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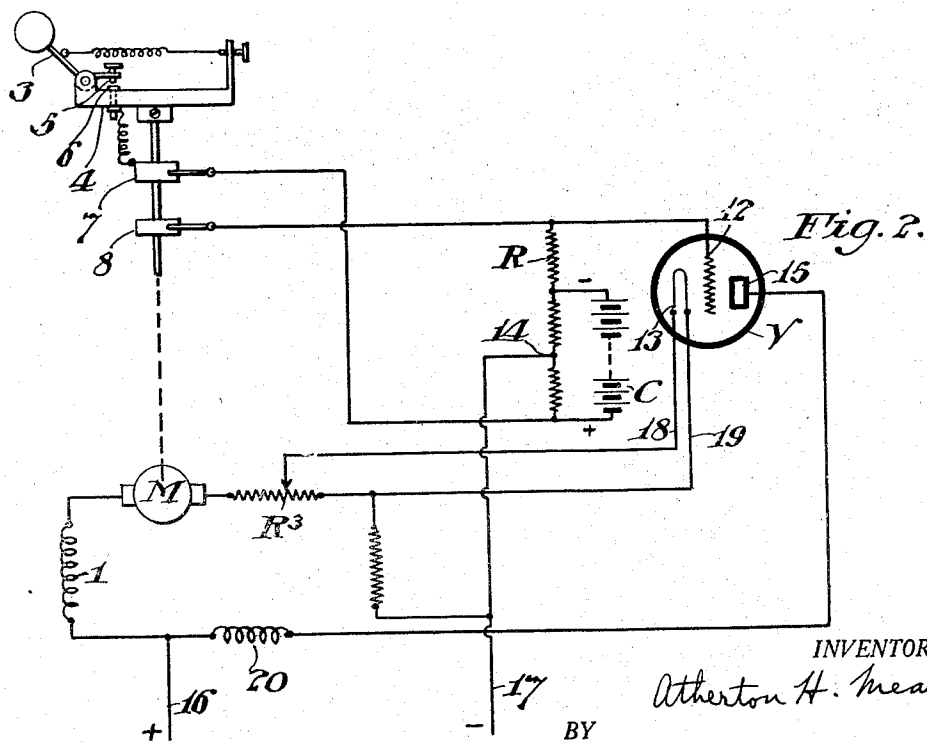
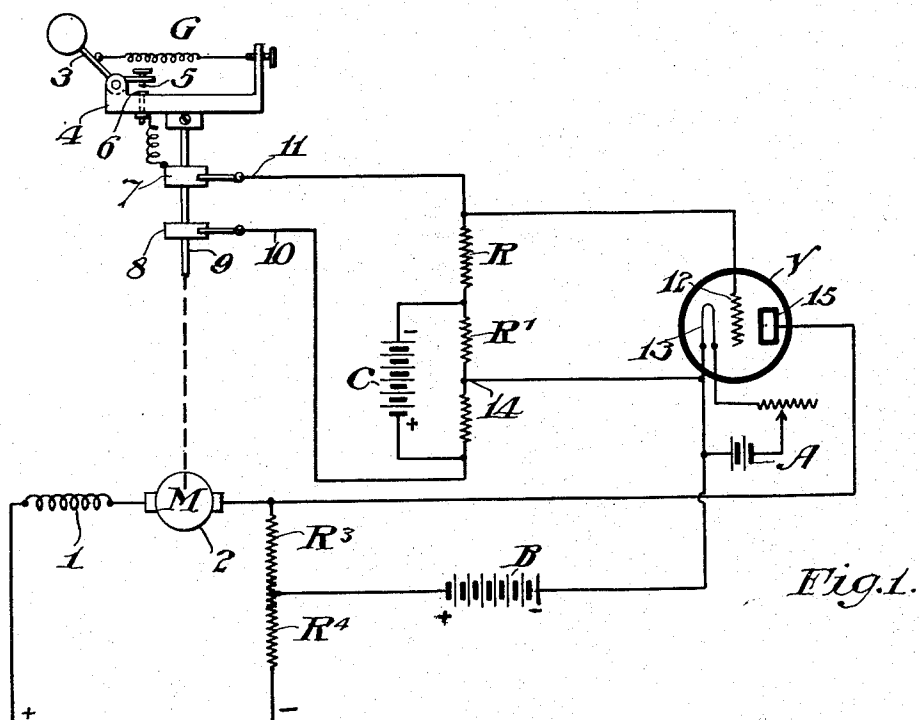
A. H. MEARS

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APPARATUS FOR CONTROLLING SPEED

Filed Nov. 14, 1931

2 Sheets-Sheet 1



INVENTOR.

Atherton H. Mears

Cornelius L. Elbert
his ATTORNEY.

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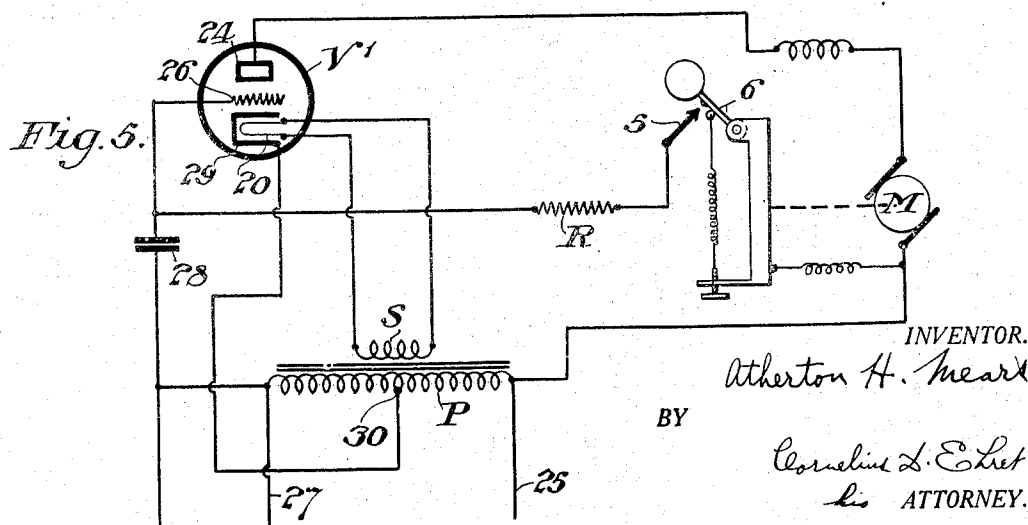
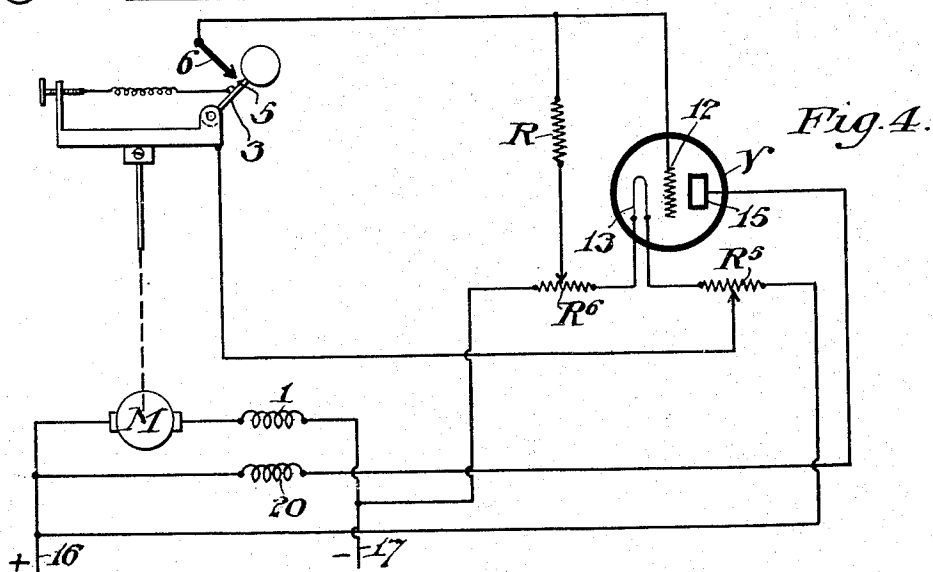
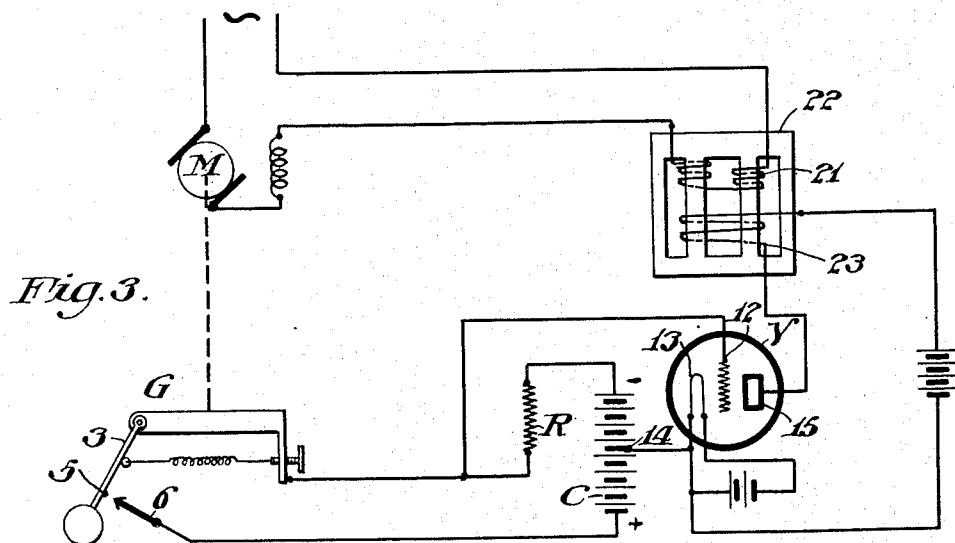
A. H. MEARS

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APPARATUS FOR CONTROLLING SPEED

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2 Sheets-Sheet 2



INVENTOR.
Atherton H. Mears
BY
Cornelius L. E. Lutz
ATTORNEY.

UNITED STATES PATENT OFFICE

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APPARATUS FOR CONTROLLING SPEED

Atherton H. Mears, Philadelphia, Pa., assignor to
Leeds & Northrup Company, Philadelphia, Pa.,
a corporation of Pennsylvania

Application November 14, 1931, Serial No. 575,046

13 Claims. (Cl. 171—312)

My invention relates to methods of and apparatus for controlling speed; specifically, the angular velocity of the armature or rotor of an electric motor.

5 In accordance with my invention, changes in position of a governor member, as the flyball, or equivalent, effect changes in the biasing voltage applied to the grid, or control electrode, of a thermionic tube and the resulting changes in
10 the internal resistance of the tube are utilized to maintain the motor speed substantially constant.

In accordance with some forms of the invention, the effective voltage impressed on the motor terminals is controlled by the tube, whereas in another form of the invention, the excitation of an auxiliary field of the motor is controlled by the tube.

Further in accordance with my invention, the
20 current supply for the motor may be utilized to furnish current for one or more of the control tube electrode circuits.

My invention further resides in the features of combination and arrangement hereinafter described and claimed.

For an understanding of my invention, reference is to be had to the accompanying figures of drawings which diagrammatically illustrate three different modifications.

30 Referring to Fig. 1, the motor M having a field winding 1 and an armature 2, drives the governor G, which may be of any suitable type having a member whose position changes in response to speed changes. Specifically, the
35 speed-responsive or centrifugal element 3 of the governor which is pivotally mounted on the governor frame 4, carries a contact 5 which moves into engagement with the relatively stationary contact 6 carried by the governor frame 4 when
40 the instantaneous motor speed is less than a desired average speed. The contacts 5 and 6 are connected respectively to the slip rings 7 and 8, mounted or rotatable with the governor shaft 9. Particularly as the current controlled by the con-
45 tacts 5 and 6, as will hereinafter appear, is extremely minute, one of the slip rings, for example the slip ring 8, and the governor member 3 carrying contact 5 may be connected through the metallic structure of the governor frame 4, drive
50 shaft 9, etc.

The contact 5 through the slip ring 8 and brush
10 in engagement with it, is connected to the positive terminal of a suitable source of direct or unidirectional current, such as for example, a
55 battery C, while contact 6 through slip ring 7 and brush 11 is connected to the grid 12 of a thermionic tube V, and also to the negative terminal of the battery C through a suitable high resistance R. The cathode 13 of the tube V is preferably connected to a point 14 whose potential is

intermediate that of the terminals of the battery C. This connection may go to an intermediate point of the battery itself, or as indicated to an intermediate tap of a potentiometer resistance R1 connected across the battery. The cathode 13
65 also connects to one terminal of a resistance R3, whose other terminal is connected to the anode 15 of the tube, so that the anode cathode resistance of the tube is in shunt to the resistance R3 which is in series with the motor M and its
70 source of supply.

The values of the series resistances R3, R4 are so chosen that except for controlling action as hereinafter described, the motor M would tend to run at a speed somewhat slower than the
75 desired speed. Under these circumstances, the contacts 5 and 6 are in engagement so that for the connections shown, the grid of the tube is positive with respect to its cathode. The inter-electrode path between the cathode and anode
80 of the tube is therefore conductive, and in effect a resistance in shunt to the resistance R3, so that the voltage across the motor terminals is increased. The resulting increase in speed of the motor causes the fly-ball 3 to move the con-
85 tact 5 out of engagement with contact 6, interrupting the connection between the grid 12 of the tube and the positive terminal of the battery C. The grid of the tube is now negative with respect to its cathode, and preferably to
90 such extent negative that the plate current is completely cut off. Otherwise expressed, the grid is so highly negative that the resistance within the tube between the anode 15 and cathode 13 is very high. The shunting effect of the anode-cathode path within the tube upon
95 resistance R3 is therefore negligible. The effective voltage at the terminals of the motor M therefore decreases, causing the motor to slow down. This cycle of operations is rapidly repeated maintaining the average speed of the
100 motor constant to a very high degree of precision.

In the system shown in Fig. 1 the filament of the tube V is heated by a separate battery or other current source A. The battery B for
105 supplying anode current to the tube may be omitted particularly if the resistance R3 is sufficiently high to obtain the proper difference of potential between the plate and cathode. The motor of Fig. 1 is shown as supplied from a
110 source of direct current, but the control system above described will also maintain the speed of the motor constant when it is energized from an alternating current source.

In the system shown in Fig. 2, the batteries
115 A and B are eliminated and the current for energizing the filament and anode circuits derived from the source of current for the motor. Specifically, the plate 15 of the tube is connected to one conductor 16 supplying current to the
120

motor while the cathode 13 of the tube is connected to the other conductor 17 supplying current to the motor. When the source of supply is direct current, the anode is, of course, connected to the positive conductor. The current for heating the filament 13 is secured by connecting the filament conductors 18 and 19 to suitable points of resistance R3, so that part of the current flowing through conductor 17 to the motor is diverted through the filament for heating it.

The speed of the motor is controlled by an auxiliary field 20 which is included in the anode circuit of the tube. In this system and with the connection specifically shown in Fig. 2, when the grid of the tube V is negative, the plate current of the tube through the auxiliary field 20 is negligible, and the motor tends to run slow. When the speed falls below a predetermined value, however, the fly-ball 3 moves inwardly effecting engagement between the contacts 5 and 6 to connect the grid of the tube V to the positive terminal of the battery C. The large positive bias on the grid of the tube greatly reduces the anode-cathode resistance of the tube and a relatively large current flows through the field coil 20 which is so poled that it opposes the main field. As a result of the decreased field excitation, the motor increases its angular velocity, causing the fly-ball 3 to move outwardly and separate the contacts 5 and 6. The grid of the tube then again becomes negative and the current through the coil 20 drops to a negligibly small value. This cycle of operation is rapidly repeated to maintain the average speed of the motor substantially constant.

By reversing the connections to both the auxiliary field coil 20 and to the battery C, similar governing may be accomplished.

Both of the preceding systems may be used to govern the speed of a series motor irrespective of whether the motor supply current is direct or alternating. However, when the motor is to be excited only from alternating current, the system shown in Fig. 3 is preferred. One of the windings, winding 21 of a saturated core reactor 22 is connected in series with the motor and the source of supply. Another winding, winding 23, of the reactor, is connected in series in the anode circuit of the control tube V. When the motor speed falls, the fly-ball 3 of the governor moves inwardly, the contacts 5 and 6 closing to complete a circuit between the grid of the tube and the positive terminal of the battery C. The resulting increased current through the winding 23 reduces the reactance of the saturated reactor causing a larger current to flow through the winding 21 to the motor.

The motor increases its speed causing the fly-ball 3 to move outwardly opening the contacts 5 and 6. The grid of the tube is now negative with respect to its cathode and the plate current of the tube which flows through the winding 23 of the reactor is greatly reduced. The reactance of the saturated core reactor 22 increases, causing a decrease in the current flowing to the motor through the coil 21. The motor speed therefore decreases, the cycle of operation repeating rapidly and continuously to maintain the average speed of the motor constant within extremely narrow limits.

In the arrangement shown in Fig. 4, the batteries A, B, and C of Fig. 1, or their equivalent, are eliminated and all of the electrode circuits of the tube V are energized from the same source

of current as the motor. As in the modification of Fig. 2, the plate or anode of the tube is connected through an auxiliary field of the motor to one of the supply conductors, for example, the positive conductor 16. The filament 13 of the tube is connected across the supply conductors 16 and 17 in series with the resistances R5, R6, which suitably reduce the potential for application to the filament. The grid of the tube is connected through a resistance R to a suitable point upon the resistance R6 which, as indicated, is between the filament and the negative conductor 17. The governor actuated contact 5 is connected to a suitable point on resistance R5 which is between the filament 13 and the positive conductor 16. With the connections shown, when the motor speed drops, the contacts 5 and 6 engage, connecting the grid 12 to a point on resistance R5 which is positive with respect to the cathode of filament 13, and the increased current through the auxiliary field 20 which is in opposition to the current through the main motor field 1, reduces the total motor field flux.

The speeding up of the motor because of the weakened field effects separation of the contacts 5 and 6, whereupon the grid by virtue of its connection through resistance R to the biasing resistance R6 becomes negative with respect to cathode 13. The anode-cathode resistance of the tube thereupon increases, causing a reduction in current through the bucking field 20. The motor therefore slows down and the cycle of operation repeats continuously and rapidly to maintain the average speed of the motor constant within very narrow limits.

Similar governing may be effected by reversing the connections to the auxiliary field 20 and to the governor contacts 5 and 6. This arrangement, although described for use with direct current supply source, can be used with an alternating current source, when the motor M is of the series-wound type.

In the system shown in Fig. 5, there is employed a thyatron V1 whose anode 24 is connected through the motor M to one conductor 25 of an alternating current power supply line, and whose grid 26 is connected to the other conductor 27 of the supply source through a condenser 28. The cathode 29 of the tube is connected to a point 30, whose potential is intermediate that of the power supply conductors, for example, to a tap of the primary winding P of a transformer whose secondary S supplies current to the cathode heating element 30 of the tube.

When the governor contacts 5 and 6 close, due to decrease in speed of the motor, the potential of the grid is more nearly in phase with the voltage applied to the plate 24. Accordingly, a greater current flows through the motor causing it to speed up. When the governor contacts open at high speed, the potential of the grid is shifted to be more nearly out of phase with the plate voltage, with the result that the plate current which flows through the motor is decreased, causing the motor speed to decrease. This governing cycle is continuously and rapidly repeated to hold the average motor speed constant. In this modification, as in Fig. 4, all of the tube circuits are energized from the power source for the motor.

Though I have illustrated several preferred arrangements, it is to be understood that my invention is not limited thereto and that further modifications may be made without departing

from the spirit of my invention as expressed in the appended claims.

What I claim is:

1. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose grid potential determines the extent of energization of said motor, and means operated by said governor member to reverse the polarity of the biasing potential applied to the grid of said tube in accordance with change in position of said governor member.

2. A speed control system for a motor comprising a governor member driven by said motor, a current supply circuit for said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, an impedance in said motor supply circuit in series with the motor, connections from said impedance to electrode structure of said tube, and means for changing the biasing potential applied to the grid of said tube in accordance with the change in position of said governor member.

3. A speed control system for a motor comprising a governor member driven by said motor, a current supply source for said motor, a thermionic tube, a resistance traversed by the anode current of said tube flowing in one direction and motor current from said source flowing in opposite direction, and means for changing the biasing potential applied to the grid of said tube in accordance with change in position of said motor.

4. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, a source of grid biasing voltage, a connection from the cathode of said tube to a point whose potential is intermediate the potentials of the terminals of said source, and means operated by said governor member for making the potential of the grid of said tube positive or negative with respect to said point in accordance with change in position of said governor member.

5. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, a source of grid biasing voltage, a resistance in shunt to said source, a connection from an intermediate point of said resistance to the cathode of said tube, a resistance connected between the grid of said tube and a terminal of said source, and means for opening or closing a connection between the other terminal of said source and said grid to reverse the polarity thereof in accordance with the position of said governor member.

6. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, conductors supplying current to said motor, a connection from one of said conductors to the anode of said tube, a connection from another of said conductors to the cathode of said tube, and means operated by said governor member for controlling the bias applied to the grid of said tube in accordance with change in position of said governor member.

7. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, conductors supplying current to said

motor, a connection from one of said conductors to the anode of said tube, a conductive impedance in another of said conductors, connections from the filament of said tube to points of said impedance to derive filament heating current therefrom, and means operated by said governor member for controlling the bias applied to the grid of said tube in accordance with change in position of said governor member.

8. A speed control system for a motor comprising a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, conductors supplying current to said motor, connections from said conductors to the anode and cathode of said tube, an auxiliary motor winding included in one of said connections, and means operated by said governor member for controlling the bias applied to the grid of said tube in accordance with change in position of said governor member.

9. A control system comprising a member movable in response to changes in magnitude of a condition, a thermionic tube whose anode-cathode resistance determines the magnitude of said condition, a source of grid-biasing voltage, a connection from the cathode of said tube to a point whose potential is intermediate the potentials of the terminals of said source, and means operated by said responsive member for making the potential of the grid of said tube positive or negative with respect to said point in accordance with the change in position of said member.

10. A speed control system for a motor comprising a source of current for supplying said motor, a governor member driven by said motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, means for changing the biasing potential applied to the grid of said tube in accordance with change in position of said governor member, and connections for exciting at least one of the electrode circuits of said tube from said motor supply source.

11. A system for controlling the speed of a motor comprising a centrifugal device driven by the motor, a thermionic tube whose anode-cathode resistance determines the extent of energization of said motor, means for applying biasing potential to the grid of said tube, and separable contacts actuated by said centrifugal device controlling the biasing potential applied to said grid by said means to control the speed of the motor.

12. A system for controlling the speed of a motor comprising a centrifugal device driven by the motor, a thermionic tube having its anode-cathode path in circuit with a winding of said motor, and separable contacts actuated by said motor and included in the grid circuit of said tube external to the path of current traversing said winding for changing the biasing potential applied to the grid of the tube.

13. A system for controlling the speed of a motor comprising a centrifugal device driven by the motor, a thermionic tube whose anode current controls the energization of the motor, means for biasing the grid of said tube negatively to such extent that the anode current is substantially completely cut off, and separable contacts actuated by said centrifugal device and included in the grid circuit for control of the grid bias.

ATHERTON H. MEARS.