1 598 844

PATENT SPECIFICATION (11) 1 598 844

(21) Application No. 2315/78 (22) Filed 20 Jan. 1978 (19)

(31) Convention Application No. 2702184 (32) Filed 20 Jan. 1977 in

(33) Fed. Rep of Germany (DE)

(44) Complete Specification Published 23 Sep. 1981

(51) INT. CL.^{3} F02D 5/00 // G05B 5/00

(52) Index at Acceptance G3N 288A 372 4X

(54) METHOD AND SYSTEM FOR ADDITIONALLY INFLUENCING THE QUANTITY OF FUEL DELIVERED BY A FUEL PREPARATION SYSTEM

(71) We, ROBERT BOSCH GMBH, a German company of Postfach 50, 7 Stuttgart 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to method and a system for additionally influencing the quantity of fuel delivered to an internal combustion engine by a fuel preparation system.

Fuel preparation systems are known which operate by means of an air quantity meter in the intake pipe of the internal combustion engine and, during computation of the quantity of fuel to be fed to the internal combustion engine, evaluate the output signal of the air quantity meter which is usually produced by a baffle flap. These known fuel preparation systems are chiefly electrically operating fuel injection systems, although the basic function of carburettors or other systems can be influenced in a suitable manner by means of the invention.

During rapid acceleration, the baffle flap of the known air quantity meter is usually in the first instance deflected to a considerable extent in the full load direction and subsequently swings back to a considerable extent under slight damping. During this swinging-back, a substantially lower state of load is simulated than that which corresponds to the actual air charge in the cylinders. The quantity of fuel which is fed to the internal combustion engine and which enters into this under-shooting, or, when applied to a fuel injection system, the injection pulses which are produced as a result of an under-shooting signal of this type, are too short. Thus, despite rapid depression of the accelerator pedal, the engine only accelerates with a delay and might even stall. Explosions can also occur in the intake pipe.

Although the change in the air quantity signal, caused in the first instance upon over-shooting of the baffle flap of the air quantity meter, and leading to an increased quantity of fuel, is desirable as transition enrichment, a correspondingly considerable prolongation of the injection pulses being effected in an injection system, this transition enrichment is only effective for a very short period of time and can only take effect in the case of those injection pulses which are produced in this period of time before the baffle flap swings back.

The invention according to one aspect resides in a method of automatically additionally influencing the quantity of fuel delivered by a fuel preparation system for fuel enrichment under acceleration, the quantity of air drawn in by the internal combustion engine being converted to an electrical air quantity signal by means of a sensor, wherein temporary additional enrichment is achieved by detecting over-shooting of the air quantity signal beyond a new steady-state air quantity value to be assumed upon an increase in the quantity of air drawn in, and wherein subsequent under-shooting is also detected and is subjected to smoothing to cause the temporary additional enrichment to gradually decline to said new steady state.

The invention according to another aspect includes a system for automatically additionally influencing the quantity of fuel delivered by a fuel preparation system for the purpose of acceleration enrichment, the quantity of air drawn in by the internal combustion engine being convertible to an electrical air quantity signal by means of a sensor, which signal is fed to the fuel preparation system, comprising a smoothing circuit for retaining over-shooting of the electrical air quantity signal with respect to time beyond a new steady-state air quantity value to be assumed upon an increase of the quantity of air drawn in, the output signal of which smoothing circuit is also fed to the fuel preparation system to cause the temporary additional enrichment effected by the over-shoot to gradually decline to the new steady-state value despite a subsequent under-shooting of the air quantity signal.

The method in accordance with the invention has the advantage that the temporary enrichment produced by over-shooting is prolonged during rapid acceleration, so that transition enrichment, as required for spontaneous reaction of the internal combustion engine during acceleration, continues for a longer period of time and compensates for the following under-shooting, so that, so far as the over-shooting is concerned, it is possible to utilize the shortcomings of the mechanical behaviour of the baffle flap for the purpose of temporary enrichment, while the undesirable under-shooting cannot exhibit any further effects.

It depends upon the type of the associated internal combustion engine as to whether a measure of this type should always be maintained, i.e. even when the engine is sufficiently hot, or should only be fully permitted when the engine is cold, the effect of this measure decreasing as the engine becomes hotter. Thus, supplementary circuits can be provided which can subject the acceleration enrichment to temperature dependence and, furthermore, can also make the acceleration enrichment dependent upon further external operating parameters of the internal combustion engine, such as the starting state, in which acceleration enrichment is not desired, and during over-running operation.

The system may have a function group which can be used additionally or, if required, alternatively, to evaluate every acceleration operation, that is also slow acceleration in the sense of acceleration enrichment which decreases with respect to time, as far as this is permitted by the slope of the air quantity signal and the change amplitude attained by the said signal.

Upon transition to over-running operation of the internal combustion engine, the acceleration enrichment can be prevented by means of an overrun cut-off, corresponding information being obtained by comparing the output signal of the air quantity meter with a desired value.

The circuit which intervenes during slow acceleration and which effects acceleration enrichment decreasing with respect to time, can produce a trigger signal for a corresponding enrichment function by differentiating the air quantity signal, since, in this case, the baffle flap of the air quantity meter does not overshoot or undershoot and thus the air quantity signal is not subjected to a corresponding evaluable change. This circuit advantageously includes, in addition to the differentiating stage, a timing circuit in the form of a Miller integrator whose output signal is fed to a specific component of an electrical fuel injection system, the so-called divider control multivibrator, in the present case, for the purpose of increasing the charging current.

Since an enrichment function, such as is produced by the function groups mentioned previously and which acts upon a divider control multivibrator of this type, can only be effective up to the level of a predetermined maximum limitation of the pulse time, a special pulse time limiting stage can be provided, since, in this instance, substantially larger pulse time values have to be formed and limited in a defined manner.

The present invention is further described hereinafter, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a block circuit diagram of a preferred system, in accordance with the invention, comprising several function groups;

Fig. 2 is a detailed electrical circuit according to one embodiment for realising the enrichment and cut-out functions of the system; and

Figures 3, 4, 5, 6a and 6b are graphs which show, in the form of function curves, the mode of operation of the acceleration enrichment circuit of the system.

The basic construction and the principal functions of the fuel enrichment system will be described briefly in the first instance with reference to the block circuit diagram of Fig. 1. It has already been mentioned above that the general aim of the invention is to provide measures which lead to enrichment of the fuel/air mixture fed to an internal combustion engine, chiefly during the acceleration phase of the internal combustion engine, i.e. upon acceleration effected by the operator. Preferably, this enrichment condition can be subjected to further peripheral conditions such that the fuel/air mixture fed to the internal combustion engine is enriched in dependence upon temperature, enrichment not being effected during starting and during overrun operation, and that the enrichment decreases with respect to time. These further peripheral conditions can partially or fully affect, or have no effect on, the possible enrichment state which, in an electrical or electronic fuel injection system operable with intermittent injection, is manifested by an increase in the maximum duration of the control pulses fed to the solenoid fuel injection valves.

It may be mentioned that this only involves one preferred field of application of the present invention which can also be used successfully in other fuel preparation systems which inject the fuel continuously or which are in the form of carburettors. The only essential feature is that the output signals produced by the system in accordance with the invention are correspondingly fed to the fuel preparation system and are evaluated to enrich the fuel/air mixture in a manner which, if required, is subjected to further peripheral conditions. Thus, when the invention is hereinafter preferentially described with reference to an intermittently operating electrical fuel injection system, this only represents a preferred field of application of the invention and does not constitute limitation to this field of application.

The block circuit diagram of Fig. 1 shows, in the first instance, a module which is designated 1 and which, in the most general case, constitutes an evaluating circuit whose input 7 receives an air meter signal (AM signal) and whose inputs 2,3 and 4 are fed with output signals, preferably having an analog curve shape, from circuit components described below. The module 1 evaluates these signals in accordance with the details given further below. The evaluating circuit 1 produces an output signal at 5 and, if required, feeds it to further-processing circuit components which then covert this output signal to trigger pulses having a pulse duration influenced by the evaluating circuit 1. In the case of an electrical fuel injection system, and particularly in the case of the so-called L Jetronic injection system of Robert Bosch GmbH, the further-processing circuit may be the multiplier stage which produces, from the so-called *tp* pulses fed thereto, the final trigger pulses *ti* for the solenoid fuel injection valves, including further correction influences.

In general, the fuel enrichment system in accordance with the invention serves to improve the admission of petrol upon accelerating an internal combustion engine which may be fitted in a motor vehicle, particularly when the engine is cold and in the case of a relatively slightly damped baffle flap of an air quantity meter which is arranged in the intake pipe of the internal combustion engine and produces an output signal which, at least in the steady state, substantially corresponds to the quantity of air drawn by the internal combustion engine. Since the air quantity meter operating with a baffle flap is not a sensor which operates in an absolutely ideal manner, the baffle flap of the air quantity meter overshoots in the full load direction during, for example, rapid acceleration and subsequently swings back to a relatively large extent, which latter operation can be designated "under-shooting". These two states do not correspond to the quantities of air effectively drawn in and processed by the internal combustion engine at these instants. Thus, a linearization or damping circuit 6 of appropriate construction is provided for the air meter signal (AM signal) present at the input 7 and, in a desired manner, has a smoothing or damping effect upon the AM signal fed. The damping circuit 6 has an associated cut-off circuit 8 which, even in the event of deceleration, for example from the average range of speed, that is when the so-called overruning state of the engine occurs, prevents a corresponding movement of the baffle flap and a change in the AM signal from being incorrectly detected and compensated for by the damping circuit 6 as a swinging-back or under-shooting operation. Alternatively the circuit 8 may be designated a so-called "overrun cut-off circuit". Furthermore, it is generally desirable to enrich the fuel/air mixture during acceleration of the internal combustion engine, so that, for example, so-called "holes" are avoided during acceleration of the internal combustion engine. This enrichment circuit, designated 9 in Fig. 1, ensures enrichment which decreases with respect to time and which is also effective during slow acceleration since, during such slow acceleration, the baffle flap in the air quantity meter does not over-shoot, so that a corrective measure acting by virtue of appropriate dimensioning of the damping circuit 6 cannot take effect.

On the other hand, as will frequently occur in the practical embodiment, the influence of the damping circuit 6 and of the enrichment circuit 9, both of which lead to enrichment of the fuel/air mixture, may only be desirable for specific operating states of the internal combustion engine, such as when the engine is cold, so that there is no unnecessary deterioration of the exhaust gas when the engine is hot. Thus, an additional circuit 10 is provided which introduces into the behaviour of the damping circuit 6 and of the enrichment circuit 9 for enrichment decreasing with respect to time a temperature dependence of optional type in the first instance, and which at the same time ensures that the influences of the circuits 6 and 9 are also suppressed when starting the internal combustion engine.

Finally, a circuit 11 for limiting the maximum pulse time is also provided which is intended to limit, in a defined manner, the substantially larger pulse time values effected by the circuit in accordance with the invention. Preferably, this limiting circuit 11 also intervenes in dependence upon temperature, that is controlled by the additional circuit 10, wherein the increase in the pulse time can be gradually reduced as the engine temperature increases.

Thus, the system in accordance with the

invention, and which may be designated "acceleration enrichment circuit" hereinafter, achieves the following:

1) The maximum pulse time is increased (or generally ensures enrichment of the fuel/air mixture fed to the internal combustion engine in the range of acceleration, the resultant increase being limited to a desired upper limiting value by means of a special pulse time limiting stage 11,

2) the AM signal produced by the air quantity meter is damped and influenced in a desired manner, thus resulting in an enrichment behaviour of the circuit components evaluating the "damped" AM signal,

3) enrichment decreasing with respect to time is undertaken which is also effective during slow acceleration and which operates in addition to the enrichment effected by the damping circuit,

4) the entire enrichment behaviour (in the range of acceleration of an internal combustion engine) is subjected to temperature dependence, wherein

5) the enrichment behaviour during starting of the internal combustion engine and

6) during overrun operation (by means of an overrun cut-off) can be suppressed.

The damping circuit 6 will first be discussed in detail hereinafter with reference to Fig. 2. The damping circuit has an input 7 to which the air quantity meter signal AM, already mentioned, is fed in its original form. A further input or circuit point P1 of the damping circuit 6 is at a predetermined positive potential, while there is produced at the output or circuit point P2 a correction signal which the further-processing circuit, which need not be further discussed, processes in addition to the air quantity signal AM fed thereto.

By way of example, the production of the air quantity signal AM can be envisaged by virtue of the fact that a voltage divider comprising the resistors R1, R2 and a potentiometer Pt1 is connected between the positive lead 20 and the negative lead 21. The junction between the resistor R1 and one terminal of the potentiometer Pt1 forms the circuit point P1 of the damping circuit 6 and, as will be seen, carries a positive potential of predetermined value resulting from the voltage divider ratio. By way of example, the tapping of the potentiometer Pt1 is displaced in conformity with the movements of the baffle flap (not illustrated) of an air quantity meter, and there is then produced between the tapping of the potentiometer and the circuit point P1 a varying output signal which has originally been processed as an air quantity signal by the further-processing circuit. In other words, the original air quantity signal is formed as a voltage difference between the circuit point P1 and the tapping of the potentiometer Pt1, the shift of a negative voltage, present on the tapping, towards a more positive constant voltage value being measured and evaluated. The smaller is this differential voltage, the greater is the extent (as stipulated) to which the baffle flap is opened, so that a greater quantity of air is drawn in by the internal combustion engine and the greater is the load on the internal combustion engine. Thus, a small air quantity signal voltage (relative to the potential of the circuit point P1) means that the internal combustion engine is operating under a high load, while a large voltage differential between the tapping or at the output of an impedance matching circuit 22, to the input of which is fed the potential of the tapping 23 of the potentiometer, corresponds to a low load on the internal combustion engine. The impedance matching circuit 22 may be provided in order to form the potential on the tapping of the voltage divider in a manner independent of load.

In order to obtain a correction signal with respect to damping of the air quantity meter behaviour, the damping circuit 6 is constructed such that a low-resistive path (formed by a diode D1 and a resistor R6) and a high-resistive path (formed by a resistor R5) are provided for discharging a capacitor C1, so that the potential across the capacitor is increased when the air quantity signal AM increases in the sense of a higher load (the voltage difference between the circuit point P1 and the input 7 is reduced), whereas, when the signal AM swings back or under-shoots, the potential on the capacitor, which is nothing other than the potential on the circuit point P1, is decreased, its change being transposed to the output terminal P2. In this manner, it is possible for the differential voltage already mentioned to be maintained constant, wherein it will be appreciated that the invariable constant positive voltage potential at the circuit point P1 is no longer fed to the further-processing circuit for evaluation, but that the further-processing circuit is fed with the corrected correction signal, varying in a desired manner, freshly produced at the circuit point P2 by the damping circuit, together with the actual air quantity signal AM. Potential characteristics, which are shown in Fig. 3 and which will be explained hereinafter, then result at the various points of this circuit. A predetermined, steady travelling operation exists in the first instance up to the instant t1, and the air quantity signal AM (shown by a solid line) has a constant potentional value U1. The interval to the more positive constant voltage potential UP1 of the circuit point P1 is Δ 1, which means that there is only a relatively low load on the internal combustion engine in the case of a large differential voltage. It will be assumed that rapid acceleration is effected from the instant t1; the baffle flap of the air quantity meter swings to a considerable extent in the direction of full load, wherein there can be a considerable amount of over-shoot up to the instant t2, i.e. a change voltage of the signal AM which corresponds to an air quantity even greater than the increased quantity of air drawn in, so that the circuit connected on the output side reacts to this over-shooting (characterised by the hatched region of Fig. 3) with, possibly, a considerable so-called "transition enrichment". In the case of a fuel injection system, this over-shooting implies a considerable prolongation of the injection pulses, which is desirable or may be desired, since one thus obtains acceleration enrichment advantageous to travelling operation.

Of course, after over-shooting in the full load direction, the baffle flap swings back to a considerable extent between the instants t2 and t3 according to the damping, so that this swinging-back momentarily simulates a substantially lower state of load than that which corresponds to the actual air charge in the cylinders of the internal combustion engine. The injection pulses which would correspond to this under-shooting would be too short, or, in other words, the quantity of fuel fed to the internal combustion engine during this period of time would be too small. Thus, the engine would be accelerated only with a delay and could even stall. Furthermore, explosions might occur in the intake pipe.

Finally, the position of the baffle flap of the air quantity meter, and thus the air quantity voltage AM detectable at the tapping of the potentiometer Pt1, approach, in the period of time between t3 and t4, the fresh steady state lying at U2 as the output voltage of the air quantity meter, and the fresh voltage difference △2 between the voltage characteristic of the air quantity signal AM and the voltage U_{P1} at the circuit point P1 is produced.

The correction undertaken by the damping circuit 6 is manifested by the fact that the voltage at the output point P2, which is still solely evaluated as "constant voltage potential" at the potentiometer terminal by the further-processing circuit, follows, so to speak, the change in the air quantity signal AM, thus resulting in the voltage characteristic U_{P2} (shown by a broken line) which, in the case of the above-mentioned swinging behaviour of the baffle flap of the air quantity meter, departs from the constant voltage potential U_{P1} and, as is shown in Fig. 3, in the first instance remains related to the characteristic of the air quantity signal AM approximately up to the instant t4 and then gradually assumes the earlier value approximately up to the instant t5, so that the two separated voltage branches U_{P1} and U_{P2} again unite at this instant. In the damping circuit 6, the differential voltage characteristic designated δ U_P between these two voltage branches otherwise appears as a voltage drop across the resistor R4. The differential voltage effectively processed by the further-processing circuit thereby always corresponds to the voltage difference from △ 1 to △ 2 characterised by the double arrows. By virtue of the tapping of the voltage potential at the output point P2, the over-shooting behaviour (manifested at the instant t2 as the minimum differential amplitude of the voltage to be evaluated) is maintained in the first instance and is prolonged so as to decay with respect to time, the under-shooting being fully covered. Thus, it is possible to retain the transition enrichment effected by over-shooting of the baffle flap and to maintain it in a controlled manner as desired and in accordance with the dimensioning of the components used and only to allow it to decrease gradually, so that, related to the range of this function group in the first instance, excellent adaptation is produced by corresponding acceleration enrichment.

As already mentioned, the curves given in Fig. 3 are rendered possible by the controlled charging or reversal of charge on the capacitor C1 which is arranged in the emitter circuit of a transistor T1 which is connected as an emitter follower and whose emitter is connected to earth or the negative lead 21 by way of a resistor R8. The transistor T1 is triggered by the output voltage of the air quantity sensor, that is by way of the tapping 23 of the potentiometer Pt1, optionally by way of the series-connected impedance matching circuit 22. The other terminal of the capacitor C1 is connected to a circuit point P3 which, provided that the forward voltages of diodes D1 and D3 interconnected at their cathodes are equal, is at the same potential as the circuit point P1 when in a normal state. Furthermore, the circuit point P3 is connected to the base of a transistor T2 which is again connected as an emitter follower and whose emitter forms the circuit point P2 and thus the output of the damping circuit 6. Finally, a control signal, which, sofar, has not been taken into account, can be applied to the circuit point P3 from another region of the circuit by way of a diode D2 and a lead L1. The diode D2 is assumed to be non-conductive. The circuit point P3 is connected directly to the resistor R5, which leads to the positive lead 20 and is relatively or highly high-resistive, and via the diode D1 to the very low-resistive resistor R6 which is connected between the common connection point (cathodes) of the diodes D1 and D3 and leads to the earth lead 21. A further resistor R_D may be connected between the anode of the diode D3 and the circuit point P1. The damping circuit 6 then functions in the following manner.

When the voltage at the input 7 increases in the period of time between t1 and t2, the emitter follower circuit comprising the transistor T1, and the low-resistive voltage divider branch comprising the diode D1 and the resistor R6, force a change in the charge across the capacitor C1 such that the voltage on that terminal of the capacitor which is connected at the circuit point P4 to the emitter of the transistor T1 changes virtually directly with the controlling input potential on the base in conformity with the air quantity signal AM, while that capacitor terminal which is connected to the circuit point P3 does not change its potential owing to the low-resistive branch R6. The charge-reversing current of the capacitor C1, whose voltage can vary considerably during this operation, then flows through the diode D1 and the resistor R6, wherein the time constant of this operation can be substantially ignored. Since the voltage at the circuit point P3 does not change, the voltage at the circuit output P2 also remains unchanged when there is a positive voltage increase at the input of the transistor T1 (up to instant t2 of Fig. 3). However, if the voltage at the input 7 drops towards negative values upon the swinging-back of the air quantity signal AM, the diode D1 becomes non-conductive (a corresponding capacitor charge-reversing current would have to flow in the opposite direction, this not being permitted by the diode D1) and the changing emitter potential of the transistor T1 forces (with a virtually constant voltage across the capacitor C1) the circuit point P3 to follow, since the charge on the capacitor C1 cannot be reversed, or can only be reversed very slowly, by way of the high-resistive resistor R5 or the base current of the transistor T2. Consequently, there is also a shift in the voltage potential at the circuit point P2 (the transistor T2 is connected as an emitter follower) and the above mentioned voltage drop δ Up is developed across the resistor R4, thus fundamentally resulting in the desired function. In one embodiment, a time constant of from approximately 1 to 2 seconds was calculated for the high-resistive discharge path for the capacitor C1 (gradual adaptation to the fresh steady operating state), while the time constant for the reversing of the charge on the capacitor is approximately 20 ms.

The diode D3 connected between the circuit point P1 and the junction between the diode D1 and the resistor R6 serves, on the one hand, to switch off the actual damping circuit region for the steady state, since the forward voltages of the diodes D1 and D3 which are not quite equal as a result of differing currents, but which are comparable so far as it goes, ensure that, in the steady state, the circuit point P3 and thus the base of the transistor T2 assume substantially the potential of the circuit point P1, so that the transistor T2 is blocked and the voltage U_{P1} is equal to the voltage U_{P2}. On the other hand, this diode serves to adjust the sensitivity of the damping circuit 6 to voltage fluctuations of the air quantity signal AM. In principle, one can proceed on the assumption that the voltage fluctuation on the emitter of the transistor T1 must be greater than the base-emitter forward voltage of the transistor T2 which thus has to be overcome in the first instance before a change in potential can be obtained at the output circuit point P2. A special advantage of this damping circuit is that the latter ceases to intervene in a well-defined manner when a steady non-varying quantity signal AM is applied and this circuit thus does not respond even to voltage changes which, for example, as a result of influencing of the signal by a fluctuating supply voltage, are caused by pulsating air flows in the intake pipe or by other voltage fluctuations, in any event for as long as such voltage fluctuations lie below a predetermined threshold value of, for example, 300 mV which is determined by the mutual reference or the difference between the forward voltages of the diodes D1 and D2 and the base-emitter forward voltage of the transistor T2, provided that the resistor R_D is chosen to be zero. Furthermore, by suitable choice of this resistor relative to the resistor R6, the voltage fluctuations to which the circuit responds can be determined more accurately, as will be readily seen.

The mode of operation of the transistor T1, and thus the damping circuit 6, is further influenced by the resistor R8 between the emitter and earth potential or the negative lead 21, and by the resistor R9 which connects the emitter of the transistor T1 to the base thereof. The resistor R8 receives the current which results from the reversal of the charge on the capacitor C1 during under-shooting of the AM signal and which also flows through the resistor R5. Thus, the value of the resistor R8 must be at least sufficiently small to allow this current to flow off, since it canot flow into the emitter of the transistor T1. If the resistor R8 is made too high-resistive, the extent of the reaction to an under-shooting operation of the AM signal can be influenced in this manner and thus also the overall sensitivity of the circuit to changes in the air quantity signal AM. In a similar manner, the sensitivity of the circuit can be dimensioned by the resistor R9 which is as high-resistive as possible, or which may be entirely omitted, since the transistor T1 can be controlled into its active range only when the corresponding potential, which overcomes the base-emitter voltage, drops across the said resistor.

Some possibilities of influencing the mode of operation of the damping circuit 6 by way of a transistor T3 will be explained before entering into a discussion of the further circuit portion which includes a Miller integrator and which also results in acceleration enrichment and is effective particularly during slow acceleration (during which no over-shooting evaluable by the damping circuit 6 occurs). The base of the transistor T3 is triggered by signals which are fed to the transistor by way of diodes D4, D5 and D6 and which, in this respect, form an OR-gate. An input E1 feeds the diode D4 with a temperature signal ϑ which may be, for example, a temperature voltage obtained by means of a NTC resistor, an input E2 feeds the diode D5 with a signal characterising the starting state of the internal combustion engine, while the air quantity signal AM is fed directly to the diode D6 by way of a lead L2. The possibility of intervention by the transistor T3, whose emitter receives a predetermined potential by way of a resistor R9 and a voltage divider circuit comprising resistors R10 and R11, is established by connecting its collector by way of the lead L1 to the junction between the diode D2 and the resistor R7 of the damping circuit 6. The resistor R7 is relatively low-resistive. When the operation of the damping circuit 6 is desired, that is in the case of a temperature signal indicating a cold engine and during normal operation of the internal combustion engine, the diode D2 is blocked when the transistor T3 is conductive, since the anode of the diode D2 is connected by way of the collector-emitter path of the transistor T3 to a potential which is more negative than the potential normally present at the circuit point P3. However, if the transistor is blocked because, for example, a correspondingly negative potential is fed to its base by way of one of the diodes D4 to D6, the current path by way of R7 and D2 is released and the very low-resistive resistor R7 is connected in parallel with the high-resistive resistor R5 with the result that the potential at the circuit point P3 is substantially maintained and no longer follows the changes in the voltage on the emitter of the transistor T1. The damping circuit 6 is then entirely or partially switched off (according as to the extent to which the transistor T3 is blocked and the extent to which the low-resistive current path across R7 is opened), this always occurring when the engine is sufficiently hot, so that a correspondingly negative temperature signal is present at the input E1, when, during starting of the internal combustion engine, a negative control signal, which may be produced in an optional manner, indicating this starting state is present at the input E2, or when, as a third possibility, the overrun cut-off already mentioned above comes into operation. During overrun operation, i.e. when the accelerator pedal is fully inoperative, the air quantity signal AM, as is shown in the graph of Fig. 4, drops to a very low value (corresponding to the position now assumed by the slider of the potentiometer Pt1) and below a threshold value voltage Us, so that the diode D6 becomes conductive and the damping circuit 6 is blocked by way of the transistor T3 in the manner just described. Although the damping circuit attempts to respond to the swinging-back movement of the air quantity signal AM in a conventional manner, and the small peak δ Up' of Fig. 4 occurs, the low-resistive current path R7, D2 is released as soon as the air quantity signal voltage UAM falls below the threshold value voltage Us, the transistor T3 thereby being blocked, and the voltage at the circuit point P3 returns to its positive constant voltage potentional and then corresponds substantially to the voltage at the circuit point P1 or at the output P2 of the damping circuit 6. Any possible swinging-in movements of the baffle flap, which are manifested by the oscillation of the air quantity signal AM after dropping below the threshold voltage Us, have no effect, since the transistor T3 remains in its non-conductive state. The same effect otherwise results during switching, so that, here also, the fuel/air mixture is not enriched. The threshold value voltage Us and thus the operation of the overrun cut-off are determined with respect to potential by the adjustability of the resistor R11. The same adjustment then applies to the temperature signal, resulting in the possibility of abruptly switching off the intervention of the damping circuit 6 or, when operation is carried out without a special threshold, of slowly bringing the transistor T3 into its non-conductive state, so that the damping circuit gradually becomes inoperative as the engine becomes hotter.

The dependence of the time constant τD determining the intervention or the blocking of the damping circuit 6, upon the temperature of the internal combustion engine is shown diagrammatically in Fig. 5. It will be seen that there are various possibilities of adjustment. Thus, for example, as is shown by curve I, the damping circuit can be switched off very abruptly from maximum efficacy to zero at a predetermined engine temperature ϑ_1 which, in order to give a criterion, can lie at, for example, 70°. Alternatively, however, a gradual drop to a predetermined fresh damping time constant can be effected in conformity with the curve II, the resistor R9 being, as is shown, of importance for adjustment of the slope. Finally, a gradual drop can be effected to the zero value of the damping time constant τ_D in conformity with the curve III, so that, at a predetermined temperature of the internal combustion engine, the effect of the damping circuit 6 no longer enters into the calculation of the quantity of fuel to be fed to the internal combustion engine.

A further possibility, mentioned above, of enriching the fuel/air mixture to be fed to the internal combustion engine is that of enrichment, decreasing with respect to time, by means of the circuit 9 which is always operative in the first instance and whose action is thus superimposed on action of the damping circuit 6 during rapid acceleration but which is solely responsible for enrichment of the fuel/air mixture during slow acceleration (when over-shooting or under-shooting does not occur). This circuit comprises a Miller integrator which comprises a transistor T4 and a feedback capacitor C2 and which is triggered by a transistor T5 by way of a resistor R12. Since, in the case of operating conditions under consideration, the emitter follower of the transistor T1 is always active, the air quantity signal AM appears on the emitter, corresponding to the circuit point P4, of the transistor T1 and is fed by way of a resistor R13 to a differentiating stage which substantially comprises the transistor T5, the latter's base voltage divider comprising the resistors R14, R15 and R16, the diode D7 and the triggering capacitor C3. The transistor T5 is normally non-conductive and is rendered conductive by a positive trigger pulse of the air quantity signal AM, so that the collector of the transistor T4, and thus one terminal of the capacitor C2, are drawn to earth potential by way of the resistor R12. Intervention is then effected by the collector potential of the transistor T4 by way of the series-connected resistors R17, R18, and by way of the diode D8, which is then conductive, to the mixture-preparing circuit. In the special case of an electrical fuel injection system, the resistors R18 and R17 are connected in parallel with the charging resistor of the control multibrator stage, which charging resistor is connected to earth, so that a larger charging current flows to cause pulse prolongation and thereby fuel enrichment dimensioned according to the time constant of the Miller integrator. In any event, the output signal at the output A1 of the circuit for enrichment decreasing with respect to time results as an intervention signal increasing (linearly) from a negative potential to positive voltage values. This enrichment decreasing with respect to time gradually becomes ineffective again by virtue of the fact that the collector potential of the transistor T4 gradually increases again after triggering. Enrichment decreasing with time is desirable particularly for reasons of travelling behaviour when the internal combustion engine is relatively cold. The extent to which the base of the transistor T5 can be held just below the conductive state of the transistor, or the minimum amount of the voltage swing which the air quantity signal AM must produce in order to effect enrichment by the circuit 9 decreasing with respect to time, may be established by the divider ratio of the resistors R15 and R16. The same applies to the slope of the change in the air quantity signal which must attain a predetermined value, since, in the case of an optionally slow change, the capacitor C3 in the base circuit of the transistor T5 is able to follow the voltages applied thereto. These conditions depend upon the dimensioning of the individual circuit elements in the base circuit of the transistor T5. There is no need to enter into the further construction and the function of the timing circuit 9 forming the Miller integrator, since the module involved is itself known and comprises the transistor T4 with its collector resistor R19, the integrating capacitor C2 and a base leakage resistor R20 which is variable. If desired, this circuit 9 for enrichment decreasing with respect to time can also be subjected to the influence of all, or only one respectively, of the further operating states already mentioned above, that is starting, over-run operation and temperature of the internal combustion engine. In the illustrated circuit, a further transistor T6 is provided whose base is fed with the temperature signal of the internal combustion engine by way of the resistor R21, and with the starting signal from the input E2 by way of the resistor R22 and the diode D9. The emitter of the transistor T6 is connected to the positive lead 20 by way of the resistor R24 and to the emitter resistor R9 of the transistor T3 by way of the diode D11. The base and the emitter of the transistor T6 are interconnected by way of a diode D12. When intervention by the enrichment circuit 9 is desired, that is when the engine is sufficiently cold and if no starting conditions exist, the transistor T6, as will be seen, is blocked, and there is no intervention by way of the diode D10 and the variable resistor R23 in the collector circuit of the transistor T6. By way of example, the starting signal may be such that the transistor T6 is abruptly controlled into its conductive state, and the collector current flowing substantially through the resistor R18 increases the voltage on the latter to an extent where the diode D8 is rendered non-conductive. Preferably, the temperature signal intervenes such that a current increasing with increasing temperature flows through the transistor T6 and has to be accepted by the resistor R18, so that this current is subtracted from the current which flows through the diode D8 upon full intervention by the enrichment circuit 9. The conductive state of the transistor T6 is again also particularly determined by the threshold predetermined by the voltage divider R10, R11. Fundamentally, the collector potential of the transistor T4 for the range of the Miller integrator, and the collector voltage of the transistor T6 gradually increasing to positive values in dependence upon the temperature, form the same possibility of intervention on the resistor R18, since, by virtue of the increase in the output potential of the integrator, the analog intervention in the mixture preparation system by way of the diode D8 is influenced in the same manner, decreasing with respect to time, as by way of the transistor T6 when the latter gradually becomes conductive with increasing temperature of the internal combustion engine. With appropriate dimensioning of the resistor R23, it is also possible to prevent the enrichment, decreasing with respect to time, from being fully cut off even when the final temperature of the engine has been attained. This possibility of temperature intervention is effected chiefly for reasons of improving the composition of the exhaust gas for the purpose of protecting the environment.

The system in accordance with the invention, or its individual circuit function groups, enable the fuel preparation system to rise to substantially longer durations of the injection pulses according to the further operating parameters of the internal combustion engine which take effect, or, expressed in general terms, render it possible to enrich the fuel/air mixture, fed to the internal combustion engine, to a considerable extent. This behaviour is caused by the evaluated changes in the air quantity signal AM and, in the last analysis, by the movement of the baffle flap of the air quantity meter and/or by the circuit 9 for enrichment decreasing with respect to time. These maximum pulse durations in a fuel injection system render it desirable to limit the larger pulse values in a defined manner, for which purpose the pulse time limiting circuit 11 may also be connected.

The pulse time limiting circuit comprises a monostable trigger circuit having a single active semi-conductor switching element (a transistor T7), a capacitor C4 to which relatively long trigger pulses are applied and a discharge circuit formed by series resistors R25 and R26. Such a trigger circuit is a so-called economy mono. It is triggered at its input E3 by a suitable pulse train in synchronism with the injection pulses, the so-called trigger pulse trains being used whose triggering edges dropping in a negative direction switch the transistor T7 to its non-conductive state by way of a diode D13 and the capacitor C4 and are spaced at sufficiently large intervals apart to enable the increased limiting time to be set on the economy mono 11 by corresponding dimensioning of the discharge resistor R25 (variable) in series with the further resistor R26 for the capacitor C4. As soon as the transistor T7 is switched to its conductive state again after triggering by the trigger pulse train, a pulse produced by the further-processing circuit, and present on the collector of the said transistor, is diverted to the earth lead or negative lead 21, thus limiting the pulse time. An important feature is that the discharge time or the charge-reversal time for the capacitor C4 is also controllable, by way of a diode D14 and a variable resistor R27, by the collector of the transistor T6 of the temperature control sub-assembly already mentioned above. This intervention can only act to shorten the control pulse to be limited, wherein, when the transistor T6 is conductive, intervention by the acceleration enrichment is generally either blocked or fully cut off, so that a value limited to, for example, the normal maximum pulse is then produced at the pulse limiter stage 11 (when the transistor T6 is conductive).

Possible functional influences by the circuit in accordance with the invention, or partial regions of the circuit, on the formation of the final trigger pulses for the solenoid injection valves are shown diagrammatically in Figures 6a and 6b with reference to curves, when the circuit is used in connection with an electrical fuel injection system. Fig. 6a shows the size of the injection pulses *ti* plotted against time, the internal combustion engine accelerated at the instant t1 by depressing the accelerator pedal. Up to the instant t1, the injection pulses have a magnitude t_{io} which, at the instant of acceleration, increases to the maximum height t_{im} (owing to overshooting and/or enrichment decreasing with respect to time). The duration of the fuel injection pulses, of the order of magnitude of *til* relevant to the fresh state of load of the internal combustion engine, results only at the instant t2.

Fig. 6b clearly shows that this additional enrichment δ *ti* is additionally dependent upon the temperature ϑ_M of the engine, wherein, corresponding to the curve IV, the additional duration of injection δ *ti* drops with a considerable slope to the fresh constant value δ *til* of the enrichment at the temperature $\vartheta 1$. It will be appreciated that a drop to $\delta\ ti = 0$ is also possible, this being indicated in the form of the curve V in which, however, intervention of the additional enrichment, plotted against temperature, can be effected gradually, that is decreasing with a predetermined slope. Since the additional enrichment and its effect on the final duration of the fuel injection pulses may be effected in an optional manner, for example by corresponding variation of the superimposing effects of the damping circuit 6 and the circuit for enrichment decreasing with respect to time by differentiating the air quantity signal AM and the likewise variable intervention of the temperature control sub-assembly, optional curves δ *ti* plotted against engine temperature can be produced, the curve VI only representing one further possible embodiment.

In a preferred development, a RD circuit, comprising a diode D20 and a resistor R30 connected between the latter and the earth lead 21, is interposed between the emitter of the transistor T1 (circuit point P4) and the resistor R13.

As a result of this measure, the charge on the differentiating capacitor is only reversed slowly after the air quantity measuring flap has swung back, and thus the differentiating stage can only be triggered again by renewed swinging-up of the flap when a specific period of time has elapsed (approximately 300 msec). As a result of this time-blocking function, acceleration enrichment during a gear change is not triggered by the fact that the engine speed is abruptly increased from the idling speed upon re-engaging the clutch, whereby the flap in the air quantity meter is also deflected. Acceleration enrichment is triggered only when the driver accelerates again after engaging the clutch.

WHAT WE CLAIM IS:

1. A method of automatically additionally influencing the quantity of fuel delivered by a fuel preparation system for fuel enrichment under acceleration, the quantity of air drawn in by the internal combustion engine being converted to an electrical air quantity signal by means of a sensor, wherein temporary additional enrichment is achieved by detecting over-shooting of the air quantity signal beyond a new steady-state air quantity value to be assumed upon an increase in the quantity of air drawn in, and wherein subsequent under-shooting is also detected and is subjected to smoothing to cause the temporary additional enrichment to gradually decline to said new steady state.

2. A method as claimed in claim 1, wherein the sensor for the air quantity signal comprises an air quantity meter having a baffle flap.

3. A method as claimed in claim 1 or 2 wherein the air quantity signal, when changing without over-shooting during gradual acceleration, is converted to enrichment which decreases with respect to time and which is matched to the change behaviour.

4. A method as claimed in claims 2 and 3, wherein the air quantity signal is differentiated and fed to a timing stage whose output signal approaches an original value with a selectable time constant.

5. A method as claimed in any of claims 1 to 4, wherein the temporary additional enrichment is additionally influenced by external operating parameters of the internal combustion engine.

6. A method as claimed in claim 5, in which said external engine operating parameters are engine temperature and/or starting operation and/or overrun operation.

7. A system for automatically additionally influencing the quantity of fuel delivered by a fuel preparation system for the purpose of acceleration enrichment, the quantity of air drawn in by the internal combustion engine being convertible to an electrical air quantity signal by means of a sensor, which signal is fed to the fuel preparation system, comprising a smoothing circuit for retaining over-shooting of the electrical air quantity signal with respect to time beyond a new steady-state air quantity value to be assumed upon an increase of the quantity of air drawn in, the output signal of which smoothing circuit is also fed to the fuel preparation system to cause the temporary additional enrichment effected by the over-shoot to gradually decline to the new steady-state value despite a subsequent under-shooting of the air quantity signal.

8. A system as claimed in claim 7, wherein the smoothing circuit has a store, and high-resistive discharge current path for the store for gradually adapting the air quantity meter signal to the new steady-state air quantity value.

9. A system as claimed in claim 7 or 8, wherein the smoothing circuit has a second, low-resistive current path for rapid reception of the over-shooting air quantity signal to be stored as a result of the reversal of the charge on a storage capacitor.

10. A system as claimed in any of claims 7 to 9, wherein the air quantity signal is taken from the tapping of a potentiometer and is fed to the base of a transistor which is connected as an emitter follower and whose emitter is connected to one supply lead by way of a resistor and to the other supply lead by way of a storage capacitor serving as the store and a series-connected high-resistive resistor.

11. A system as claimed in claim 10, in which the potentiometer tapping is connected via an impendance matching circuit to the transistor base.

12. A system as claimed in claim 10 or 11, wherein a relatively low-resistive reversal current path, effective for reversing the charge on the storage capacitor when the air quantity signal is increasing, is provided by a series combination comprising a diode and a resistor which are connected to said one supply lead in parallel with the storage capacitor and the transistor triggering the latter.

13. A system as claimed in claim 12, wherein the base of a further transistor is connected to the junction between the storage capacitor, the high-resistive resistor and the diode forming part of the low-resistive charge reversal path, the emitter of which transistor forms the output circuit point of the smoothing circuit.

14. A system as claimed in claim 13, wherein the potentiometer tapping is connected to the output circuit point by way of a resistor and to the junction between the diode and the resistor in the low-resistive charge-reversal current path by way of a further diode, such that the output circuit point is substantially at the same potential as the potentiometer tapping when the smoothing circuit is inoperative.

15. A system as claimed in claim 14, wherein the potentiometer tapping is connected to said further diode by way of a resistor for the purpose of determining the response behaviour of the smoothing circuit.

16. A system as claimed in any of claims 7 to 15, which further comprises a timing circuit for producing an output signal, decaying with respect to time, when an air quantity signal change of predetermined amplitude and slope exists.

17. A system as claimed in claim 16 wherein said timing circuit is a Miller integrator and a differentiating trigger stage is connected to the input of the Miller integrator for producing an output signal which decays with respect to time.

18. A system as claimed in claim 17 when appendant to any of claims 11 to 15, wherein the transistor emitter terminal connected to the storage capacitor, is connected by way of a resistor to a differentiating trigger circuit of the Miller integrator, and the output of the Miller integrator is connected to a further-processing circuit by way of a resistor and a diode.

19. A system as claimed in claim 18, wherein a resistance/diode circuit is connected between said transistor emitter terminal, connected to the storage capacitor, and said one supply lead for the purpose of obtaining a cut-off function, limited with respect to time, during acceleration enrichment.

20. A system as claimed in any of claims 7 to 19, which further comprises a cut-off circuit which is adapted to respond to an internal combustion engine temperature signal, an engine starting signal or a signal for overrun operation, which cut-off circuit is operatively connected to said smoothing circuit, such that the switching behaviour of the smoothing circuit for the purpose of acceleration enrichment is entirely or partially blocked.

21. A system as claimed in any of claims 7 to 20, which further comprises a threshold circuit for detecting a drop in the air quantity signal below a predetermined threshold value during overrun operation, and for blocking the switching behaviour of the smoothing circuit accordingly.

22. A system as claimed in claims 10, 20 and 21, wherein the threshold circuit comprises a transistor whose emitter is connected to a pre-determined potential by way of a voltage divider and whose base is fed with the temperature signal, the starting signal and the overrun cut-off signal by way of a selection circuit and whose collector is connected to the junction between a low-resistive resistor and a diode such that, when the engine is hot and/or during starting and/or during overrun operation, the last-mentioned diode is entirely or partially conductive such that a low-resistive additional current path is connected in parallel with the high-resistive discharge current branch of the storage capacitor.

23. A system as claimed in claims 17 and 22, wherein the cut-off circuit comprises a transistor whose base is triggered by the temperature signal and/or the engine starting signal, whose emitter is connected by way of a diode and a resistor to the said voltage divider by which the transistor emitter is connected to the predetermined potential and whose collector acts, by way of a series combination comprising a diode and a resistor, to block a diode of a collector voltage divider of the Miller integrator.

24. A system as claimed in claim 22 or 23 for an intermittent fuel injection system, wherein a blocking signal is fed to a pulse time limiting stage by way of a diode from the collector of the said transistor whose emitter is connected by way of the voltage divider to the predetermined potential, which pulse time limiting stage is triggered at its input by a trigger pulse train in synchronism with the injection pulses and makes available an increased limiting time for the acceleration enrichment range of the internal combustion engine.

25. A system as claimed in claim 24, wherein the pulse time limiting stage comprises a monostable trigger stage.

26. A method of additionally influencing the fuel quantity fed to an internal combustion engine substantially as hereinbefore described with reference to the accom-

panying drawings.

27. A system for additionally influencing the fuel quantity fed to an internal combustion engine constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

W.P. THOMPSON & CO.,
Coopers Building,
Church Street,
Liverpool L1 3AB.
Chartered Patent Agents.

Printed for Her Majesty's Stationery Office,
by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.

1598844 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1

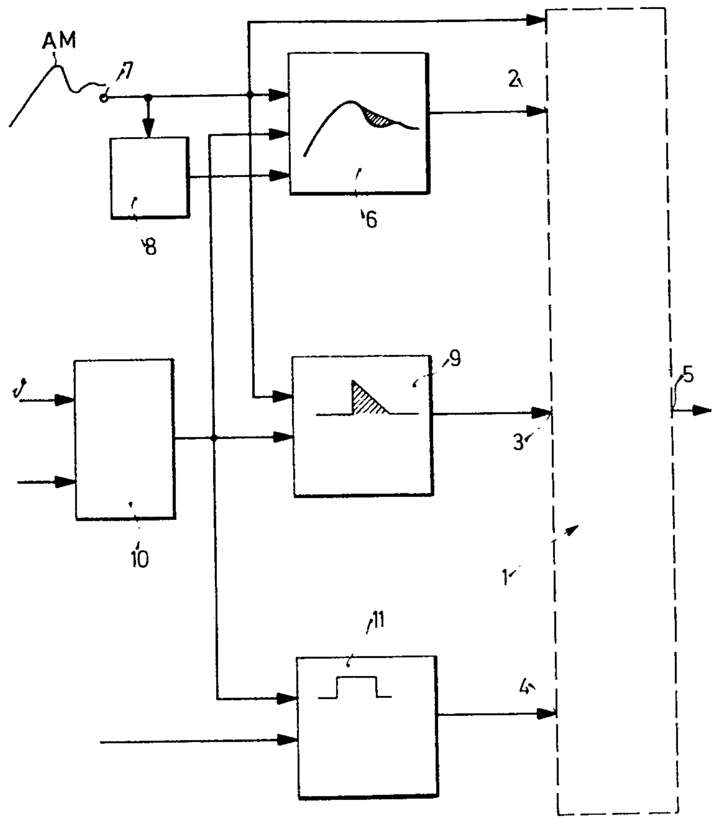
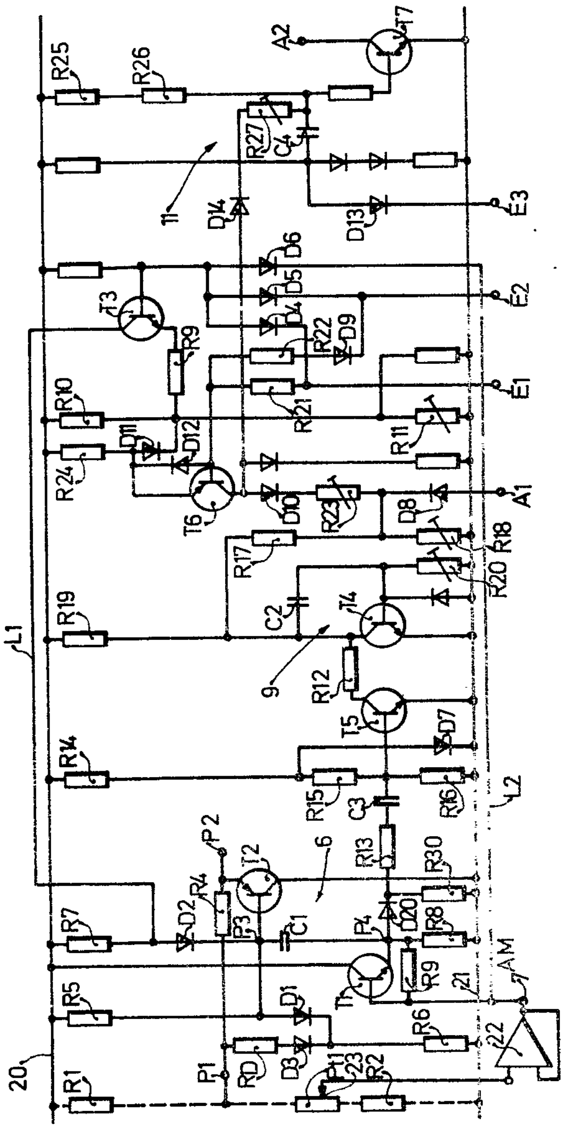


Fig.2

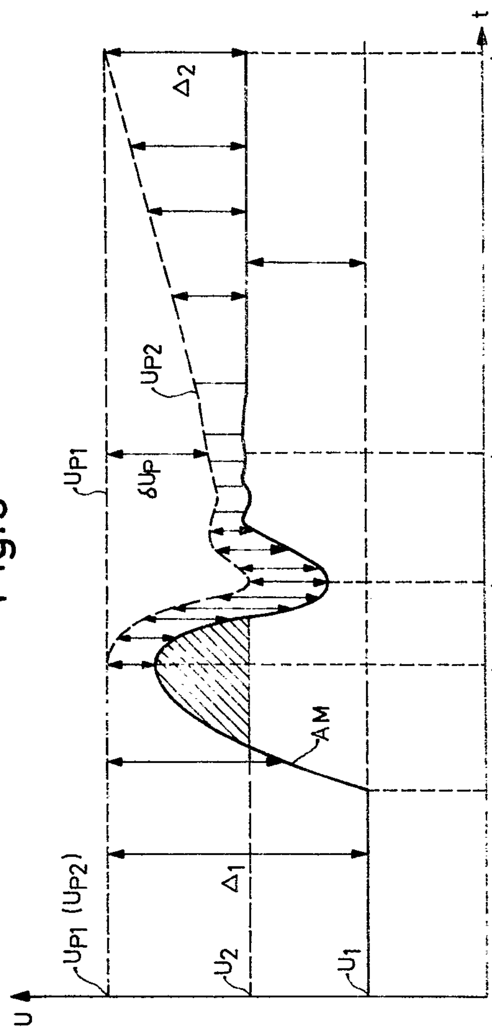

R25
R26
A2
T7
R27
C4
11
D14
D13
E3
D6
D5
T3
D4
E2
R9
R22
D9
R10
D11
D12
R21
E1
R24
R11
T6
D10
R23
D8
A1
R17
R18
R20
R19
C2
T4
L1
9
R12
T5
D7
R14
R15
C3
R16
L2
P2
T2
6
R13
R30
R7
D2
R4
P3
C1
P4
D20
R8
R9
AM
R5
D1
T1
21
R6
22
P1
RD
D3
P11
23
R2
20
R1

1598844 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

Fig. 3



1598844 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

Fig.4

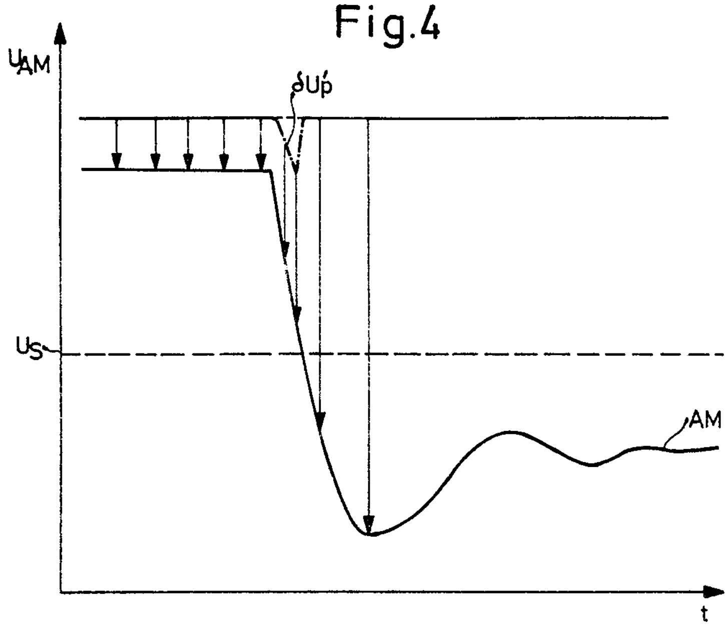


Fig.5

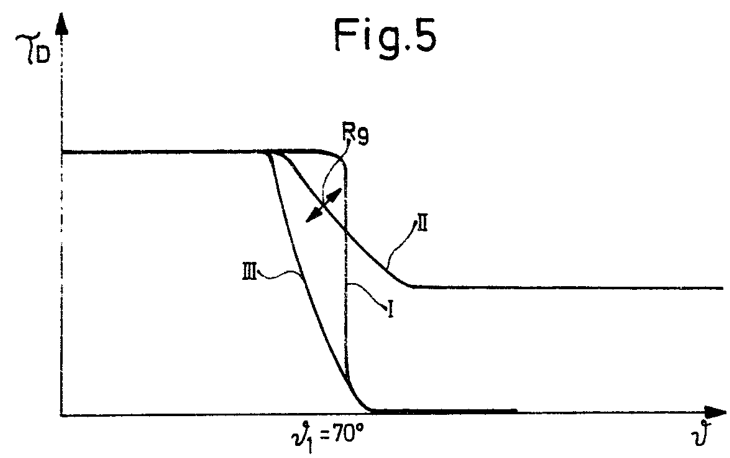


Fig.6a

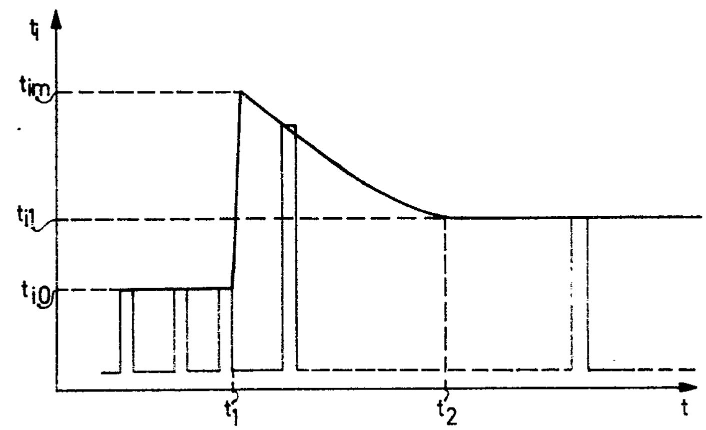
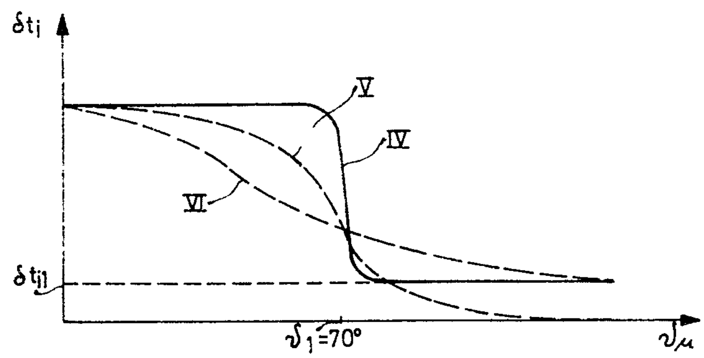

t_i
t_{im}
t_{i1}
t_{i0}
t_1
t_2
t

Fig.6b


δt_i
V
IV
VI
δt_{i1}
$\vartheta_1 = 70°$
ϑ_μ