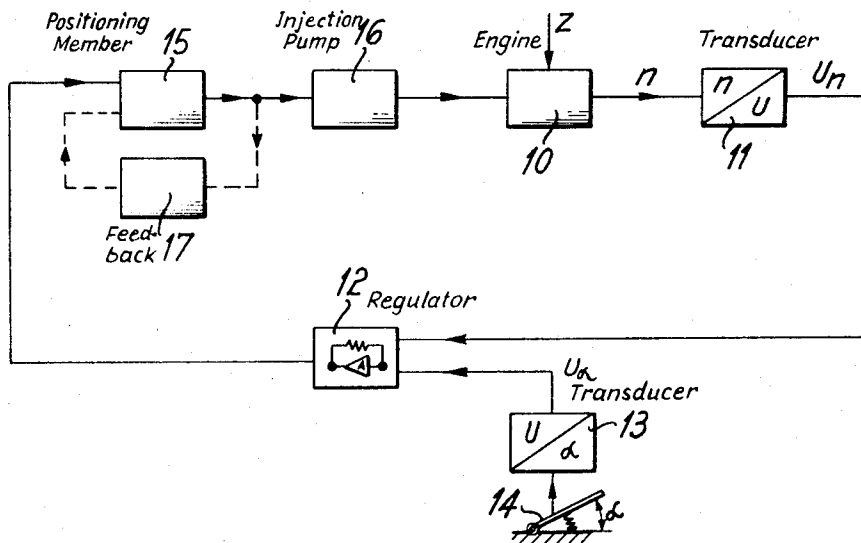


FIG. 2

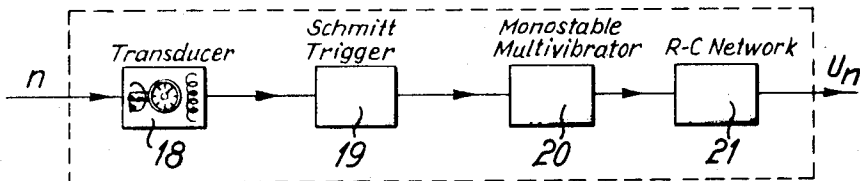
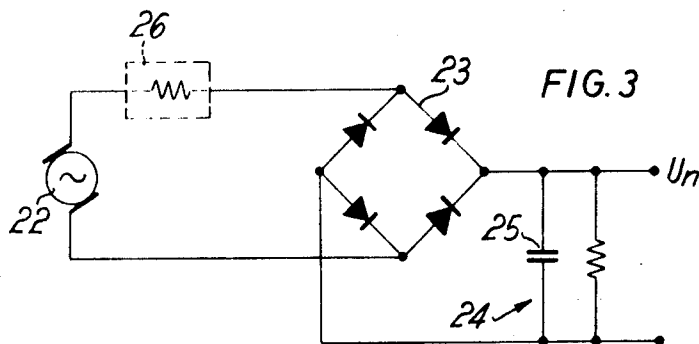
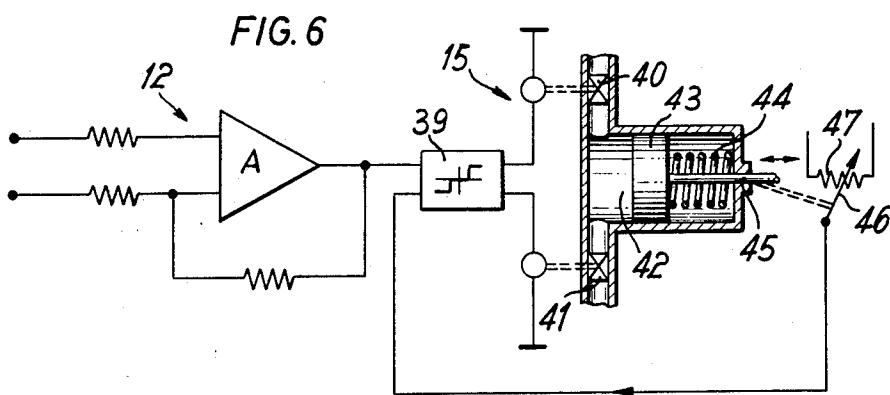
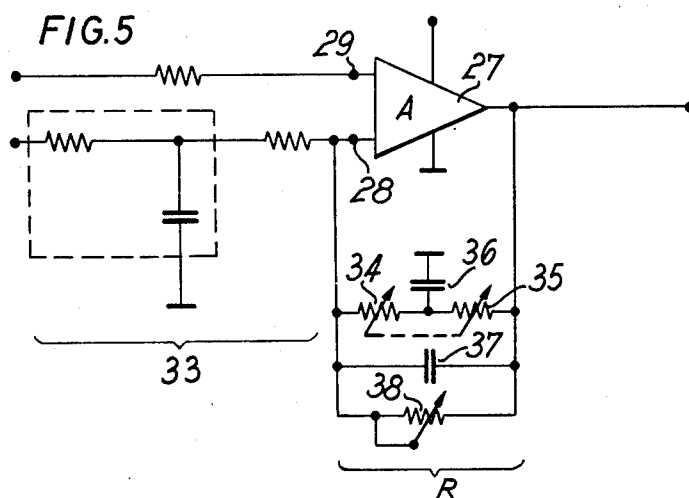
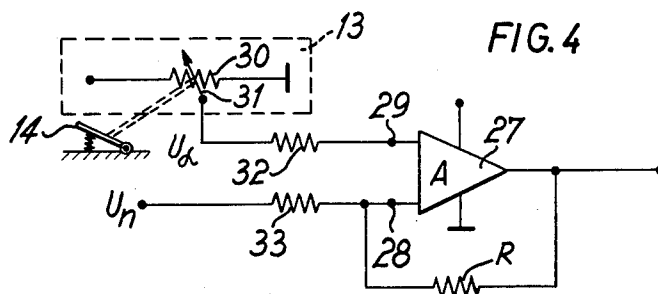


FIG. 3



INVENTOR
Karl-Heinz ADLER

By
Walter S. Haeberle
his ATTORNEY



INVENTOR :
Karl-Heinz ADLER

By
Karl-Heinz Adler
his ATTORNEY

FUEL INJECTION REGULATOR FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention resides in a regulating arrangement for internal combustion engines, particularly of the diesel type. The arrangement serves to regulate the amount of fuel injected as a function of the rotational speed of the engine and other parameters, particularly the position of the accelerating lever or accelerating pedal.

Regulating arrangements are known which operate under principle of centrifugal-force regulators, or pneumatic and hydraulic speed regulating methods. In such arrangements, the regulator is directly coupled with the displacement member for setting the amount of fuel injected. These conventional arrangement which are known in the art, do not have sufficient displacement force or power at low rotational speeds of the engine, in view of their inherent design. The regulators known in the art, furthermore, are complex and massive, when provided with auxiliary force or driving power.

Accordingly, it is an object of the present invention to provide a regulator which does not have the preceding disadvantages.

The object of the present invention is achieved by providing the regulator for varying the quantity of fuel injected, in the form of a DC voltage amplifier which has high amplification in the idling state of the engine. This amplifier has, furthermore, the desired regulating characteristic through a corresponding feedback network.

With the arrangement of the present invention, the following advantages are realized.

In such a regulator, the desired regulating characteristics for displacement regulators and idling speed regulators may be designed well through simple means by merely selecting the corresponding feedback network. Such regulators of the present invention, also may be adapted readily and simply to different types of engines. For this reason, the regulating arrangements are also very adapted for motor vehicle driving, especially since they are relatively insensitive to temperature. By selecting the feedback network, furthermore, the timing relationship of the entire regulating circuit may be influenced.

SUMMARY OF THE INVENTION

A regulating arrangement for internal combustion engines, particularly those of the diesel type. A fuel injection pump is set through a displacement member which may be of the hydraulic type and is equipped with a hydraulic piston coupled to the input of the pump. The piston of the hydraulic displacement arrangement is controlled in its position through the actuation of flow valves which, in turn, are controlled by the output signal of a DC voltage amplifier. The inputs to the amplifier are derived from speed transducers which apply to the amplifier signals as a function of the speed of the engine. The input to the amplifier may also be operatively coupled to the accelerating pedal of the engine. The feedback network of the amplifier is such that the amplifier has substantially high amplification at the idling speeds of the engine.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic block diagram of the regulating arrangement of the present invention;

FIG. 2 is a schematic block diagram of a speed transducing circuit used in the regulating arrangement of FIG. 1;

FIG. 3 is an electrical schematic diagram of another embodiment of the speed transducing arrangement of FIG. 2;

FIG. 4 is an electrical schematic diagram of a regulating unit used in the arrangement of the present invention;

FIG. 5 is an electrical schematic diagram of a regulating unit with feedback coupling network of the present invention; and

FIG. 6 is a functional schematic diagram and shows a regulating unit in combination with a hydraulic displacement arrangement for adjusting the amount of fuel injected into the engine, in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, FIG. 1 shows an internal combustion engine which is an element within a regulating circuit and to which a disturbing parameter is applied. Such disturbing parameter z may be due, for example, to the loading of the machine. As a result of this distributing parameter z , the rotational speed n varies. Connected to the output of the internal combustion engine 10, is a transducer 11 which provides a first signal in the form of a voltage U_n proportional to the rotational speeds n of the engine. This voltage U_n is applied to a regulator 12. A voltage U_α is also applied to the regulator 12. This voltage U_α is derived from an electromechanical transducer 13 which is mechanically coupled to the acceleration lever 14 or the gas pedal constituting signalling means furnishing second signals. The regulator 12 processes the actual rotational engine speed n and the desired speed as determined from the position of the acceleration lever 14, and emits thereupon a signal to the positioning member 15. Through this signal, an injection pump 16 is displaced or set through a regulating rod, not shown. With such setting or displacement of the pump 16, the quantity of fuel injected per stroke, and thereby the rotational speed of the engine 10, become varied. From the viewpoint of stability, it may advantage under certain circumstances, to include the feedback arrangement 17 for applying the output of the positioning member 15 directly to the input thereof in a feedback group, and thereby stabilize the unit. Thus, the members 15 and 17 can be comprised of, for example, a servo system with feedback through which the signal derived from the regulator 12 is translated into mechanical motion for setting the injection pump 16.

FIGS. 2 and 3 show transducers which serve to apply to the regulator a DC voltage which corresponds to the rotational speeds n of the internal combustion engine.

In the embodiment of FIG. 2, an inductive transducer 18 is driven by the rotational speed of the engine and provides thereupon a pulsed signal with frequency proportional to this rotational speed. The output of the transducer 18 in the form of electrical pulses, is applied to a Schmitt trigger circuit 19 which serves the purpose of shaping the pulses so that they have steep edges. The output of the Schmitt trigger circuit 19 is then applied to a monostable multivibrator 20 which, when actuated, provides pulses having unity duration and amplitude. An R-C network connected to the output of the multivibrator 20 emits a DC voltage U_n which is proportional to the arithmetic average of the pulses generated by the monostable multivibrator 20. The lower limit frequency of the R-C network 21 is determined through selected resistors and capacitors, so that it is still above the highest regulating frequency of approximately 10 Hz.

FIG. 3 shows another embodiment for the transducer used to derive an electrical signal proportional to the rotational speed. In this embodiment, an alternating current rate generator 22 provides an alternating voltage with amplitude dependent upon the rotational speed. The output of the rate generator is rectified through a rectifying bridge 23, for example, and is then applied to an R-C network 24. The voltage U_n proportional to the rotational speed of the engine is taken from this R-C network. For realizing symmetrical behavior for increase and decrease in the rotational speed, corresponding to charging and discharging of the capacitor 25, it is essential that the internal resistance of the bridge 23 and the AC rate generator 22 be equal to the load resistance. This condition may be achieved by either winding the rate generator 22 so that it has a high ohmic or resistance value, or by making the load resistance so that it is of low value. When resorting to a high resistance winding, an NTC resistor combination 26 can be provided for temperature compensation of the rate generator voltage output. This temperature compensation element 26 may be connected between the output of the rate generator 22 and the bridge 23, and compensates for the positive temperature coefficient of the copper winding.

FIG. 4 shows the principle of the regulator. A DC voltage amplifier with high idling amplification is denoted by the reference numeral 27. A voltage U_n proportional to the rotational speed n of the engine, is applied to the first input 28 of this amplifier. The position of the acceleration lever 14, corresponding to the voltage U_a is applied to the second input 29 of the amplifier. The electromechanical transducer 13 is comprised of a potentiometer having a resistance winding 30 to which a reference voltage is applied for energizing the winding. The sliding contact 31 of the potentiometer is positioned in accordance with the acceleration lever position 14, and the voltage output of the sliding contact 31 is applied to the second terminal 29 of the amplifier 27, through an input resistor 32. The voltage U_n dependent upon the rotational speed of the engine, is applied through an input resistor 33, to the first input terminal 28 of the amplifier. The resistor 33 may be of complex form, similar to that for the feedback resistor R.

Since the positioning member will often give rise to a delay in the regulating process, through which instabilities in the regulating circuit may result, it is often of advantage to include a differential and/or integral element in the feedback network at the input of the regulator.

FIG. 5 discloses the details of the circuit for the DC voltage amplifier 27. The voltage U_n dependent upon the rotational speed of the engine is applied through an R-C network and a resistor, to the first input of the DC amplifier 27. The R-C network may be contained within the speed transducer. The feedback network R of the DC amplifier 27 is formed of the combination of two variable resistors 34 and 35 and a capacitor 36 connected to the junction of these adjustable resistors. This feedback network also includes the combination of a capacitor 37 in parallel with the windings of the two variable resistors, and a further variable resistor 38 with winding connected in parallel to the capacitor 37. Through the resistors 34 and 35, the proper stability for the regulating circuit is adjusted. The capacitor 37 is required for amplifier stabilization, and with the aid of the resistor 38, the desired setting of the regulator is realized.

FIG. 6 shows the arrangement of the regulator and the positioning element 15 connected thereto. A discriminator 39 is connected in front of this positioning element 15 in view of its three-point relationship. Depending upon the output signal of the regulator 12, either one or both of the control valves 40 and 41 become actuated through the discriminator 39. Another operating condition of these control valves is that they are both in their quiescent or inoperative states. When the control valve 40 becomes actuated, the pressurized fluid associated with the positioning member or positioning element flows into the pressure chamber 42 and displaces the piston head 43 to which a regulating rod 45 is secured. The pressure within the chamber 42 forces the piston 43 towards the right against the action of the spring 44, and the resulting motion of the regulating rod 45 serves to set the injection pump denoted by the reference numeral 16 in FIG. 1. With such setting of the injection pump, for example, the amount of fuel introduced into the engine is increased. If, on the other hand, the control valve 41 becomes opened, the spring 44 moves pressing the piston head 43 and thereby the regulating rod towards the left in the drawing. This results from the feature that the pressurized fluid is able to flow out of the chamber 42. The amount of fuel introduced into the engine becomes thereby reduced. When both valves 40 and 41 close, the positioning element or displacement element is in its quiescent or inoperative state.

In place of the hydraulic displacement element, an electrical motor can also be provided, which moves the regulating rod 45 for the injection pump either to the right or to the left as required.

Displacement members of that type require feedback of their output and to their input, in view of their integral behavior. For this reason, the regulating rod 45 is mechanically coupled to the sliding contact 46 of a variable resistor 47. The winding of this variable resistor is connected to a reference voltage. The voltage value taken from the sliding contact 46, is dependent upon the positioning of this contact and hence the position of the regulating rod 45. This voltage from the slid-

ing contact 46 is then fed back to the three-point discriminator 39.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in regulating arrangements for internal combustion engines, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A regulating arrangement for an internal combustion engine, comprising, in combination, fuel injection means for introducing fuel into said engine as a function of a fuel-injection signal applied to said fuel injection means; speed sensing means coupled to said engine for providing a first signal corresponding to the speed of said engine; signalling means for providing a second signal corresponding to a desired operating characteristic of said engine; direct-current difference amplifier means comprising an output connected with said fuel injection means for applying thereto a fuel-injection signal; input means comprising a pair of inputs respectively connected with said speed sensing means and with said signalling means; and feedback network means connected with said output means and said input means for synthesizing a desired characteristic functional relationship between the signals at said input means and the signals generated at said output, said difference amplifier means being operative for controlling operation of said fuel injection means as a function of said first and second signals and in accordance with said characteristic functional relationship.

2. The regulating arrangement as defined in claim 1, wherein said feedback means comprises passive electrical components.

3. The regulating arrangement as defined in claim 1, wherein said engine comprises a diesel engine.

4. The regulating arrangement as defined in claim 1 wherein said feedback network means comprises means for diminishing delay times in the response of the output signal of said amplifying means relative to the input signal applied to said amplifying means.

5. The regulating arrangement as defined in claim 1 including displacement means coupled to said fuel injection means and connected to said output of said amplifier means for setting said fuel injection means to a predetermined position for introducing a predetermined quantity of fuel into said engine.

6. The regulating arrangement as defined in claim 5 wherein said displacement means comprises a hydraulic arrangement with two control valves actuated by said output of said amplifier means; a pressure chamber in which fluid flow is controlled through said control valves; a displaceable piston communicating with said pressure chamber and displaced as a function of the pressure within said chamber; and piston rod means connected between said piston head and said fuel injection means for setting said fuel injection means so that a predetermined quantity of fuel is introduced into said engine as a function of the position of said piston.

7. The regulating arrangement as defined in claim 6 including a three-point discriminator connected between the output of said amplifying means and said control valves for actuating said valves.

8. The regulating arrangement as defined in claim 7 including variable resistor means with movable contact coupled to said piston rod and electrical voltage output of said movable contact connected to said discriminator for applying to said discriminator a feedback voltage dependent upon the output displacement of said piston rod.

9. The regulating arrangement as defined in claim 5, wherein said displacement means comprises an electrical motor for displacing said fuel injection means in one direction and alternatively in the opposite direction dependent upon the quantity of fuel to be introduced into said engine.

10. The regulating arrangement as defined in claim 1 including displacement means with integral operating characteristic connected to the output of said amplifier means; and feedback means connected between the output and input of said displacement means.

11. The regulating arrangement as defined in claim 1 wherein said speed sensing means comprises an alternating current rate generator with output AC voltage having an amplitude proportional to the rotational speed of said engine; rectifying means connected to the output of said alternating current rate generator for rectifying the voltage output of said generator; and resistor-capacitor network means connected between the output of said rectifier means and input of said amplifying means.

12. The regulating arrangement as defined in claim 11 wherein the equivalent internal resistance of said rectifying means and said rate generator is equal to the equivalent load resistance applied to said rectifying means.

13. The regulating arrangement as defined in claim 12 including resistor means with negative temperature coefficient connected to the output of said alternating current rate generator for temperature compensating the output voltage of said generator against fluctuations due to variations in the internal resistance of the winding of said generator due to temperature variations, said winding of said rate generator having a substantially high electrical resistance.

14. The regulating arrangement as defined in claim 1 wherein said speed sensing means comprises a rate generator providing an alternating current with frequency dependent upon the rotational speed of said engine; pulse shaping means connected to said rate generator and receiving said alternating current signal for shaping said alternating current signal into a pulsed signal; and monostable multivibrator means connected to the output of said pulse shaping means for providing rectangular-shaped pulses dependent upon the rotational speed of said engine.

15. The regulating arrangement as defined in claim 14, wherein said pulse-shaping means comprises a Schmitt trigger circuit.

16. The regulating arrangement as defined in claim 14 including a resistor-capacitor network connected to the output of said monostable multivibrator for converting rectangular-shaped pulses dependent upon said rotational speed of said engine into a DC voltage de-

pendent upon said rotational speed, said DC voltage being applied to said one input of said amplifier.

17. The regulating arrangement as defined in claim 16 including resistor means connected between the output of said resistor-capacitor network and said one input of said amplifier.

18. The regulating arrangement as defined in claim 16, wherein the lower frequency limit of said resistance-capacitor network is higher than the highest regulating frequency.

19. A regulating arrangement for an internal combustion engine comprising, in combination, fuel injection means for introducing fuel into said engine; speed sensing means coupled to said engine for providing a signal indicative of the speed of said engine; and direct current operational amplifying means connected between said fuel injection means and said speed sensing means for regulating said fuel injection means

so that the quantity of fuel injected into said engine is a function of the speed of said engine, said amplifying means having substantially high amplification at stall loads of said engine, said direct current operational amplifying means comprising a DC amplifier with feedback network, said feedback network being comprised of passive electrical components, said feedback network comprising further an adjustable resistor connected between the output and the input of said amplifier, a capacitor connected in parallel with the resistance winding of said adjustable resistor, a combination of two series-connected resistors in parallel with said capacitor and said adjustable resistor, and auxiliary capacitor means connected between ground potential and the junction of said two series-connected resistors.

* * * * *

20

25

30

35

40

45

50

55

60

65