An arrangement for regulating the current flow in the solenoid of an electromagnetically actuated mechanism, particularly a high-speed solenoid valve, of the type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position. The arrangement includes a power supply connected to the solenoid, a switch for initiating the build-up of current in the solenoid and a control arrangement responsive to the solenoid current and operative for maintaining the voltage across the solenoid substantially constant until the solenoid current reaches a predetermined threshold value. The control arrangement further includes a current-regulating arrangement operative after said threshold value has been reached for maintaining the solenoid current at a holding value lower than said threshold value.
REGULATING ARRANGEMENT FOR SOLENOID VALVES AND THE LIKE

BACKGROUND OF THE INVENTION

The invention relates to the energization of solenoids of electromagnetically actuated mechanisms, and most particularly solenoid valves.

More specifically, the invention relates to the energization of high-speed solenoid valves of the type requiring a higher activating current to effect opening of the valve and a lower holding current to maintain the valve open.

It is desirable in the operation of solenoid valves and the like to supply to the solenoid a current no larger than actually necessary for proper operation of the mechanism. Ideally, it is desirable to supply an activating current no higher than necessary to effect valve opening, for instance, and a holding current no higher than actually required to keep the valve open. The reduction of the solenoid current to these minimum necessary values is a matter of economy. In addition, however, if the solenoid current is significantly in excess of that actually needed, additional heat is generated and the dissipation of such additional heat is troublesome in many situations, for instance in the engine of a vehicle. Moreover, the additional heat generation can have an adverse effect on the vehicle electrical system, and particularly those components which actually carry the solenoid current. Variations in component values may even constitute interference signals interfering with proper timing of the valve operations.

It is not a simple matter to keep the solenoid current as low as actually necessary at any given moment in the operation of the valve. Particularly in vehicles, the variations of battery output necessitate a considerable degree of over-compensation of the solenoid currents. Thus, when the battery output is maximum, the solenoid currents will conventionally be higher than really necessary, in order to account for the eventual lower output of the battery.

It is already known to provide a solenoid valve control arrangement which applies to the solenoid an energizing pulse having a higher leading edge and a lower trailing edge. This takes somewhat into account the difference between the current needed to open the valve and the current needed to maintain the valve open. However, such shaping of the energizing pulse does not satisfactorily account for variations in battery output, and accordingly in the prior art both the leading and trailing edge of such shaped pulse must be of greater magnitude than absolutely necessary in order to guarantee proper valve operation.

SUMMARY OF THE INVENTION

It is the general object of the invention to overcome the disadvantages of the prior art.

More particularly, it is the object of the invention to provide a solenoid valve control arrangement for regulating the current flow in the solenoid of an electromagnetically actuated mechanism, particularly a solenoid valve.

It is another object of the invention to provide a solenoid regulating arrangement which permits a very fast build-up of solenoid current.

It is a further object to provide a solenoid control arrangement which positively limits the build-up of solenoid current to a preselected appropriate threshold value.

It is yet another object to provide a solenoid control arrangement which positively limits the holding current to a value corresponding very closely to the value actually needed to maintain the armature in activated position.

It is still a further object to provide an arrangement which permits adjustment of the value of holding current.

It is yet a further object to provide an arrangement having compensation against changes in supply voltage, so that the operation of the solenoid valve will tend to be unaffected by changes in supply voltage.

These objects, and others which will become more understandable below, can be met by an arrangement for regulating the current flow in the solenoid of an electromagnetically actuated mechanism, particularly a high-speed solenoid valve, of the type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position. The arrangement includes a power supply connected to the solenoid, switch means for initiating the build-up of current in the solenoid, and control means responsive to the solenoid current and operative for maintaining the voltage across the solenoid substantially constant until the solenoid current reaches a predetermined threshold value. The arrangement further includes current-regulating means operative after such threshold value has been reached for maintaining the solenoid current at a holding value lower than said threshold value.

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 generalized block diagram of an arrangement for controlling the solenoid current in an electromagnetically actuated mechanism;

FIG. 2 is a circuit diagram of one such arrangement; and

FIG. 3 is a timing diagram of the operation of the circuit of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a generalized block diagram of an arrangement according to the invention. A power supply $U_p$ is connected across positive supply line 91 and ground line 92. Connected across the power supply is a series connection of three components, namely, the solenoid 70 of a solenoid valve, the collector-emitter path of a power transistor contained in an output stage 20, and a series resistor 41 whose purpose will become evident later.

The voltage across resistor 41 corresponds to the solenoid current and is applied, via voltage divider 40, across the input of a current-monitoring circuit 50 which is operative after the solenoid current has reached a certain threshold value. A feedback-signal
amplifier 30 controls the conductivity of the power transistor in unit 20, and is adapted to amplify a feedback signal corresponding to the solenoid voltage. A constant current source 60 serves to bias the series resistor 41. Switch E initiates the build-up of solenoid current. The relationships between these components will become clearer from a consideration of the specific example of FIG. 2.

The circuit of FIG. 2 is merely exemplary. Basically, the circuit has four parts: the solenoid 70 of a solenoid valve, a voltage supply $U_a$, switch means 10 for initiating the build-up of solenoid current and for thereafter terminating the solenoid current, and a control means comprising units 20, 30, 40, 50, and 60.

Unit 20 is an output power stage including a power transistor 22 whose collector-emitter path is connected in the current path of solenoid 70. The base of power transistor 22 is controlled from the emitter of preliminary transistor 21 whose emitter current flows through resistors 24 and 25, and whose input circuit includes a resistor 23. The base of transistor 21 constitutes the input to the power stage 20. As the base voltage of transistor 21 varies, the base voltage of transistor 22 will vary, and the conductivity of transistor 22 will vary, and accordingly the effective resistance in series with the solenoid coil 70 will vary. During the build-up of solenoid current, the output resistance of transistor 22 will be kept low, in a manner to be described, so as to permit the fastest possible build-up of solenoid current.

Unit 30 constitutes feedback-signal and amplifying means, and includes a feedback-signal amplifying transistor 33 whose emitter-collector path is connected between ground line 92 and, via high-voltage diode 34, with the input (base of transistor 21) of power unit 20. The base-emitter junction of transistor 33 is shunted by resistor 35, and a Zener diode 32 is connected between the base of transistor 33 and the cathode of diode 31.

Functionally, unit 30 serves to amplify feedback signals of different types to be described later. It will be clear, for example, that as the base voltage of transistor 33 rises, its collector-emitter voltage will fall; the decreased collector-emitter voltage produces a decrease in the base voltage of preliminary transistor 21, a lowered conductivity of transistor 21, and thus a lower base voltage and lower conductivity of power transistor 22. The complete operation will be described below. Unit 10 is a simple switch comprising switching transistor 12, and biasing resistors 11, 13 and 14. When switching transistor 12 is OFF, its collector-emitter voltage is great, its collector voltage is thus close quite low, and transistors 21, 22 will be OFF. However, when switching transistor 12 is ON, its collector-emitter voltage is small, and transistors 21, 22 are forward-biased and conductive, so that solenoid current can flow. Thus, when switch 10 is rendered conductive, the build-up of solenoid current is initiated.

Unit 40 is a voltage divider whose function will become clearer below.

However, an important component is series resistor 41, connected directly in the current path of the solenoid 70. The voltage across resistor 41 is a measure of the solenoid current; and as will be specifically seen below, the changes in voltage across resistor 41 are directly proportional to the changes in solenoid current.

Unit 50 is a current-monitoring circuit which monitors the solenoid current. It includes a current-monitoring transistor 56 whose collector current flows through resistors 52, 57. The base-emitter circuit of current-monitoring transistor 56 is connected across series resistor 41, via diode 44 and resistor 42 of voltage divider 40. As the solenoid current varies, the voltage drop across series resistor 41 varies, and so also varies the base-emitter bias of current-monitoring transistor 56. The resistance value of series resistor 41 is so chosen that when the solenoid current reaches a predetermined threshold value, the voltage applied by resistor 41 to the input circuit of transistor 56 will be sufficient to render transistor 56 conductive; conversely, when the solenoid current is lower than such threshold value, transistor 56 is OFF.

Current-monitoring circuit 50 also includes a second transistor 51, sharing the emitter resistor 52 of transistor 56, and having a base biased from the tap of a voltage divider composed of resistor 53, diode 55 and resistor 54. The function of second transistor 51 will be discussed after the basic operation has been explained.

Unit 60 is a constant current source including a transistor 61 having an emitter resistor 62 and a base connected to the input of output stage 20 via capacitor 63. It is the purpose of capacitor 63 to suppress stray voltage signals. The fixed-magnitude current flowing through the collector-emitter path of transistor 61 flows to ground line 92 from higher-voltage line 91. The flow of this fixed-magnitude current is chiefly through series resistor 41, and to a much lesser extent through the base-emitter junction of current-monitoring transistor 56. While most of the current of transistor 61 does flow through resistor 41, the total current through resistor 41, when the solenoid current has built up to a significant extent, consists predominantly of the solenoid current, and the current from transistor 61 will be only a fraction of the total current through resistor 41. Constant current source 60 is adjustable by way of adjustable resistor 62 and serves to adjustably establish the threshold value of solenoid current which will render transistor 56 conductive. That is, constant-current source 60 establishes a flow of current through, and thus a voltage drop across, components 41, 42, 44 even when the solenoid current is practically zero. Thus, the additional solenoid current through resistor 41 needed to turn transistor 56 ON, is less than if no biasing current flowed through components 41, 42, 44 from constant current source 60.

The operation of the circuit will be described with reference to FIGS. 2 and 3. Initially, transistor switch 12 is OFF, the collector-emitter voltage of transistor 12 is great, the collector voltage of transistor 12 is low, the base voltage of transistor 21 is low, and transistors 21, 22 are OFF. The solenoid current $I_{s}$, the solenoid voltage $U_{s}$, and thus the feedback signal $U_{fb}$ are all zero.

Switching transistor 12 is rendered conductive, and the base voltage of transistor 21 rises sharply, so that transistor 21 and thereby transistor 22 are rendered conductive. Current flows through solenoid 70 via the collector-emitter path of power transistor 22 and series resistor 41.
Diode 26 together with resistors 27, 28 act as a voltage divider and apply to the input of feedback-signal amplifier 30 (cathode of 31) a feedback signal proportional to the voltage across the solenoid. Components 26, 27, 28 and feedback-signal amplifier 30 together form first negative feedback means serving to stabilize the voltage $U_{on}$ across the solenoid at a fixed value 101 during the build-up of solenoid current $i_{on}$.

Voltage $U_{on}$ is stabilized at value 101 during the build-up of solenoid current by shifting the operating point of transistor 22 as the solenoid current builds up. If power transistor 22 were maintained at fixed base bias, then, when the solenoid current is still low, the collector-emitter voltage of transistor 22 would be high, and accordingly $U_{on}$ would be low and only build up as the solenoid current increased. However, to effect the fastest possible build-up of solenoid current it is desirable to maintain $U_{on}$ constant at the highest regulatable magnitude, and this is accomplished by varying the base bias of transistor 22 during the build-up of solenoid current, through the use of negative feedback.

Specifically, when switch 12 is rendered conductive, the solenoid voltage is very low, the base voltage of transistor 33 is low, its collector voltage is therefore high, the base voltage of transistor 21 is high, and the base voltage of transistor 22 is very high, so as to maintain a low collector-emitter voltage despite the flow of only low solenoid current. As the solenoid current builds up, the collector-emitter voltage of transistor 22 tends to decrease, and the solenoid voltage $U_{on}$ tends slightly to decrease, tending to increase the conductivity of transistor 33 and decreasing the base voltage on transistor 22. Thus, as the solenoid current builds-up, the base voltage of transistor 22 shifts in a sense maintaining the solenoid voltage $U_{on}$ constant at voltage level 101. Since the solenoid voltage $U_{on}$ is fixed during this time, the feedback signal $U_{on}$ proportional to the solenoid voltage, will also be fixed. This is evident in FIG. 3.

Because the solenoid voltage $U_{on}$ is fixed, the solenoid current rises linearly, until it reaches a value 103 sufficient to effect armature movement. The plateau in the rise of $i_{on}$ corresponds to the period of no increase of stored magnetic energy, because the energy furnished from the battery $U_{b}$ is dissipated as work in moving the armature.

The current $i_{on}$ continues to rise until it reaches a predetermined threshold value 104. At this point, the total voltage drop across resistor 41 (solenoid current plus constant current from source 60) plus the voltage drop across components 44, 42 (due to current from source 60) renders current-monitoring transistor 56 conductive.

When transistor 56 goes ON, its collector-emitter voltage decreases and the feedback signal $U_{on}$ rises a small amount to a new level 105 (FIG. 3) sufficient to back-bias coupling diode 26. With diode 26 non-conductive, the voltage-stabilizing feedback network is broken, because now a voltage proportional to solenoid voltage $U_{on}$ can not be transmitted via diode 26 to the base of feedback-signal amplifying transistor 33.

Moreover, the small rise in voltage $U_{on}$ when transistor 56 goes ON is greatly amplified by transistor 33, rendering transistor 33 quite conductive, and causing the collector voltage of transistor 33 to fall considerably. Thus, the base voltages of transistor 21 and transistor 22 fall sharply, and the output impedance of the power transistor 22 increases greatly. This results in a rapid and very considerable drop (107 in FIG. 3) of the solenoid current from value 104 to lower holding value 109. Although the drop in solenoid current results in a smaller voltage drop across resistor 41, transistor 56 remains ON, because the sharp drop of $U_{on}$, which occurs due to the sharp increase in collector-emitter voltage of transistor 22, results in a lowered voltage at the cathode of diode 26, and thus in an increase in the total voltage across the voltage divider composed of components 41, 42, 44, 43. Accordingly, the voltage at the cathode of diode 44 is lowered, and the base-emitter junction of transistor 56 is not back-biased as a result of the sharp decrease of the voltage drop across resistor 41. The magnitude of holding current 109 depends on the dimensioning of resistors 41, 42, 43 and on the current associated with transistor 61.

The important point to appreciate is that, once the threshold solenoid current 104 has been reached, and the transistor 56 turned ON, the circuit of FIG. 2 exhibits current regulation of the solenoid current, as opposed to the previous regulation of the solenoid voltage. The regulation of solenoid current serves to maintain the total amper-turns of the solenoid constant, despite the very considerable temperature-dependent variations of solenoid ohmic resistance.

Specifically, components 20, 40, 50 and 60 now form second feedback means, which serve to apply a solenoid-current-dependent feedback signal to the input (anode of 31) of feedback-signal amplifying unit 30. Thus, units 20, 30, 40, 50 and 60 together now constitute current regulating means.

As will be appreciated by those familiar with feedback principles, any tendency of solenoid current $i_{on}$ to decrease below holding value 109 will result in a decreased voltage across resistor 41, a decreased conductivity of transistor 56, a decreased feedback signal $U_{on}$ (corresponding to the solenoid current decrease), an increased collector voltage of transistor 33, an increased base voltage of transistor 22, a lowered collector-emitter voltage of transistor 22, and a stabilizing increase of solenoid current to counteract the solenoid current decrease. Conversely, if the solenoid current should for any reason tend to increase, a similar feedback will render transistor 22 less conductive, and affect a compensating decrease of the solenoid current.

The predetermined threshold value 104 is higher than the solenoid current 103 necessary for actual armature activation, in order to ensure the quickest possible opening of the valve.

It will be noted that any adjustment of the current established by constant-current source 60 will effect a corresponding change in the magnitude of the holding value 109 of the solenoid current; this is of course because of the changed voltage drop across resistor 41 in response to a change of the current through transistor 61.

The current-monitoring unit 50, aside from determining when the threshold value has been reached and from applying to the input of unit 30 a current-dependent feedback signal, also serves to some extent to stabilize the circuit against variations in the power supply $U_{b}$. Such compensation results from the similar
In response to variations of the supply voltage, the emitter and base voltage of transistor 56 will vary in the same sense, so that the base-emitter voltage of transistor 56 will tend to vary only with the changed voltage drop across resistor 41. The energization of solenoid 76, because of such stabilization, will be maintained at the optimum value despite changes in the supply voltage; this is in contrast to the prior art, where the solenoid energization varied with varying supply voltage by a very significant factor, and where accordingly the circuit design had to be established on a worst-case basis.

To de-activate the solenoid, switching transistor 12 is turned OFF, which immediately turns preliminary transistor 21 and power transistor 22 OFF. As can be seen at 112 in FIG. 3, the solenoid current \( i_{so} \) immediately drops to zero, and the sudden decrease of solenoid current induces a negative-going spike 111 in the solenoid voltage \( U_{so} \). Likewise, the turning OFF of switch 12 and the consequent turning OFF of transistor 56, reduce the feedback signal \( U_{fb} \) to zero, as seen at 113 in FIG. 3. High voltage diodes 26 and 34 serve as protection at this time against voltage spikes.

It is specifically contemplated to build the arrangement of FIG. 2 in integrated-circuit form, and care was taken in the design of FIG. 2 to provide a circuit configuration which could make use of ohmic resistors having resistance values of no higher than about 50,000 ohms.

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 circuits differing from the types described above.

While the invention has been illustrated and described as embodied in an arrangement for controlling the energization of the solenoid of a magnetic valve, 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.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

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

1. In combination with the solenoid of an electro-magnetically actuated mechanism, particularly a high-speed solenoid valve, of the type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position, an arrangement for regulating the current flow in said solenoid, the arrangement comprising a power supply connected to said solenoid; switch means connected to said power supply and connected to said solenoid and operative for initiating a build-up of current in said solenoid; and control means responsive to the solenoid current and operative for stabilizing the voltage across said solenoid until the solenoid current reaches a predetermined threshold value, said control means comprising a negative-feedback loop including controllable impedance means connected in circuit with said power supply and said solenoid and carrying at least a portion of the current flowing through said solenoid, feedback-signal amplifier means having an output connected to said controllable impedance means, and means connected to said solenoid and connected to the input of said feedback-signal amplifier means for applying to the latter a negative-feedback signal dependent upon the voltage across said solenoid and serving to vary the impedance of said controllable impedance means in a sense counteracting changes of the voltage across said solenoid from a predetermined value.

2. Arrangement as defined in claim 1, wherein said control means further includes current-regulating means operative after said threshold value has been reached for maintaining the solenoid current at a holding value lower than said threshold value.

3. Arrangement as defined in claim 1, wherein said control means includes current monitoring means for detecting when the solenoid current reaches said threshold value.

4. An arrangement as defined in claim 1, wherein the said controllable impedance means comprises a power-transistor having a collector-emitter path connected in the current path of the solenoid, and wherein the solenoid and said collector-emitter path are together connected across said power supply, whereby changes in the collector-emitter voltage of said power transistor will result in opposite changes of the voltage across the solenoid.

5. Arrangement as defined in claim 4, wherein said control means includes current-regulating means operative after said threshold value has been reached for maintaining the solenoid current at a holding value lower than said threshold value, and wherein said current-regulating means includes negative feedback means for applying to the base of said power transistor a voltage corresponding to the solenoid current.

6. Arrangement as defined in claim 5, wherein said control means includes current monitoring means for detecting when the solenoid current reaches said threshold value.

7. An arrangement as defined in claim 1, wherein said means for applying to said input of said feedback-signal amplifier means a negative-feedback signal dependent upon the voltage across said solenoid is operative only after the solenoid current has reached said predeterminated threshold value, and wherein said control means further includes means operative after the solenoid current has reached said predetermined threshold value for applying to said input of said feedback-signal amplifier means a negative-feedback signal dependent upon the solenoid current, to form another negative-feedback loop serving to effect variations in the impedance of said controllable impedance means in a sense counteracting deviations of the solenoid current from a predetermined holding value lower than said predetermined threshold value.

8. An arrangement for regulating the current flow in the solenoid of an electromagnetically actuated mechanism, particularly a high-speed solenoid valve, of the type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position, comprising, in combi-
A power supply connected to the solenoid; switch means for initiating a build-up of current in the solenoid; and control means responsive to the solenoid current and operative for maintaining the voltage across the solenoid substantially constant until the solenoid current reaches a predetermined threshold value, said control means comprising a power transistor having a collector-emitter path connected in the current path of the solenoid, and the solenoid and said collector-emitter path being together connected across said power supply, so that changes in the collector-emitter voltage of said power transistor will result in opposite changes of the voltage across the solenoid, said control means further including first negative feedback means for applying to the base of said power transistor a voltage corresponding to the voltage across the solenoid, and wherein said control means includes current-regulating means operative after said threshold value has been reached for maintaining the solenoid current at a holding value lower than said threshold value, said current-regulating means comprising second negative feedback means for applying to the base of said power transistor a voltage corresponding to the solenoid current, said first negative feedback means comprising feedback-signal amplifier means for amplifying a voltage corresponding to the solenoid voltage and applying said amplified voltage to the base of said power transistor, and said current regulating means comprising a current-monitoring transistor whose output is connected to the input of said feedback-signal-amplifying means, and a series resistor connected in the solenoid current path and connected across the base-emitter circuit of said current-monitoring transistor and having a resistance value such as to render said current-monitoring resistor conductive when the solenoid current reaches said threshold value, and wherein said series resistor is operative for applying to the base-emitter circuit of said current-monitoring transistor a voltage corresponding to solenoid current, whereby said current-monitoring transistor will apply to said feedback-signal-amplifying means a signal corresponding to the solenoid current.

An arrangement as defined in claim 8, wherein said control means includes voltage divider means whose tap is connected to the base of said current-monitoring transistor and which has a first resistance portion connected between said tap and the output of said power transistor and a second resistance portion including said series resistor as well as a diode and a further resistor connected between said tap and one terminal of said series resistor, and wherein the component values of the components of said voltage divider means determine the ratio between said threshold value and said lower holding value of solenoid current.

An arrangement as defined in claim 8, wherein said control means includes constant-current source means for establishing a flow of biasing current through said series resistor and thereby establishing said threshold value by establishing an additional solenoid current necessary to cause said series resistor to render conductive said current-monitoring transistor.

An arrangement as defined in claim 10, wherein said constant-current source means is adjustable and thereby operative for adjusting the magnitude of said holding value.

In combination with the solenoid of an electromagnetically actuated mechanism, particularly a high-speed solenoid, a type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position, an arrangement for regulating the current flow in said solenoid, the arrangement comprising a power supply connected to said solenoid; switch means connected to said power supply and to said solenoid and operative for initiating a build-up of current in said solenoid; first negative-feedback stabilizing means operative during build-up of solenoid current and until such current reaches a predetermined threshold value for maintaining the voltage across said solenoid substantially constant at a predetermined value; and second negative-feedback stabilizing means operative after the solenoid current has reached said threshold value thereafter maintaining the solenoid current substantially constant at a holding value lower than said threshold value.

In combination with the solenoid of an electromagnetically actuated mechanism, particularly a high-speed solenoid, of the type requiring a higher activating current to effect movement of the armature from a first to a second position and a lower holding current to maintain the armature in such second position, an arrangement for regulating the current flow in said solenoid, the arrangement comprising a power supply connected to said solenoid; switch means connected to said power supply and to said solenoid and operative for initiating a build-up of current in said solenoid; and negative-feedback stabilizing means connected to said power supply and connected to said solenoid and operative after the solenoid current has built up to a predetermined threshold value for thereafter maintaining the solenoid current substantially constant at a holding value lower than said threshold value.
UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3 786 314  
DATED : January 15, 1974  
INVENTOR(S) : Wolfgang Misch

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 9, line 35:

delete "resistor", substitute --transistor-- .

Signed and Sealed this  
Third Day of March 1981

[SEAL]

Attest:

RENE D. TEGTMeyer
Attesting Officer  
Acting Commissioner of Patents and Trademarks
Notice of Adverse Decision in Interference

In Interference No. 100,493, involving Patent No. 3,786,314, W. Misch, REGULATING ARRANGEMENT FOR SOLENOID VALVES AND THE LIKE, final judgment adverse to the patentee was rendered November 16, 1981, as to claims 1-7, 12 and 13.

[Official Gazette February 23, 1982.]