

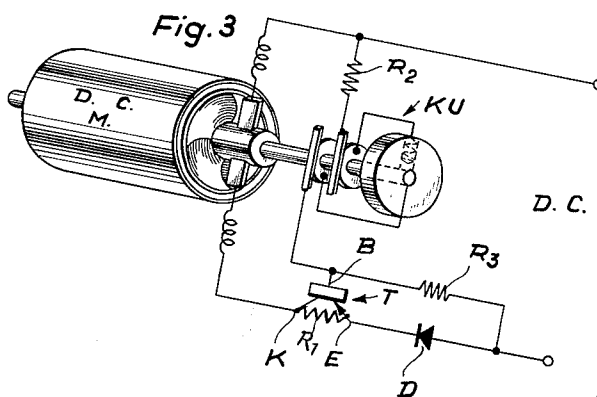
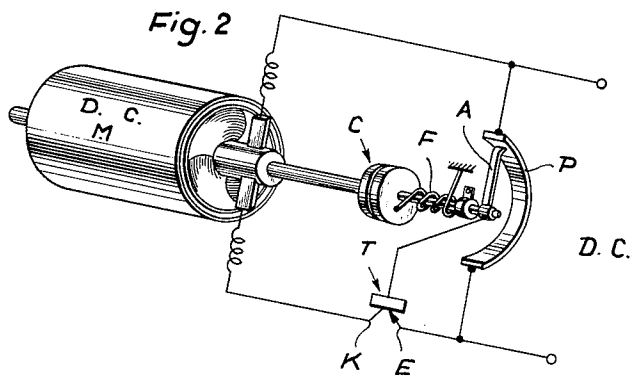
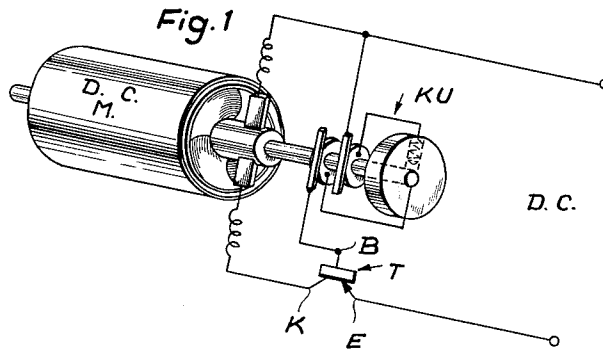
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CIRCUIT FOR REGULATING THE SPEED OF D.C. MOTORS

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CIRCUIT FOR REGULATING THE SPEED OF D.C. MOTORS

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The invention relates to a circuit for regulating the speed of D.C. motors, and relates principally to motors having permanent field magnets used more particularly for operating magnetic sound recorders under the control of a centrifugal circuit-breaker.

In all sound recording and reproducing apparatus it is essential for satisfactory recording and reproduction to maintain the speed of the motor constant, otherwise considerable distortion is liable to occur. A known device for controlling the speed of a D.C. motor is a centrifugal regulator which comprises a centrifugally controlled contact breaker in the supply circuit of the motor for breaking the circuit whenever the rated speed is exceeded. Governors have also been proposed in which a variable resistor in the motor supply circuit is controlled in accordance with the speed, by centrifugal means. In both cases the circuit-breaker or sliding contacts carry the full operating current for driving the motor. In very small and compact motor units such as those required for pocket-size sound recording and reproducing apparatus, the construction of the necessary small regulators presents considerable difficulties. On the one hand, the centrifugal forces required for accurate control cannot be made sufficiently large to operate the contacts reliably. On the other hand, the current load is heavy enough to cause rapid burning of the very small contacts which will then either stick or make unsatisfactory contact. Moreover, a centrifugal contact-breakers with bad contacts generally give rise to troublesome noise.

The circuit arrangement according to the present invention overcomes these difficulties by connecting an emitter-collector circuit of a transistor in series with the motor and controlling a resistance between the emitter and collector in accordance with the speed by varying the voltage applied to the base. According to the potential applied to the base the current path between the collector and emitter will either be rendered conductive or assume its nonconductive resistance and then considerably reduce the supply current to the motor and hence the speed of the motor, without the need of opening contacts in the motor supply circuit. The necessary controlling current for the base electrode of the transistor need be only a fraction of the current required for driving the motor and it is in fact so low that without fear of damaging the contacts, it can be taken through a centrifugal contact-breaker or a variable resistance controlled by the speed of the motor. The contact-breaker contacts or wipers can therefore be made suitably small and they will then operate noiselessly. In both forms of control, the bias applied to the base of the transistor is changed and the resistance between the collector and emitter varied accordingly. For the purpose of controlling the bias a centrifugal contact-breaker may be connected between the base electrode of the transistor and the source of potential. Alternatively the bias may be varied by a potentiometer connected across the source of potential and tapped by a sliding contact arm operated by centrifugal force according to the speed of the motor.

To prevent the speed of the motor from being excessively reduced when the current path from the emitter to collector is non-conductive, the invention provides a re-

sistance connected across the emitter and collector, the value of the said resistance being such that it will not by itself permit the rated speed to be reached. The motor current, and hence the speed, will then merely vary between the values determined by the parallel operation of the fixed resistor in conjunction with the non-conductive emitter-collector junction and the parallel operation of the fixed resistor and the conductive emitter-collector junction.

If the motor is fed from a source of power which supplies a variable potential such as a battery, then the parallel resistor may be embodied conveniently in a resistor which varies with the voltage in such a way that its resistance increases with increasing voltage. For fractional horse-power motors subject to very fluctuating load the parallel resistor may also be arranged to vary with the current. Moreover, a combination of current and voltage variable resistors is also feasible. In a circuit devised according to the present invention and incorporating a centrifugal circuit-breaker in circuit with the base electrode, the motor may also be controlled to run at several different predetermined speeds. If this is required a centrifugal contact-breaker may be employed which opens a number of contacts at different speeds, in conjunction with several resistors of appropriate values connected across the emitter-collector junction. The centrifugal contact system associated with a definite speed is then arranged to co-operate with the appropriate parallel resistor.

The accompanying drawings illustrate schematically two embodiments of the circuit proposed by the present invention, in which:

FIG. 1 shows a circuit incorporating a centrifugal contact-breaker in the supply lead to the base contact of the transistor;

FIG. 2 shows a circuit in which the voltage for the control of the base electrode of the transistor is tapped from a potentiometer connected across the source of supply, the potentiometer contact arm being connected with the base electrode and adapted to be slidably displaced on the potentiometer by the centrifugal force engendered by the speed of the motor, and

FIG. 3 shows further details of the arrangement illustrated in FIG. 1.

In the circuit illustrated in FIG. 1 the emitter-collector junction of a plate type transistor T is connected in series with a motor D.C.M. driven from a D.C. source of supply, such as a battery. The base electrode is connected through a centrifugal contact-breaker KU, of known construction, with the negative pole of the source of supply. So long as the contacts of the contact-breaker KU are closed the base electrode B will be negatively biased and hence maintain the emitter-collector junction E-K conductive. When the rated speed is exceeded the contacts of the circuit-breaker will open, the resistance across emitter and collector will rise to its non-conducting value, and an immediate drop in the motor speed will be the result, which in turn leads to the reclosing of the contacts of the circuit-breaker KU.

To confine the fluctuation in the speed of the motor to within narrow limits a resistor R_1 is connected across the emitter-collector junction E-K as shown in FIG. 3. The value of this resistor R_1 is such that the current it passes is too small for maintaining the rated speed. However, when a current can pass both the resistor R_1 and through the emitter-collector junction, then the rated speed of the motor will be slightly exceeded and the contacts of the circuit-breaker KU will re-open.

To limit the current flowing through the circuit-breaker contact KU to the base electrode and to the emitter E a resistor E_2 is provided. If the source of supply is connected with the transistor in such a way that the emitter

E is positive in relation to the base electrode B, then suitable arrangements must be made for the base electrode B to be more positive than the emitter E when the contacts of the circuit-breaker KU are open, to ensure that the emitter-collector junction K-E will definitely become non-conducting. In the circuit illustrated in FIG. 3 this is ensured by the provision of a resistor R₃ and a diode D. The presence of the diode D has the additional advantage that it will prevent the motor from starting if the connections with the source of supply should be accidentally reversed, because the diode passes a current in one direction only.

The operation of the circuit shown in FIG. 3 does not depend upon whether the fluctuations in the speed of the motor D.C.M. are due to alterations in the load or the supply voltage. If the operating voltage is likely to vary considerably, for instance when using a battery as a source of supply, then the resistor R₁ should be adapted to vary with the voltage. The increase in its resistance at increased voltage will then reduce the driving current sufficiently to prevent it from rising much beyond the current required for driving the motor at rated speed.

In the circuit illustrated in FIG. 2 the contact arm or slide A of a potentiometer connected across the terminals of the source of power is displaceable by centrifugal means. To this end the motor D.C.M. is arranged to rotate a slipping clutch C of known construction. The driven member of the clutch is braked elastically by a spring F and carries the contact wiper arm A which slides over the potentiometer windings P. As shown in examples FIGS. 1 and 3, the emitter-collector junction E-K of the transistor T is in series with the supply circuit of the motor D.C.M. The base electrode B is connected with the wiper arm A. Centrifugal force displaces this wiper arm A when the speed rises in such a way that the potential applied to the base electrode B will cause the collector-emitter junction to assume its blocking resistance. Conversely, when the speed drops, the wiper arm A will be displaced in the direction which results in the emitter-collector junction becoming conductive. Owing to the high resistance between the base electrode and the emitter electrode, only a very small current will flow through the wiper arm A. In this form of construction the provision of a suitable resistor across the emitter-collector junction will compensate speed fluctuations of the motor D.C.M. or voltage fluctuations of the source of supply.

We claim:

1. A constant-speed electric motor system comprising an electric motor having a rotatable shaft, a governor switch mounted on said shaft, said switch being normally closed and being caused to open when the motor speed exceeds a given value, a voltage source for energizing said motor, a control circuit for connecting said motor to said source, said control circuit including a transistor having base, collector and emitter electrodes, said source being connected in series with said emitter and collector electrodes to said motor, and means including said closed governor switch to apply a bias to said transistor rendering same conductive to provide a current path for said motor, said transistor being rendered non-conductive when said switch is opened.

2. Speed regulating apparatus for a variable speed motor, which apparatus comprises a switching means having a pair of normally closed contacts, means for opening said contacts at times related to the speed of said motor, a transistor having base, collector and emitter electrodes, a power supply capable of supplying sufficient current to cause the motor to be regulated to operate at speeds

above a desired speed, a source of bias potential, a first electrical circuit comprising the switch contacts, the base and emitter electrodes and the bias source, and a second electrical circuit comprising the power supply, the emitter and collector electrodes and the motor to be regulated.

3. In an energizing circuit for a variable speed motor including a motor, a motor power supply and a pair of governor driven electrical contact members, the improvement which comprises a semi-conductor device having collector and emitter electrodes and a base electrode, a first series circuit including the armature, the motor power supply and the collector and emitter electrodes, and a second series circuit including the pair of contacts, the base and emitter electrodes, and a source of bias potential for said base electrode.

4. Speed regulating apparatus for regulating the speed of electric D.C. fractional horse-power motors comprising a transistor having base, emitter and collector electrodes, a centrifugal contact-breaker operated by said motor and connected in series with said base electrode, said transistor being connected in series with the motor through said collector and emitter electrodes, whereby the electrical resistance of said transistor in the motor circuit is controlled by varying the potential applied to said base electrode in accordance with the speed of the motor by said contact breaker.

5. An apparatus as set forth in claim 4 wherein said centrifugal contact breaker which is interposed between the base electrode and its source of potential is a type in which the duration of the contact is in accordance with the speed of the motor whereby the period of application of potential to the base electrode is controlled.

6. An apparatus as set forth in claim 4 wherein said contact-breaker is a potentiometer having a wiper arm coupled to said motor and is connected across the terminals of the source of supply of the motor and said wiper arm is slidably displaced by centrifugal force whereby the value of the potential applied to the base electrode is controlled by said wiper arm.

7. An apparatus as set forth in claim 4 wherein a resistor is connected in parallel with the emitter and collector electrodes of said transistor.

8. An apparatus as set forth in claim 7 wherein said resistor is of the type in which its resistance may vary with the voltage or with the current or a combination thereof.

9. An apparatus as set forth in claim 4 wherein a resistor is connected in the circuit between said source of supply and said transistor so that the potential applied to the base electrode when the centrifugal circuit breaker is open will maintain a non-conductive resistance in said transistor and when said circuit breaker contacts are closed said transistor will be rendered conductive.

10. An apparatus as set forth in claim 4 wherein a diode is interposed between the source of potential and the emitter electrode whereby the potential difference between said emitter electrode and said base electrode is controlled.

11. An apparatus as set forth in claim 4 wherein said centrifugal contact breaker has a plurality of contacts for different motor speeds and a resistor is inserted in said motor circuit associated with said contacts whereby said motor is regulated to maintain different speeds.

No references cited.

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