

March 14, 1950

R. LEE
SPEED REGULATOR

2,500,190

Filed Dec. 6, 1943

2 Sheets-Sheet 1

FIG. 1

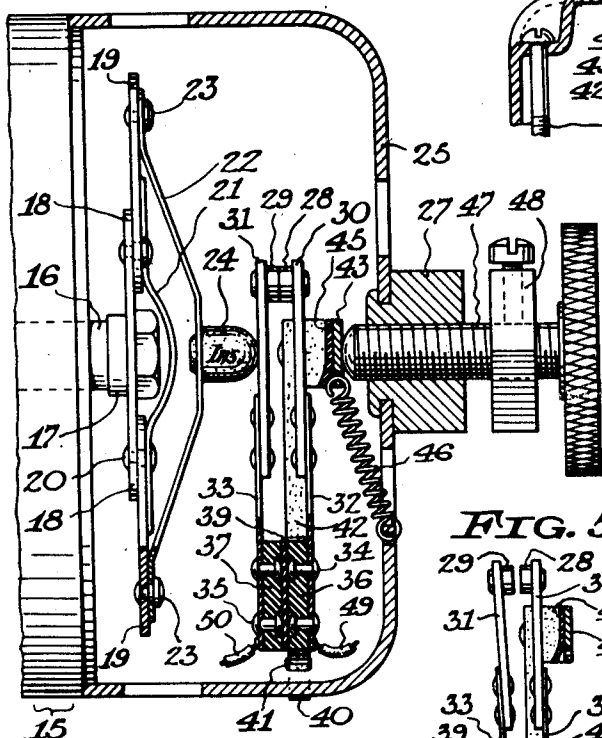


FIG. 4

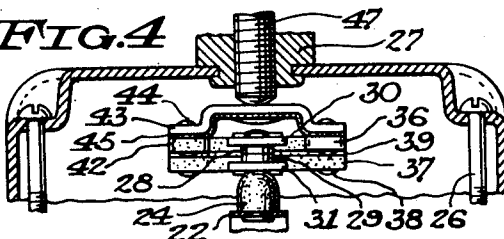


FIG. 8

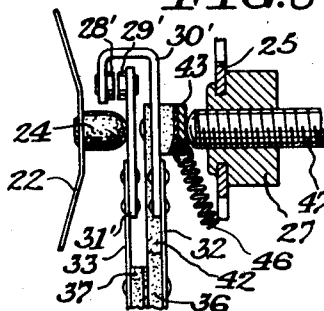


FIG. 5

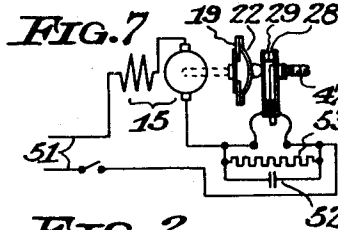
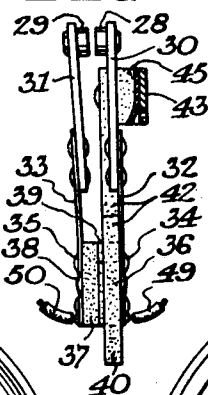


FIG. 3

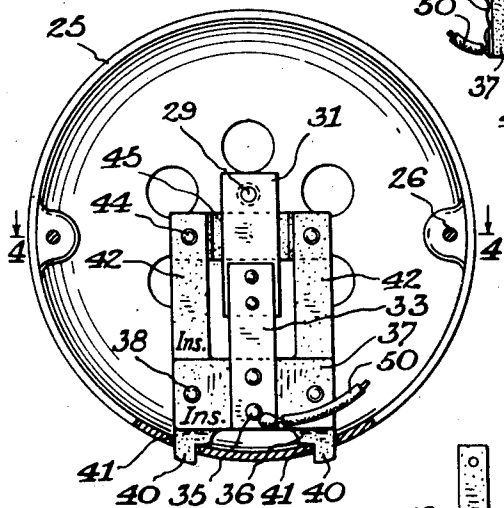


FIG. 2

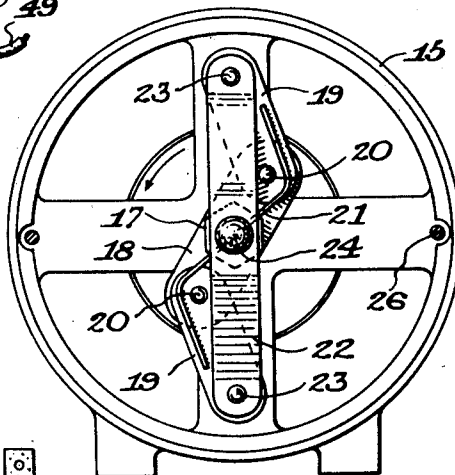
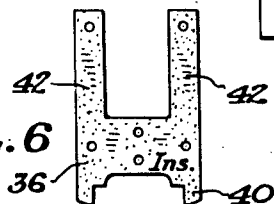


FIG. 6



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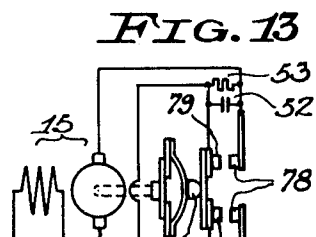
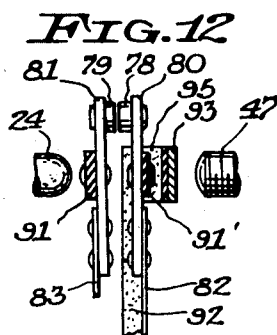
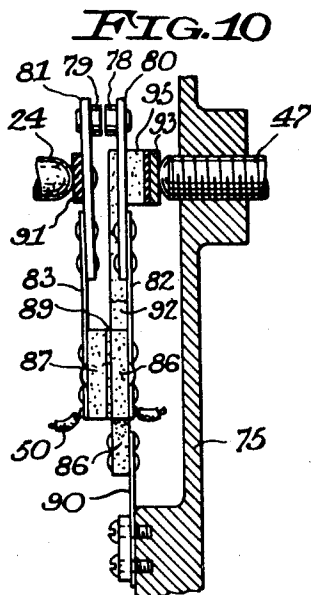
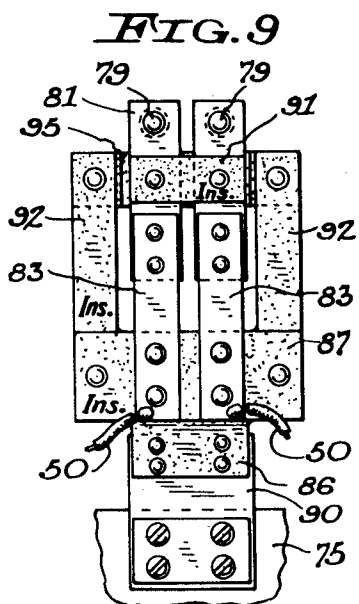
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

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SPEED REGULATOR

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Application December 6, 1943, Serial No. 513,086

1 Claim. (Cl. 318—325)

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The present invention relates to speed regulators.

An object of the invention is to provide an improved speed regulator which is capable of controlling the speed of an electric motor within close limits.

Another object is to provide a speed regulator including an improved switch device which is so arranged as to permit a high rate of contact vibration.

A further object is to provide a speed regulator which is relatively free from gravitational effects and which is so arranged as to simplify wiring connections.

A still further object is to provide a speed regulating switch device which is of simple and durable construction and which is capable of inexpensive manufacture.

The invention further consists in the several features hereinafter described and claimed.

In the accompanying drawings, illustrating certain embodiments of the invention,

Fig. 1 is a side elevation of an electric motor provided with a speed regulator of the invention, parts being broken away and parts being shown in section;

Fig. 2 is an end view of the motor with parts removed and showing a rotatable switch actuator on the motor shaft;

Fig. 3 is an elevation of an end casing of the motor and showing a speed regulating switch device carried by the casing;

Fig. 4 is a sectional view taken generally on the line 4—4 of Fig. 3;

Fig. 5 is a detail view of the switch device, parts being broken away and parts being shown in section;

Fig. 6 is a detail elevation of an insulating support of the switch device;

Fig. 7 is a diagrammatic view showing one form of circuit for the motor speed regulator;

Fig. 8 is a view generally similar to Fig. 1, but showing a modified form of switch device in which the contacts are arranged to close on increase of motor speed;

Fig. 9 is an elevation of another modified form of switch device including a plurality of switch units;

Fig. 10 is a side elevation of the switch device of Fig. 9, parts being broken away and parts being shown in section;

Fig. 11 is a top view of the switch device of Fig. 9;

Fig. 12 is a sectional elevation similar to Fig. 5

10, but showing a further modified form of switch device;

Fig. 13 is a diagrammatic view showing a form of motor controlling circuit including the switch devices of either Fig. 9 or Fig. 12;

Fig. 14 is a diagrammatic view of a modified form of motor controlling circuit in which the speed is controlled by an electrical characteristic of the motor;

Fig. 15 is a detail view of a resilient spider for the switch actuating means of Fig. 14;

Fig. 16 is a side elevation, partly in section, showing a modified form of switch mounting, and

Fig. 17 is a view similar to Fig. 16, but showing another form of switch mounting.

In that form of the invention shown in Figs. 1 to 6, 15 designates a variable-speed electric motor having a rotor shaft 16. By way of example, the motor may be of the series or universal type, as indicated in Fig. 7, although the invention is applicable to other types of motors.

A hub member 17 is rigidly secured to an end of the motor shaft and is provided with flat radial arms 18 extending in opposite directions. Flat weight-forming link bars 19 are pivotally secured to the respective hub arms 18, as by shoulder rivets 20, and project outwardly therefrom, the axes of the rivets being equidistant from, and parallel to, the shaft axis. A bent wire biasing spring 21 is secured at opposite ends to the pivoted bars 19, as by soldering or welding, and urges these bars to the angular position seen in Fig. 2, each bar being angularly displaced in the direction of rotation from a radial position. The link bars are thus resiliently coupled to the motor shaft. A bowed leaf spring 22 is pivotally secured at its outer ends to the outer ends of the link bars 19, as by means of shoulder rivets 23 which are equidistant from, and parallel to, the shaft axis. The center line of the bowed leaf spring lies in the plane of the shaft axis, and the pivot rivets 23 also lie in this plane. The middle portion of the bowed leaf spring is spaced axially from the end of the motor shaft and has secured thereto a button 24 of fibre or other insulating material coaxial with the shaft. The button 24 is adapted to engage a movable element of a switch or circuit-closer device hereinafter described.

The spring-biased link bars 19 form centrifugally-influenced weight members and also form inertia members responsive to changes in motor speed, these bars having a degree of freedom of movement about their axes of rotation and having a component of tangential movement with respect to the motor shaft. The link

bars thus provide both radial and tangential inertia action. Under the influence of centrifugal force, the link bars are urged outwardly toward radial positions against the action of the biasing spring, thus tending to straighten the bowed leaf spring 22 and axially displacing the middle portion of the spring toward the adjacent end of the rotating motor shaft. Upon a momentary increase in motor speed the rotative speed of the outer ends of the link bars, by reason of the inertia of these bars, will tend to remain at the former value and thus lag behind the motor speed. As a result, the link bars will swing outwardly against the action of the biasing spring and effect an axial retraction of the bowed leaf spring. In a similar manner a momentary decrease in motor speed will effect an axial advance of the bowed leaf spring.

An apertured cup-shaped end casing 25 is detachably secured to the housing or frame of the motor 15, as by screws 26, the end casing having a central screw-threaded bushing 27. A switch or circuit-closer assembly is detachably mounted in the end casing and comprises a pair of cooperating contacts 28 and 29 secured to the upper ends of respective radiator plates 30 and 31, the lower ends of these plates being riveted or otherwise secured to respective leaf springs 32 and 33, thus forming spring arms for the contacts. At their lower ends the leaf springs 32 and 33 are secured by respective rivets 34 and 35 to respective insulating plates 36 and 37, these plates being secured together as by rivets 38, Fig. 3, and there being an interposed insulating sheet 39 to prevent short-circuiting between the rivets 34 and 35. The insulating plate 36 is fulcrumed at its lower end on the lower portion of the end casing and for this purpose is provided with guide lugs 40 disposed in openings 41 in the casing. Upwardly projecting fingers 42 are formed at opposite sides of the insulating plate 36 and are spaced laterally from the leaf spring 32 and contact-carrying radiator plate 30. A metal bridge member 43 is secured, as by rivets 44, to the upper ends of the fingers 42 of the insulating plate 36 and is provided with an insulating liner 45. The middle portion of the bridge member is offset so as to allow for angular deflection of the contact-carrying arm 30, 32, which is free to vibrate. A coiled tension spring 46 connects the bridge member 43 and the end wall of the casing member 25 to urge the circuit-closer assembly away from the rotary actuator and hold the lugged insulating plate 36 down in firm fulcrumed engagement with the casing member. An adjusting screw 47 is threaded in the bushing 27 and bears at its inner end on the middle portion of the bridge member 43 to adjust the angular position of the circuit-closer assembly. The radiator plates extend across the projected axis of the motor shaft approximately at right angles to this axis, and the insulating button 24 is adapted to bear on the radiator plate 31 to urge the contact 29 against the contact 28. The leaf spring 33 is biased to urge the contact 29 away from the contact 28, as seen in Fig. 5, so that the retraction of the actuator button will cause the contacts to separate. The adjusting screw 47 may be retained in adjusted position by a lock nut 48. When the adjusting screw 47 is turned outwardly a sufficient distance the spring 46 swings the circuit-closer assembly away from the actuator button 24 and the leaf spring 33 then holds the contact 29 out of engagement with the contact

28. Current is conducted to the circuit-closer contacts by flexible conductors 49 and 50 connected to the lower ends of the respective leaf springs 32 and 33, these conductors avoiding interference with the angular adjustment of the circuit-closer assembly.

The centrifugally actuated circuit-closer or interrupter can be utilized in various circuits and by way of example is shown in Fig. 7 to be connected in series with the motor 15 which is supplied with current from mains 51. The circuit-closer may be shunted by a suitable spark suppressor, such as a condenser 52, and if desired may be shunted by a resistor 53 which passes part of the motor current. The resistor will also form a path for the discharge current of the condenser.

When the motor is to be operated, the adjusting screw 47 is turned inwardly to effect engagement of the contacts 28 and 29. The motor is started in operation by connecting it to the supply mains to admit current to the motor, the motor current flowing through the then closed contacts. The motor accelerates to a critical speed at which the spring-biased contact 29 separates from the contact 28 incident to the axial retraction of the button 24 carried on the centrifugal actuator, thus reducing the motor current and causing the motor speed to drop slightly. The contacts then re-engage under the pressure of the rotary button 24 which advances axially upon reduction of motor speed, causing the motor speed to again increase slightly, and the cycle of operation is repeated. By the action of the centrifugal actuator the spring-mounted contact 28 is caused to vibrate at a high frequency, for example 50 to 500 cycles per second, and the motor speed remains substantially constant. The pivoted rotating inertia members 19 are quickly responsive to slight changes in motor speed, so as to permit rapid axial vibration of the actuator button 24 which controls the vibratory spring-mounted contact 29.

When the higher speed of operation is desired the adjusting screw 47 is turned inwardly, and, conversely, when a lower speed is desired the adjusting screw is turned outwardly. By turning the screw outwardly a sufficient distance the contacts 28 and 29 will remain open, whereupon the motor current will be limited by the resistor 53.

It is desirable to permit a slight sparking between the contacts 28 and 29, as the explosive effect of the sparking has a tendency to separate the contacts and appears to be the force which maintains the vibration of the contact-carrying spring arm 32. This spring arm freely vibrates at or near its natural frequency, and its travel in one direction is limited by the engagement of the contacts. The rate of vibration of the contact 29 is usually much lower than that of the contact 28. Under certain motor load conditions the contact 29 may move quite slowly, or may even remain stationary for a short time, but the contact 28 will nevertheless continue to vibrate.

In a centrifugal motor speed regulator of the vibrating contact type, the closeness of speed regulation depends to a considerable extent on the rate of contact vibration. The speed regulating apparatus of the present invention permits a high rate of contact vibration to be obtained while also providing the advantages of a stationary or non-rotative contact mounting,

such type of mounting obviating the use of current-collector rings and brushes for conducting current to the contacts.

In the modified form of the invention shown in Fig. 8, the contacts 28' and 29' are arranged to close when the motor speed increases, permitting the device to be used in circuits requiring this contact relation. The contacts 28' and 29' are carried on the upper ends of the respective spring-mounted radiator plates 30' and 31', the upper end of the former being hooked to extend over the upper end of the latter and both spring arms 32 and 33 being free to vibrate. The construction is otherwise similar to that of the device of Fig. 1.

The modified form of switch device or circuit-closer assembly shown in Figs. 9 to 11 is arranged to provide a plurality of current-interrupting contact sets and is adapted for use in motor circuits such as are shown in Figs. 13 and 14, hereinafter described. A U-shaped insulating plate 86, similar to the plate 36 of Figs. 1 and 3, has its lower end secured to the upper portion of an upright leaf spring 90 forming a spring hinge, the lower portion of the leaf spring being clamped to a support 75, which if desired may form a part of the motor housing. The insulating plate 86 carries insulating members 87 and 89 similar to the members 37 and 39 of Fig. 3. The plate 86 has upwardly projecting side fingers 92 to the upper ends of which are secured a bridge member 93 with an insulating liner 95. The switch device comprises two sets of cooperating contacts 78 and 79 secured to the upper ends of respective radiator plates 80 and 81, the lower ends of these plates being riveted to or otherwise secured to the respective leaf springs 82 and 83. At their lower ends the leaf springs 82 and 83 are secured, as by riveting, to the insulating plates 86 and 87. The leaf springs 82 are arranged side by side, and the leaf springs 83 are similarly arranged side by side, and are preferably arranged for independent vibration. The radiator plates 81 are rigidly connected by a cross bar 91 on which bears the button 24 of the speed-responsive switch actuator. The cross bar is of insulating material in cases where it is desired to insulate the two contacts 79.

The speed-responsive switch of Figs. 9 to 11 can be utilized in various circuits one of which is shown in Fig. 13. In this circuit the switch is connected in series with a series motor 15 supplied with current from mains 51, the two pairs of contacts 78 and 79 being arranged to provide two breaks in series so as to divide the break voltage between them. Each pair of contacts may be shunted by a suitable spark suppressor, such as a condenser 52 and resistor 53. One set of corresponding contacts, say the contacts 79, are electrically connected, while the other two corresponding contacts form the terminals of the switch.

The operation of the system is similar to that of Fig. 7, the resiliently mounted contacts 79 vibrating with the speed-responsive actuator 24, and the resiliently mounted contacts 78 vibrating freely at a high frequency. The vibration of the contacts 78 appears to be maintained by the explosive effect of the sparking between the opposed contacts.

The modified switch device of Fig. 12 is similar to that of Figs. 9 to 11, except that the radiator plates 80 are rigidly connected by a cross bar 91', similar to the cross bar 91, so that the contacts 78 will vibrate in unison. The operation of the

device of Fig. 12 is similar to that of Figs. 9 to 11.

In the motor controlling system of Fig. 14 the speed regulating switch is actuated by means responsive to an electrical characteristic which varies with the motor speed. In the present instance use is made of the fact that the motor armature voltage increases with the speed. In this system 110 designates a variable speed electric motor, here indicated to be a series motor of the universal type having a rotor or armature 111 and field coils 112, the armature being connected between the field coils and the latter being connected to current mains 113 furnishing either direct or alternating current.

The speed regulating switch is preferably of the type shown in Fig. 9, and the two switch units comprising the contacts 78 and 79 thereof are connected in series between one armature brush and one of the field coils by respective conductors 114 and 115, so as to complete the motor circuit when the contacts are engaged. Preferably, two series-connected resistors 116 and 117 are shunted across the terminals of the switch to pass part of the motor current when the switch units are open, the junction between the resistors being connected to the switch contacts 79 by a conductor 118. The resistors are shunted by respective protective condensers 119 and 120 and by respective normally open switches 121 and 122.

The position of the contacts 79 of the switch device is controlled by a reciprocity actuator 24' carried by a plunger rod 123 secured to the shiftable coil 124 of an electromagnetic device 125 of the moving coil type commonly used for loud speakers. The plunger rod 123 is supported for straight line motion by suitable resilient spiders 126, one of which is shown in detail in Fig. 15. The field structure 127 of the electromagnetic device is here shown to be of the permanent magnet type. The moving coil 124 is supplied with current through a bridge type rectifier 128, as of the copper oxide type, one of the input terminals of the rectifier being connected by a conductor 129 to one of the armature brushes, and the other input terminal being indirectly connected to the other armature brush by way of a conductor 130. An adjustable impedance 131 is preferably connected in the conductor 129 and is adapted to form a speed control. In some instances a condenser 132 may be connected across the moving coil 124. The moving coil system is of relatively light weight and is quickly responsive to voltage changes.

In the operation of the system of Fig. 14, electric current, either alternating or direct, flows through the motor windings from the mains 113 by way of the contact members 78 and 79 of the two series-connected switch units, causing the motor armature to rotate and increase in speed. As the motor speed increases the voltage across the armature also increases and is impressed on the input terminals of the rectifier, causing direct current to flow through the moving coil 124. The coil and the attached actuator are thereby displaced in a direction to separate the contacts 78 and 79 of the two switch units, the break voltage being divided between the switch units. The motor current thereupon drops to a subnormal value determined by the resistors 116 and 117, thereby limiting the motor speed. The separation of the contacts also causes the current flowing through the moving coil 124 to drop through a subnormal value determined by the resistors 116 and 117, whereupon the actuator plunger moves outwardly and recloses the switch contacts 78 and 79. The

motor current thereupon increases, tending to increase the motor speed, and the cycle of operation is repeated. Fine regulation of the motor speed is effected by the high-frequency vibration of the freely vibratable contact members 78. The net result is that the motor speed is governed within close limits. The motor speed may be adjusted by varying the position of the switch assembly, as by means of the screw 47 of Fig. 10. The moving coil either executes occasional movements or vibrates, as desired.

If the resistors 116 and 117 are properly set and the switches 121 and 122 are both open, the opening and closing of the switch contacts 78 and 79 will have little or no effect on the actuator coil 124, the coil then being closely responsive to armature voltage so as to provide good speed regulation. With both switches 121 and 122 closed the motor will operate without speed regulation. The motor may be connected to direct current mains without regard to polarity, as the rectifier will insure the proper polarity of the current flowing through the moving coil 124.

The modified switch device of Fig. 16 is similar to that of Fig. 1 except that it is mounted for translation to adjust the speed setting. The insulating plate 36 has a bridge member 43' which is rigidly carried on the inner end of a stem 97 slidably but non-rotatably fitting in a support 25', the stem being urged axially toward the actuator 24 by a coiled spring 96 and being axially adjusted by a nut 99 threaded on the outer end of the stem.

The modified switch device of Fig. 17 has its bridge member 43' rigidly carried on the inner end of a screw stem 47' threaded in a support 75', the stem having a knob 99' at its outer end. A coiled spring 96' takes up back lash in the threads, and a lock nut 48' on the stem retains the stem in adjusted position. The screw stem is turned through a limited angle, preferably less than one revolution, for axially shifting the switch assembly and thereby adjusting the speed setting.

The switch adjusting means of Figs. 16 and 17 may also be applied to the switch devices of Figs. 9 and 12.

This application constitutes a continuation in part of my application Serial No. 424,450, filed December 26, 1941, for Speed regulating apparatus, which has matured into Patent No. 2,353,314, granted July 11, 1944.

What I claim as new and desire to secure by Letters Patent is:

In a speed regulator for controlling the speed of an electric motor having a rotatable armature, a circuit-closer including relatively movable interrupter contacts, actuating means responsive to the speed of said armature for controlling the position of one of said contacts, said last-named means including an electromagnetic device with a moving coil responsive to armature voltage and further including a rectifier for supplying unidirectional current to said moving coil, and resilient supporting means for the other contact freely vibratable to interrupt the engagement of said contacts during the rotation of said armature.

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