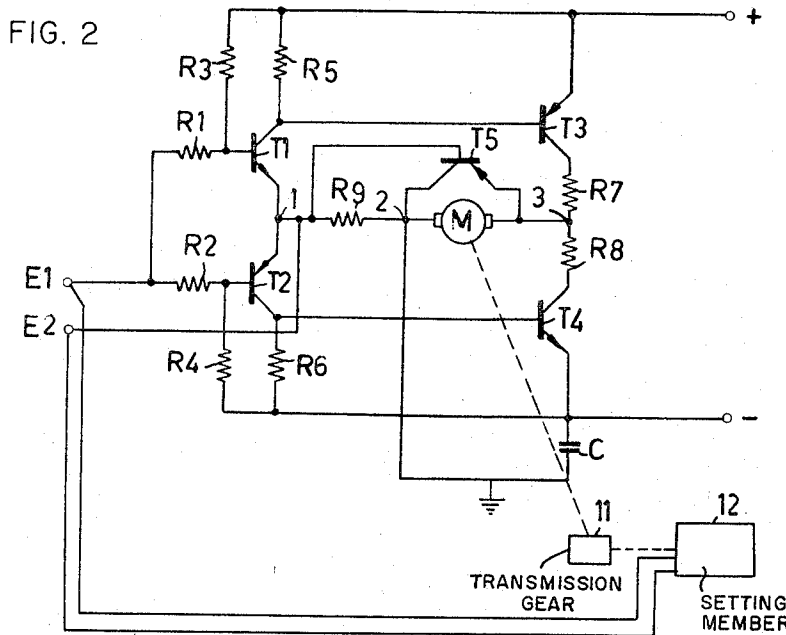
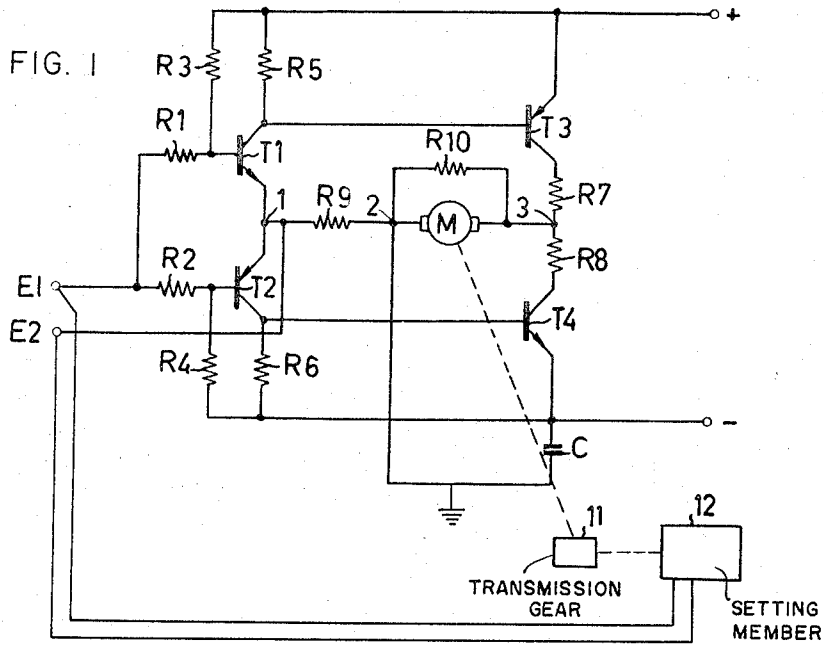


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DIRECT-CURRENT MOTOR CONTROL CIRCUIT EMPLOYING
A PARALLEL DAMPING MEMBER
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DIRECT-CURRENT MOTOR CONTROL CIRCUIT EMPLOYING A PARALLEL DAMPING MEMBER
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ABSTRACT OF THE DISCLOSURE

A control system for a reversible motor having a constantly excited field, consisting of a difference amplifier connected to apply current in different directions through the armature. A damping member, such as a resistor, is connected in parallel with the armature. The damping member may also be a transistor connected to conduct only when the motor approaches the desired position from one direction.

The invention relates to a D.C. controlled setting member comprising a D.C. difference amplifier and a D.C. motor with constant field excitation. The armature of the motor is included in an output circuit of the amplifier.

Such setting members are employed for example in broadcast receivers having automatic tuning for the displacement of the tuning member. The two inputs of the amplifier may then be connected to the tapings of two direct-voltage potentiometers, one of which is coupled with the tuning member, which is displaced thereby and the other is pre-adjusted in accordance with the desired position of the tuning member. The motor is excited by the difference voltage appearing between these two tapings in the non-adjusted state through the amplifier, the motor displacing the tuning member and hence the first potentiometer until the division ratio thereof corresponds with that of the second potentiometer. Then the tuning member occupies the position preselected on the second potentiometer.

The accuracy of adjustment attainable by means of such a setting member depends for a great part upon the behaviour of the motor in the vicinity of the adjusting point, i.e. the zero point of the difference amplifier.

Owing to its comparatively high inertia the motor will not arrive aperiodically at the adjusting point (equilibrium of the bridge at the output of the amplifier), but it will fluctuate around this point for some time. By a reduction of the number of revolutions of the motor by means of a transmission gear the fluctuation around the adjusting point is not markedly diminished, whereas on the contrary the adjusting time of the setting member is considerably prolonged.

The invention has for its object to obviate this disadvantage of the setting member described above.

This problem is solved by using a setting member of the kind set forth in which a damping resistor is connected in parallel with the armature of the motor.

In a further development of the invention said resistor is formed by a transistor, which is controlled in accordance with the current through a further output circuit of the amplifier so that the resistance of the transistor decreases in accordance with the gradual attainment of the state of equilibrium. To this end the emitter-collector path of the transistor may be connected in parallel with the armature of the motor, while the collector-base voltage controlling the same is derived from a resistor included in the said further output circuit of the D.C. difference amplifier.

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The invention will be described more fully with reference to the accompanying drawing which shows two embodiments.

FIG. 1 shows the circuit diagram of a first embodiment of a setting circuit according to the invention and

FIG. 2 shows a circuit diagram of a second embodiment of a setting circuit according to the invention.

FIG. 1 shows the circuit diagram of a setting member according to the invention. The circuit comprises a transistor T1 having its collector connected to the positive terminal of a source of operating voltage by way of collector load resistor R5, a transistor T2 having its collector connected to the negative terminal of the source by way of collector load resistor R6, a transistor T3 having its emitter connected to the positive terminal, and a transistor T4 having its emitter connected to the negative terminal. The emitters of transistors T1 and T2 are connected to a common point 1, and thence through a common emitter resistor R9 to ground (point 2). A voltage divider consisting of resistors R3, R1, R2 and R4 is connected in that order between the positive and negative terminals. The junction of resistors R3 and R1 is connected to the base of transistor T1, and the junction of resistors R2 and R4 is connected to the base of transistors T2. Resistors R3 and R4 have equal values, and resistors R1 and R2 have equal values, so that the transistors T1 and T2 are normally not conductive.

The collector of transistor T1 is connected to the base of transistor T3, and the collector of transistor T2 is connected to the base of transistor T4. Since transistors T1 and T2 are normally non-conductive, there will be no current flow through resistors R5 and R6, and consequently transistors T3 and T4 will be non-conductive. The collectors of transistors T3 and T4 are connected by way of resistors R7 and R8 respectively to a common point 3. The armature M of a motor having constant field excitation is connected between point 3 and ground. A resistor R10 is connected in parallel with the armature M. The amplifier circuit is provided with one input E1 connected to the junction of resistors R1 and R2, and a second input E2 is connected to point 3.

Since all of the transistors are normally non-conductive, no current flows through the armature M. If a potential difference of sufficient magnitude is applied between E1 and E2, one of the transistors T1 and T2 will become conductive. Thus if E1 is positive with respect to E2, only transistor T1 will conduct. (Transistors T1 and T4 are NPN transistors and transistors T2 and T3 are PNP transistors.) As a result of current flow through collector resistor R5, transistor T3 will be biased in the forward direction and collector current will flow in one direction through armature M to ground point 2. If the voltage between E1 and E2 is reversed, transistors T2 and T4 will conduct, and collector current of transistor T4 will flow in the opposite direction in armature M. The voltage applied between E1 and E2 is obtained from a setting member 12. This member is connected to the motor shaft and is arranged so that no voltage appears between E1 and E2 when the setting is at the desired position, and has positive and negative values when the setting is to one side or the other respectively of the desired position. The setting member 12 may be the tuning member of a radio receiver. In order to reduce the adjusting speed and to raise in this way the accuracy of the adjustment, a transmission gear 11 may, as stated above, be provided between the motor and the member to be adjusted.

The aperiodic adjustment of the setting member to the desired position is achieved in accordance with the invention by means of a resistor R10, connected in parallel with the armature of the motor M for braking the motor. With a resistance of the armature of 20 ohms, a parallel-con-

nected resistor R10 of 80 or 100 ohms provides a dying-out of the conventional fluctuation and an adjustment into the state of equilibrium of the bridge circuit of the setting member and the member to be adjusted within very narrow limits. If the setting member is employed in a broadcast receiver, for example a television receiver for the adjustment of the tuning members, an admissible tolerance of the accuracy of adjustment with respect to the inputs E1 and E2 of the setting member has a value of about 10 mv. with a possible maximum voltage variation of 40 v.

By reducing the value of the resistor R10 to about 33 ohms, an aperiodic adjustment to the state of equilibrium can be obtained. The parallel connection of the resistor R10 with the armature of the motor brings about, however, a limitation of the speed of the motor and hence, in accordance with the chosen value, a prolongation of the time necessary for traversing the whole range of setting. Since it is desirable, however, to minimize this transverse-time, whereas on the other hand the adjustment to the state of equilibrium should be as aperiodical as possible, the resistor R10 may be replaced by a transistor T5 in a further embodiment of the invention, shown in FIG. 2. The emitter-collector path of the transistor T5 is connected in parallel with the armature of the motor M in such a way, that its collector is connected to the point of reference potential 2. The base of the transistor is connected to point 1 or, if desired, to a tapping of the resistor R9 included in the output circuit 1, 2 of the amplifier.

The arrangement operates as follows:

In the state of equilibrium the resistor R9 does not convey current. The base of the transistor is thus substantially at the collector potential, which means that the resistance of the collector-emitter path of the transistor T5 is very low (about 3 to 5 ohms). This low resistance, connected in parallel with the armature, brakes the motor M very strongly, so that it cannot pass beyond this state of equilibrium.

When a deviation from the state of equilibrium occurs, the transistor is so controlled by the voltage produced across the resistor R9, which then conveys current, that the transistor becomes high ohmic and the motor is no longer braked.

Whilst the time required for covering the whole setting range is very short, fluctuation around the state of equilibrium during the rotation of the motor can thus be avoided on one side. When the motor arrives from the other side at the state of equilibrium, the voltage appearing across the armature of the motor has opposite polarity, as a result of which the transistor T5 is always cut off. Therefore the motor will pass beyond the state of equilibrium and it is not braked until it has reversed its direction of rotation and hence the voltage across its armature. This arrival from only one side at the state of equilibrium has to be considered as being very advantageous, since this improves the accuracy of the tuning, as is known, by a factor 2.

With practical embodiments of setting members in accordance with the embodiments described above the structural elements had the following values:

M: air-core motor with rotating winding	v	1.5 to 6
T1, T4	AC	127
T2, T3	AC	132
T5	AC	125
R1, R2	ohm	1K

R3, R4	ohms	100K
R5, R6	do	150
R7, R8	do	33
R9	do	820
R10	do	30 to 100
C	μ f	100
Supply voltage	v	12 to 18

What is claimed is:

1. A control system for a direct current motor of the type having a constant field excitation and an armature, comprising a source of control potential, a source of operating potential having first and second terminals and an intermediate terminal, first and second switch means connected between said first and second terminals respectively and one terminal of said armature, means connecting the other terminal of said armature to said intermediate terminal, means applying said control potential to said switch means for selectively rendering them conductive, a transistor having a collector electrode connected to one terminal of said motor and an emitter connected to the other terminal of said motor, a resistor connected between the base of said transistor and said collector, and means passing a current through said resistor having an amplitude and polarity dependent upon said control voltage, whereby said motor is braked only in one direction of rotation.

2. A control system for a direct current motor of the type having a constant field excitation and an armature, comprising a setting member mechanically coupled to said armature for providing a difference control potential, a source of operating potential having first, second and intermediate terminals, first and second transistors having their emitter-collector paths connected between said first and second terminals respectively and one terminal of said armature, means connecting the other terminal of said armature to said intermediate terminal, means applying said difference control potential to the bases of said first and second transistors for selectively controlling their conduction, a third transistor having its emitter-collector path connected in parallel with said armature, a resistor connected between the collector and base of said third transistor, and means passing a current through said resistor having an amplitude and polarity dependent upon said control voltage, whereby said motor is braked only in one direction of rotation.

3. The control system of claim 2 in which said means applying said control potential to the bases of said first and second transistors comprises fourth and fifth transistors, means connecting the emitters of said fourth and fifth transistors to the side of said resistor connected to said base of said third transistor, said means connecting the collectors of said fourth and fifth transistors to said first and second terminals respectively, means connecting the collectors of said fourth and fifth transistors to the bases of said first and second transistors respectively, and means applying said control potential between the emitters and bases of said fourth and fifth transistors.

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