

- [54] **ELECTRONIC SPEED REGULATOR FOR INTERNAL COMBUSTION ENGINES**
- [75] Inventors: **Franz Butscher, Eriskirch; Werner Bader, Tettngang, both of Germany**
- [73] Assignee: **Motoren- und Turbinen-Union Friedrichshafen GmbH, Friedrichshafen, Germany**
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- [51] **Int. Cl.** ..... **H02p 9/02**
- [58] **Field of Search** ..... **123/32 EA, 102; 290/40, 51**

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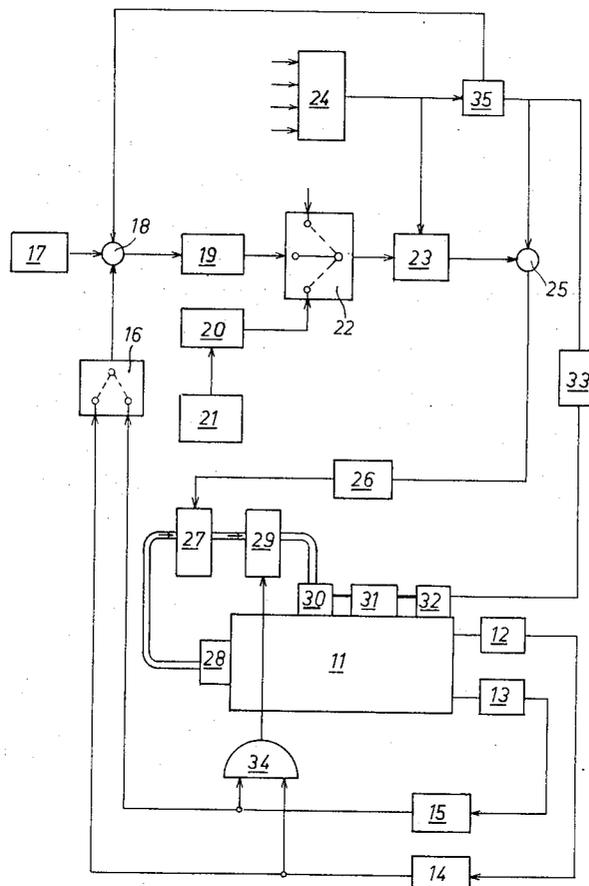
Primary Examiner—G. R. Simmons  
Attorney—Paul M. Craig, Jr. et al.

[57] **ABSTRACT**

An electronic rotational speed control device for internal combustion engines of large power output with a desired-value adjustment for the rotational speed and filling of the internal combustion engine, a desired-actual-value comparison of the rotational speed, a control stage, an amplifier, and adjusting member with a servo-valve for the filling control which is provided with a motion pickup and a feedback; a pure rotational speed control stage with P-I-D behavior or a filling-rotational speed control stage can be selectively engaged while between the control stage and amplifier a filling-limit signal intended to limit the engine filling is compared with the filling-signal produced by the control stage whereby the respective smaller signal is transmitted to the amplifier; two measuring systems are provided for the rotational speed measurements which are utilized selectively for the supply of the rotational-speed existing-value and which can be connected by way of an OR-circuit so as to act, in case of excess rotational speed, on a stoppage mechanism of the internal combustion engine.

17 Claims, 7 Drawing Figures

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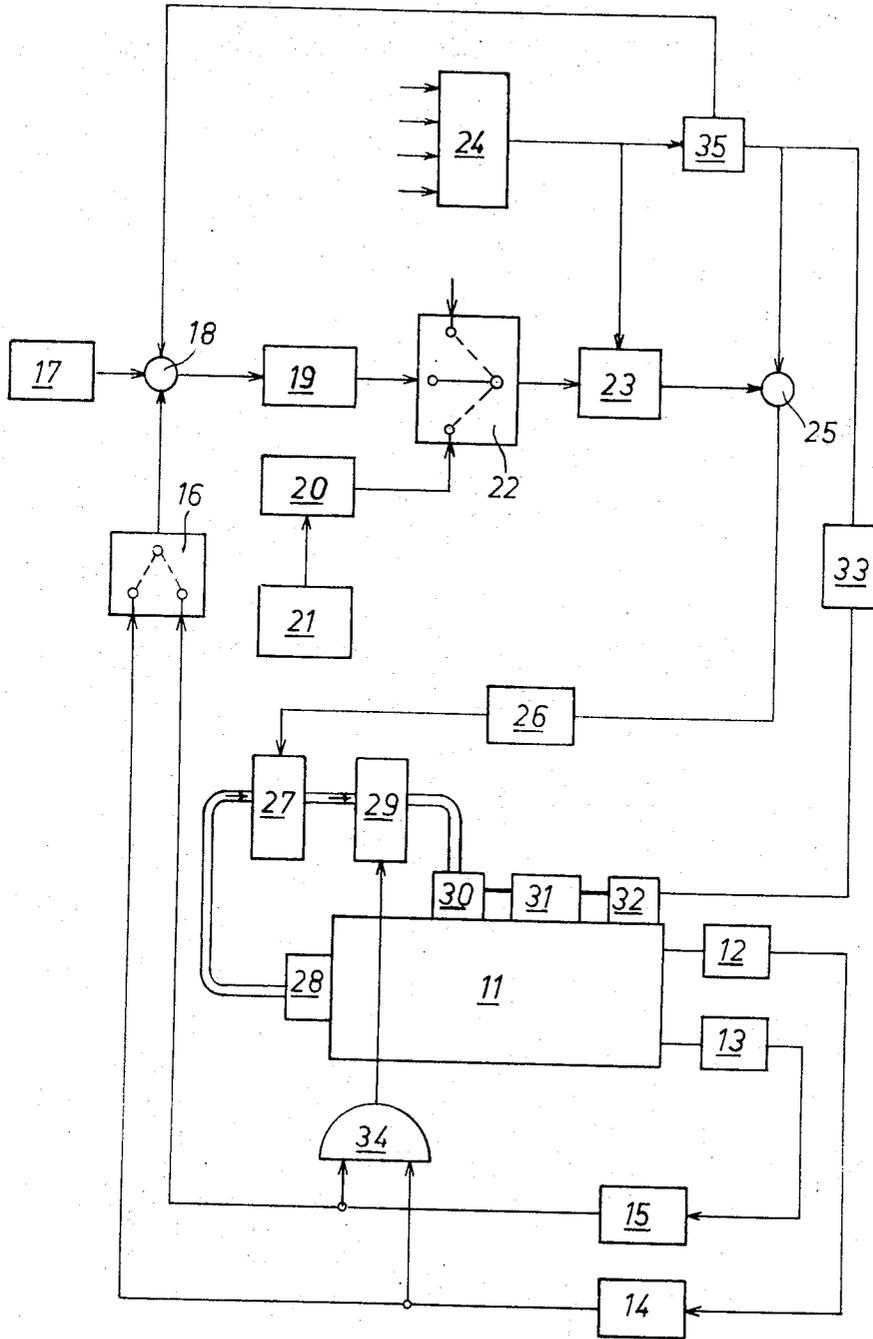


FIG. 1

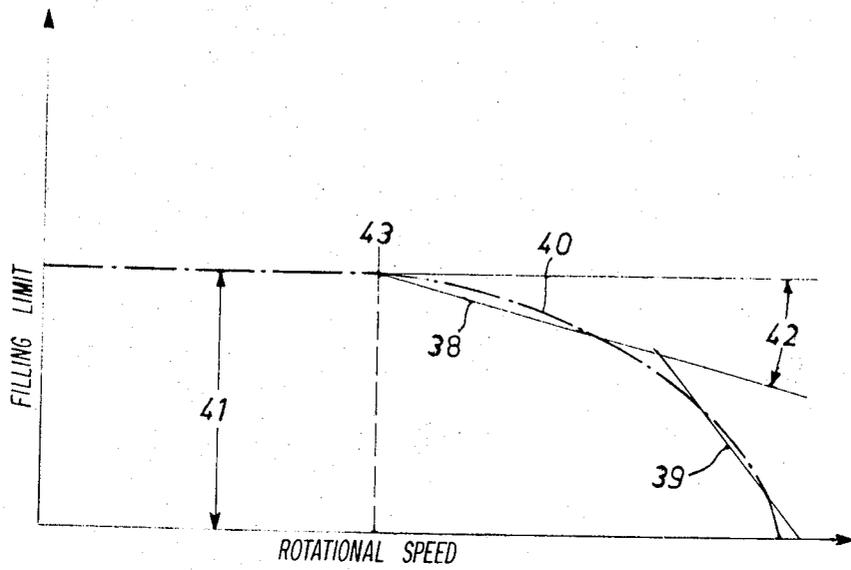


FIG. 2

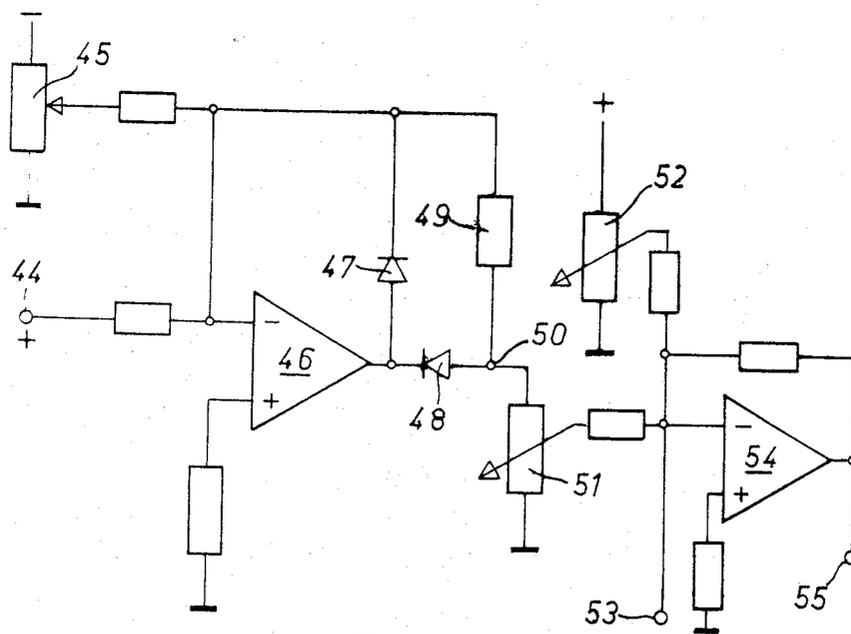


FIG. 3



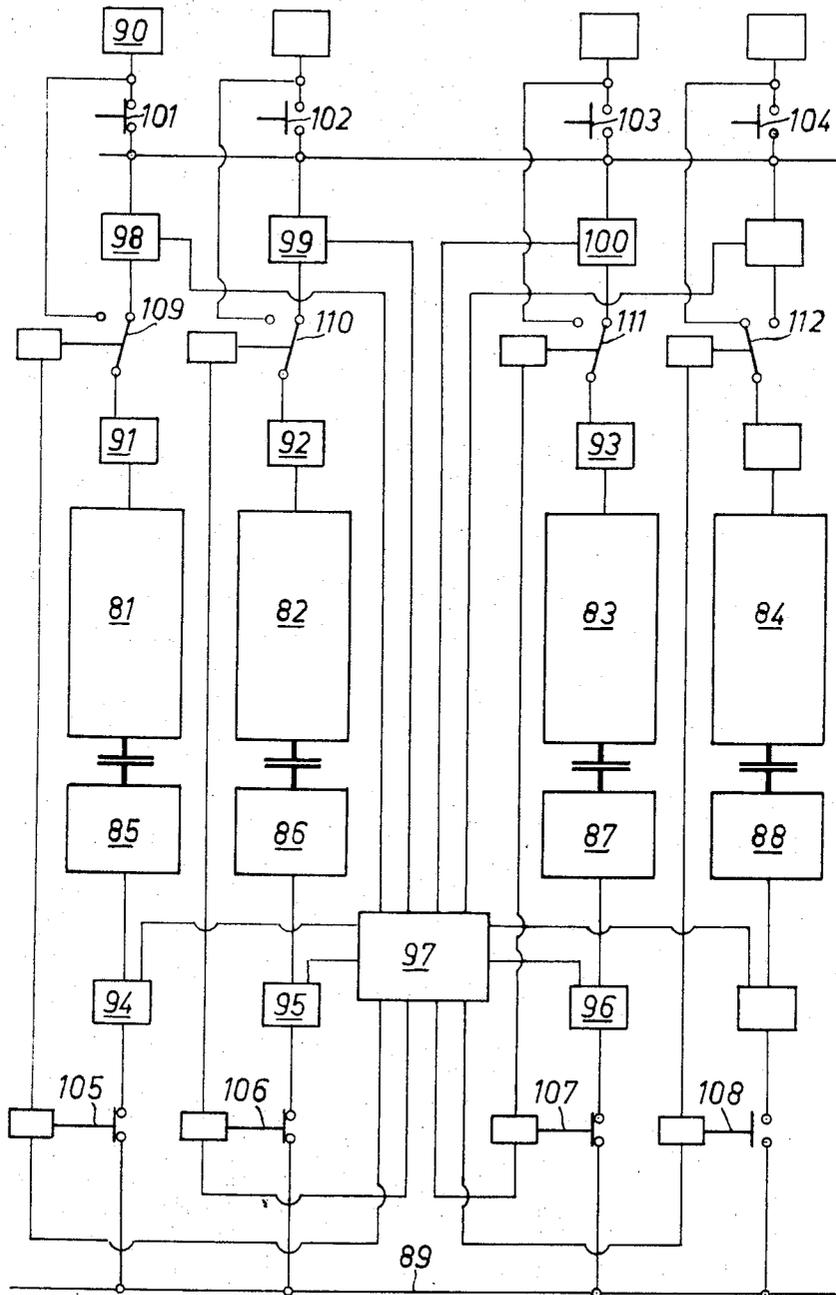


FIG. 6

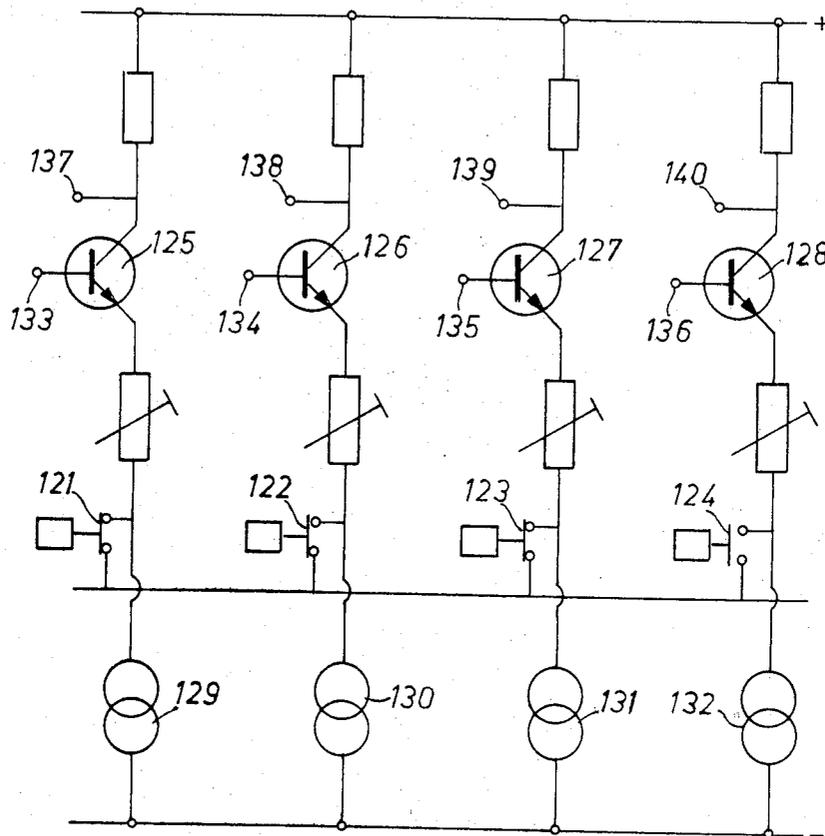


FIG. 7

## ELECTRONIC SPEED REGULATOR FOR INTERNAL COMBUSTION ENGINES

The present invention relates to an electronic rotational speed regulating device for internal combustion engines of high power output with a desired-value adjustment or setting for the rotational speed and filling of the internal combustion engine, an actual-desired-value comparator of the rotational speed, a control stage, an amplifier, and an adjusting member with a servo-valve for the filling control with a displacement pickup and a feedback system.

Electronic speed regulators are provided for internal combustion engines for the control of the rotational speed and filling by reason of their simple construction, their easy adjustability and by reason of the universal applicability to different types of internal combustion engines.

With internal combustion engines of high power output, such as for example, Diesel engines for rail vehicles, there exists the requirement for a selective rotational speed control or for a combined filling-rotational speed regulation.

For example, with a torque converter transmission connected in the output of the engine, a rotational speed and filling control is possible, whereas with a coupling or clutch transmission connected in the output of the engine, a filling control is required.

By reason of the high initial cost of the engines special requirements exist for the prevention of premature wear during the operation of the engines under unfavorable conditions. The filling of the engines has to be reduced, for example, in dependence on the engine rotational speed, when the ignition pressure at low rotational speeds becomes excessive for the bearing support of the crankshaft or when the so-called smoke limit is reached. If the external air pressure drops, for example, when reaching a greater altitude during the drive of vehicles, or if the oil temperature of the engine increases to a non-permissive extent, for example, due to a defect in the cooling system, or if the temperature of the suction air is excessively high, then the filling has to be reduced for the protection of the engine and for the completely satisfactory combustion.

In case of an excessive rotational speed it has to be assured that the filling of the internal combustion engine is reduced under all circumstances.

It is the aim of the present invention to fulfill these manifold requirements and conditions by means of an electronic control device.

The underlying problems are solved according to the present invention by the combination of the following features:

a. pure rotational speed control stage with a P-I-D behavior or a filling-rotational speed stage can be selectively engaged as the control stage;

b. filling-limit signal which is to limit the engine filling, for example, in dependence on the engine rotational speed, the outside air pressure, the oil temperature and/or the charging air temperature, is compared between the control stage and the amplifier with the filling-signal derived from the control stage whereby the respectively smaller signal is transmitted to the amplifier;

c. two measuring systems are present for the rotational speed measurement which can be utilized selectively for the supply of the actual-value of the rota-

tional speed and which are both operable to act by way of an OR-circuit on a stopping mechanism of the internal combustion engine in case of an excessive rotational speed.

The advantages of the electronic control are further refined by the present invention and a far-reaching safeguard of high-cost internal combustion engines against premature wear and destruction due to excessive rotational speeds is achieved by the present invention.

It is necessary for the different areas of application to construct the proportionality range of the controller adjustable from 0 percent to about 10 percent. According to the present invention a control stage with a P-I behavior is used for that purpose having a 0 percent rotational speed deviation between idling and full-filling whereas a P-behavior with adjustable proportionality range is attained by changing the rotational-speed desired-value as a function of the actual-value of the filling.

Furthermore, it is desirable for the adjustment and testing of the proportionality range on the test stand and for the maintenance of the required desired-rotational-speed that the control device commences with the limit control at maximum possible power output at the selected desired rotational speed. This is achieved according to the present invention in that a new signal to be added to the rotational-speed desired-value is formed from the sum of the filling-limit-signal and the filling actual-valve-signal with the aid of a further constant signal corresponding to the maximum filling signal.

If several internal combustion engines operate in parallel on a common output, then it was customary heretofore to coordinate to each internal combustion engine its own control device. However, it is difficult in that connection to assure the uniform loading of all internal combustion engines.

This disadvantage is eliminated in that with a parallel operation of several internal combustion engines only one command or guide-control device with a control stage exists and the remaining systems derive the filling-signal from this control stage.

A uniform loading which is satisfactory for most applications is achieved thereby.

With the drive of generators, which operate on a common electric power supply network, a still more accurate load equalization may become necessary, especially in order to equalize changes of the adjusting member or of the filling control which may occur in the course of time.

This problem is solved according to the present invention in that a signal taking into consideration the effective load of the generator driven by the corresponding internal combustion engine is added to the filling signal of the common guide control stage for an individual combustion engine so that all installations are operated with the prescribed load.

Accordingly, it is an object of the present invention to provide an electronic rotational speed control device for internal combustion engines which avoids by simple means the aforementioned shortcomings and drawbacks encountered in the prior art.

Another object of the present invention resides in an electronic control device for internal combustion engines operable to control the rotational speed or the

filling and rotational speed of the internal combustion engine in an effective manner.

A further object of the present invention resides in an electronic control device for internal combustion engines of the type described above which is simple in construction, utilizes relatively simple commercially available parts and provides far-reaching protection against premature wear of the engine, yet offers great versatility in operation and universal applicability to different engine installations.

Still another object of the present invention resides in an electronic control device for internal combustion engines which assures uniform loads of all internal combustion engines when driven in parallel with a common load.

These and further objects, features and advantages of the present invention will become more apparent from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one embodiment in accordance with the present invention, and wherein

FIG. 1 is a block diagram of an electronic control device for an internal combustion engine in accordance with the present invention,

FIG. 2 is a diagram illustrating the filling limit curve as a function of rotational speed,

FIG. 3 is a schematic circuit diagram of the circuit for limiting the filling-signal,

FIG. 4 is a diagram illustrating filling-limit curves, and  
FIG. 5 is a schematic circuit diagram for limiting the filling,

FIG. 6 is a schematic diagram illustrating a correcting system for the internal combustion engine outputs in accordance with the present invention, taking into consideration the effective loads of generators operating in parallel on a common network, and

FIG. 7 is a schematic circuit diagram of the differential amplifier used in the present invention.

Referring now to the drawing, wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIG. 1, a high power Diesel engine 11 is illustrated in this figure as the controlled system. The rotational speed of the Diesel engine 11 is measured both with a conventional tachogenerator 12 which produces a rotational speed voltage, as also with a conventional digital rotational speed measuring device 13 which develops a frequency corresponding to the rotational speed. The produced output signals are converted into respective analog D.C. voltage signals in a rotational speed receiver 14 and in a frequency-voltage converter 15, respectively, and are selectively made available by way of a switch 16 as rotational speed "existing" or "actual"-value for the control.

The desired value adjustment or setting for the rotational speed takes place by way of a potentiometer 17 while the comparison between both values is carried out in an adding point 18 formed by a conventional comparing circuit and is fed to a P-I-D control stage 19 of conventional type. In addition to the P-I-D control stage 19, there is provided a filling stage 20 with a "desired" or "intended"-value adjustment 21 for the filling. The filling signal corresponding to the rotational speed desired-value or corresponding to the filling desired-value or corresponding to the command of a guide control device can be selectively utilized by way of a switch 22.

In low value gate circuit 23, the filling signal of the control stage is compared with the filling limit signal of a filling limit device 24 which is influenced, for example, by the engine rotational speed, the oil temperature, the charging air temperature and/or the air pressure. The smaller signal is compared with a feedback signal in a further adding point 25, is amplified in an amplifier 26 and is converted in an electro-hydraulic servo-valve 27 into a corresponding hydraulic pressure. This pressure is produced by a pump 28 driven by the Diesel engine 11 and reaches by way of a stop valve 29 a cylinder 30 which actuates an injection pump 31. A displacement pick-up 32 produces the feedback signal which is fed by way of an amplifier 33. Upon reaching an excessive rotational speed, the stop valve 29 is actuated by means of an OR-gate 34 from one of the two rotational speed actual value signals. A proportionality adjustment 35 is influenced by the feedback signal as actual-value of filling and by the filling limit signal from filling limit device 24 and supplies a new signal to be added to the rotational-speed desired-value in the adding point 18.

FIG. 2 illustrates the curve of the filling limitation 40 divided into two straight partial sections 38 and 39 as a function of rotational speed. Each section 38 and 39 is adjustable by three values, namely the maximum limit height 41, the angle of inclination 42 and the commencing rotational speed 43.

FIG. 3 illustrates a schematic circuit for achieving such a partial section.

A voltage proportional to the rotational speed is applied to terminal 44 and is compared with a negative voltage adjusted by means of potentiometer 45. If this negative voltage is larger than the rotational speed voltage, a positive voltage is produced in the output of the operational amplifier 46 which is fed back directly by way of a diode 47. Only when the rotational speed voltage at terminal 44 becomes larger than the negative voltage adjusted by means of the potentiometer 45, the signal in the output of the operational amplifier 46 becomes negative, can flow by way of diode 48 and is fed back by way of a resistance 49. The voltage at a point 50 is determinative for the feedback. The voltage in the output of the operational amplifier 46 adjusts itself corresponding to the forward voltage of the diode 48 whereby the temperature influence of this diode is eliminated.

The limit decrease or reduction per rotational speed unit can be adjusted at a potentiometer 51 corresponding to the angle of inclination 42 (FIG. 2). The adjustment at the potentiometer 45 produces the commencing rotational speed 43 (FIG. 2), i.e., the point where the limit control begins.

The limit height 41, in contrast, is adjusted at a further potentiometer 52. The negative voltage stemming from the potentiometer 51 is subtracted from the positive voltage adjusted at the potentiometer 52 by means of a further operational amplifier 54. The signal occurring at terminal 53 is a measure for the magnitude of the limitation. Further correcting members for further sections, for example, section 39 may be connected to terminal 53.

In FIG. 4 different desired-filling-limit control curves 60, 61 and 62 are illustrated. The point of intersection with the rotational speed desired-values 63, 64 and 65 should lie on the maximum possible filling curve 66 which deviates from the filling curve 67 for a 100 per-

cent filling by the filling limitation 68. Additionally, the non-uniformity degree or proportionality range, i.e., the inclination of the filling limit control curves is to be adjustable.

FIG. 5 illustrates a schematic circuit diagram for obtaining the filling limit control curves according to FIG. 4.

A positive voltage which corresponds in its height to the filling signal for a 100 percent filling, is adjusted at the potentiometer 69. The filling limit signal is connected to terminal 70 while the filling actual-value signal is connected to terminal 71.

The difference signal of the sum of filling limit signal and filling actual-value signal, on the one hand, and the adjusted voltage of the potentiometer 69, on the other, is amplified by an operational amplifier 72. The output signal can be taken off at terminal 73 which will be added to the desired-value for the filling limitation. A potentiometer 74 permits the adjustment of the non-uniformity degree.

If, for example, the engine is operated with the desired rotational speed 63 (FIG. 4) and maximum possible filling, then it operates at the operating point 75. The sum of filling-actual-value signal and filling-limit signal corresponds to the value for 100 percent filling adjusted at the potentiometer 69. No difference voltage exists and consequently also no signal is produced at terminal 73. The desired-value is not changed.

If, in contradistinction thereto, the engine is operated at point 76, then a smaller filling-actual-value signal is present. The sum of the filling-limit signal and filling-actual-value signal does not attain the value adjusted at the potentiometer 69 and a differential signal results which is amplified by way of the operational amplifier 72 and appears at terminal 73 corresponding to non-uniformity degree adjusted at the potentiometer 74. The desired-value is increased by this signal so that the engine operates actually at point 77.

Four internal combustion engines 81 to 84 with the generators 85 to 88 are illustrated in FIG. 6. The generators 85, 86 and 87 operate in parallel on a network 89 whereas the generator 88 is turned off, for example, for repair purposes. The rotational speed of the three internal combustion engines 81, 82 and 83 is compared only by one command or guide-control device 90 with the desired-value (frequency of the network) and a common filling signal is formed therefrom. This signal is fed by way of a common bar to the filling control devices 91, 92 and 93 for the control of the internal combustion engines. The effective output produced by the generators is detected in effective-output measuring devices 94, 95 and 96 of conventional construction and is indicated to a differential amplifier 97 in the form of signals. An average value is formed from all input signals and a corresponding output signal is formed from the difference between the input signal and the average value and is transmitted to correcting members 98, 99 and 100. In these correcting members 98, 99, 100 the correcting signal is added to the common filling signal and as a result thereof controls the corresponding internal combustion engines in such a manner that all installations operate with the same or predetermined effective output.

All control devices of the installed internal combustion engines can be utilized as guide-control device by means of switches 101 to 104.

Each individual installation can be disconnected from the network by way of switches 105 to 108. In the illustrated embodiment, the installation with the internal combustion engine 84 and the generator 88 is illustrated in the disconnected condition. Simultaneously with the actuation of one of the switches 105 to 108, the disconnected installation is connected with its own control device by way of a corresponding switch 109 to 112 and the separation is carried out in the differential amplifier.

The schematic circuit diagram of a differential amplifier for four generators connected in parallel is illustrated in FIG. 7. Switches 121 to 124 are opened respectively when the corresponding installation is turned off. In the illustrated example, the fourth installation is again disconnected and therewith the switch 124 is opened.

One transistor 125 to 128 and one constant current source 129 to 132, respectively, is provided for each installation.

The corresponding signal for the effective load of the individual installations is connected to the base 133 to 136 of the transistors 125 to 128 and controls the current flowing through the transistors.

Depending on the flow of current and therewith depending on the effective load a voltage is produced at the collector 137 to 140 which is added to the common filling signal in the correcting members 98 to 101 (FIG. 6).

Owing to the constant current sources 129 to 132 coordinated to each installation, further installations can be connected or disconnected at any time without the need that the heretofore connected installations have to be matched. The individual controls of the internal combustion engines are corrected continuously so that always the prescribed effective loads are produced.

Since those elements and circuits indicated in block diagram in the drawing are known as such and are commercially available items, a detailed description thereof is dispensed with herein.

While we have shown and described only one embodiment in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art and we therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

What we claim is:

1. An electronic control device for internal combustion engines with high-power output, characterized by a first desired value means for setting a desired rotational speed for the internal combustion engine, a second desired value means for setting a desired fuel quantity filling value for the internal combustion engine, means for comparing the desired-value and actual-value of the rotational speed, first pure rotational-speed control means with P-I-D behavior responsive to the output of said rotational speed comparing means, second fuel quantity filling-rotational speed control means responsive to the output of said second desired-value means, means for selectively engaging as a control stage one of said first and second control means, means for providing a fuel quantity filling limit signal, second means for comparing the output signal of the selected first and second control means with the fuel

quantity filling signal, and providing an output of the respective smaller signal, and adjusting means responsive to the second comparing means for controlling the fuel quantity filling of the internal combustion engine in accordance with the smaller signal.

2. An electronic control device according to claim 1, characterized in that amplifier means are provided between said second comparing means and said adjusting means, said adjusting means including a servo-valve for controlling the fuel quantity filling of the internal combustion engine, motion pick-up means providing an output signal indicative of the actual fuel quantity filling value, and feed-back means for feeding back to actual filling value.

3. An electronic control device according to claim 2, characterized in that two measuring means are provided for the rotational speed measurement which can be utilized selectively for the supply of the actual-value of the rotational speed, and means selectively connecting the two measuring means by way of an OR-circuit with a stopping means of the internal combustion engine to render the stopping means effective in case of excess rotational speed.

4. An electronic rotational speed control device according to claim 3, with a control stage having a P-I behavior, characterized by means for obtaining the P-behavior with adjustable proportionality range by changing the rotational speed desired value in dependence on the actual-value of the filling signal.

5. An electronic rotational speed control device according to claim 2, with limit control means at maximum possible output at the desired rotational speed, characterized by means forming from the sum of the filling-limit signal and filling-actual-value signal a new signal for adding to the rotational speed-desired value signal and including a further substantially constant signal corresponding to a maximum filling-signal.

6. An electronic rotational speed control device according to claim 5, characterized by parallel operation of several internal combustion engines, and a single common guide control means with a control stage are operatively connected with said several internal combustion engines to provide a filling signal therefor.

7. An electronic rotational speed control device according to claim 6, in which the internal combustion engines are operatively connected with generators which operate on a common network, and characterized in that a signal taking into consideration the effective load of a respective generator driven by the corresponding internal combustion engine is added to the filling signal of the common guide control means for the individual internal combustion engine so that all engine-generator installations are operated with the prescribed load.

8. An electronic rotational speed control device according to claim 7, characterized in that the amplifier means includes operational amplifiers with diodes included in the feedback means so that the temperature influence of the diodes is eliminated.

9. An electronic rotational speed control device according to claim 8, characterized in that the filling limit signal is operable to limit the engine filling and said filling limit means provide the filling limit signal in dependence of at least one of the parameters consisting of engine rotational speed, outside air pressure, oil temperature and charging air temperature.

10. An electronic rotational speed control device according to claim 9, characterized in that the filling limit signal is operable to limit the engine filling as a function of all of said parameters.

11. An electronic rotational speed control device according to claim 2, with a control stage having a P-I behavior, characterized by means for obtaining the P-behavior with adjustable proportionality range by changing the rotational speed desired value in dependence on the actual-value of the filling signal.

12. An electronic rotational speed control device according to claim 2, with limit control means at maximum possible output at the desired rotational speed, characterized by means forming from the sum of the filling-limit signal and filling-actual-value signal a new signal for adding to the rotational speed desired-value signal and including a further substantially constant signal corresponding to a maximum filling-signal.

13. An electronic rotational speed control device according to claim 2, characterized by parallel operation of several internal combustion engines, and a single common guide control means with a control stage are operatively connected with said several internal combustion engines to provide a filling signal therefor.

14. An electronic rotational speed control device according to claim 13, in which the internal combustion engines are operatively connected with generators which operate on a common network, characterized in that a signal taking into consideration the effective load of a respective generator driven by the corresponding internal combustion engine is added to the filling signal of the common guide control means for the individual internal combustion engine so that all engine-generator installations are operated with the prescribed load.

15. An electronic rotational speed control device according to claim 2, characterized in that the filling limit signal is operable to limit the engine filling and said filling limit means provide the filling limit signal in dependence of at least one of the parameters consisting of engine rotational speed, outside air pressure, oil temperature and charging air temperature.

16. An electronic rotational speed control device according to claim 15, characterized in that the filling limit signal is operable to limit the engine filling as a function of all said parameters.

17. An electronic rotational speed control device according to claim 2, characterized in that the amplifier means includes operational amplifiers with diodes included in the feedback means so that the temperature influence of the diodes is eliminated.

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