No. 793,570. PATENTED JUNE 27, 1905.

A. C. EASTWOOD.

MOTOR CONTROLLING SYSTEM.

APPLICATION FILED APR. 15, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

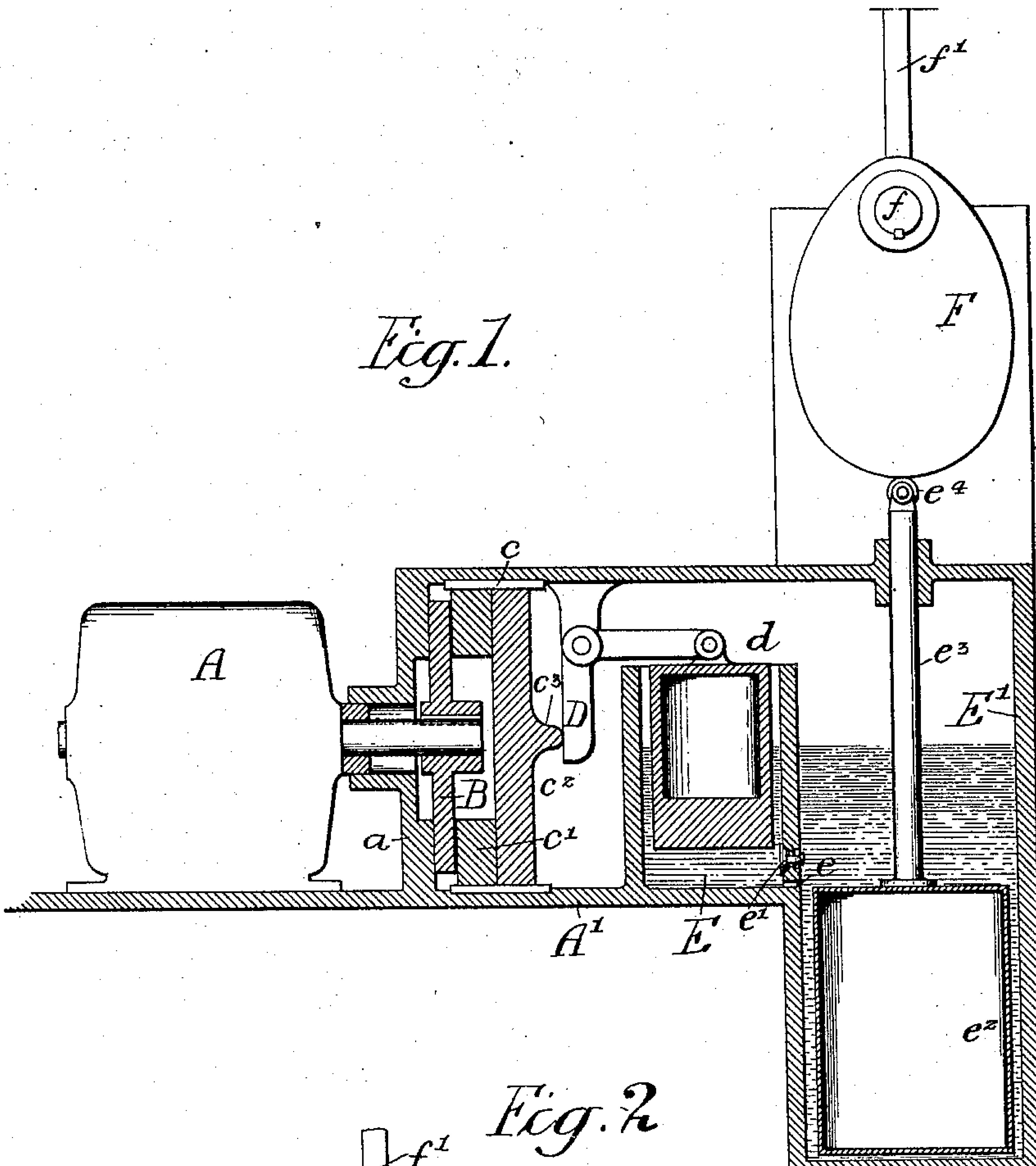
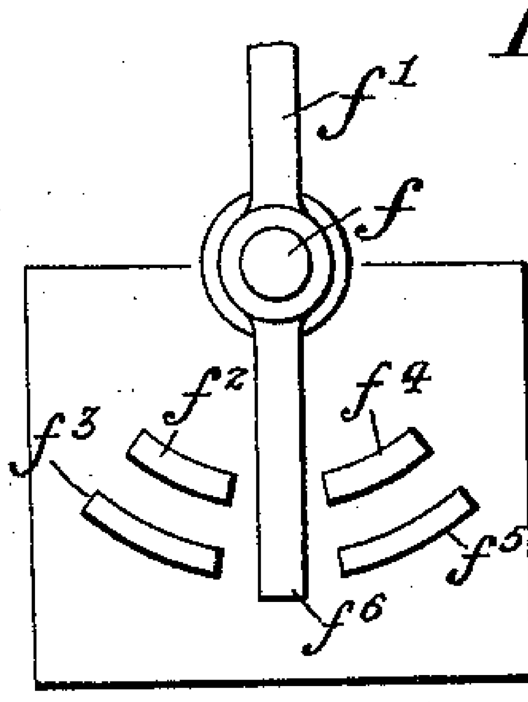


Fig. 2



Witnesses:-
Walter F. Pullinger
Titus Nelson

Inventor:
Arthur C. Eastwood
by his Attorneys
Howson & Howson

No. 793,570. PATENTED JUNE 27, 1905.

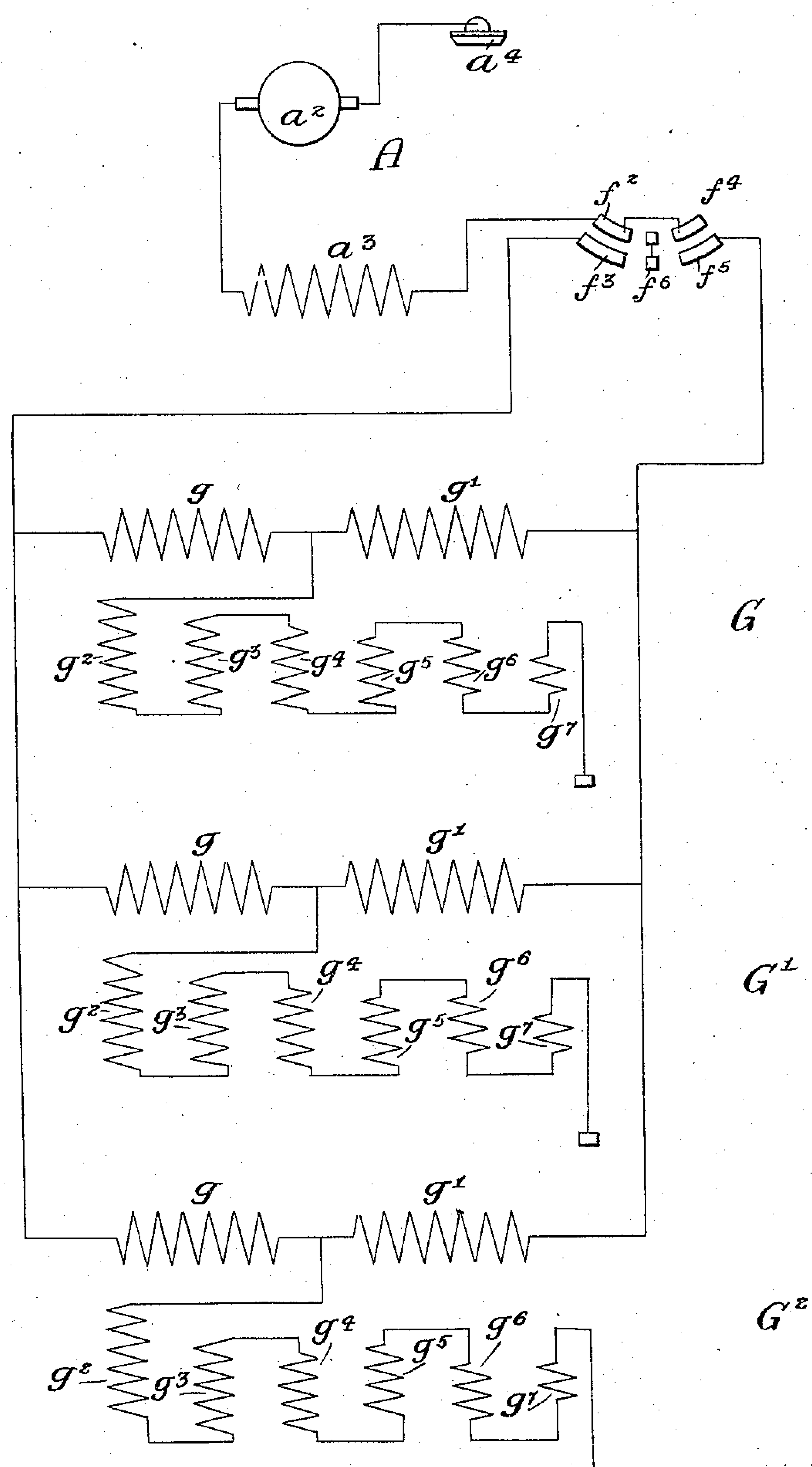
A. C. EASTWOOD.

MOTOR CONTROLLING SYSTEM.

APPLICATION FILED APR. 15, 1905.

3 SHEETS—SHEET 2.

Fig. 3.



Witnesses:
Walter F. Pullinger.
Titus H. Irons

Inventor:
Arthur C. Eastwood
by his Attorneys:
Howson & Howson

No. 793,570. PATENTED JUNE 27, 1905.

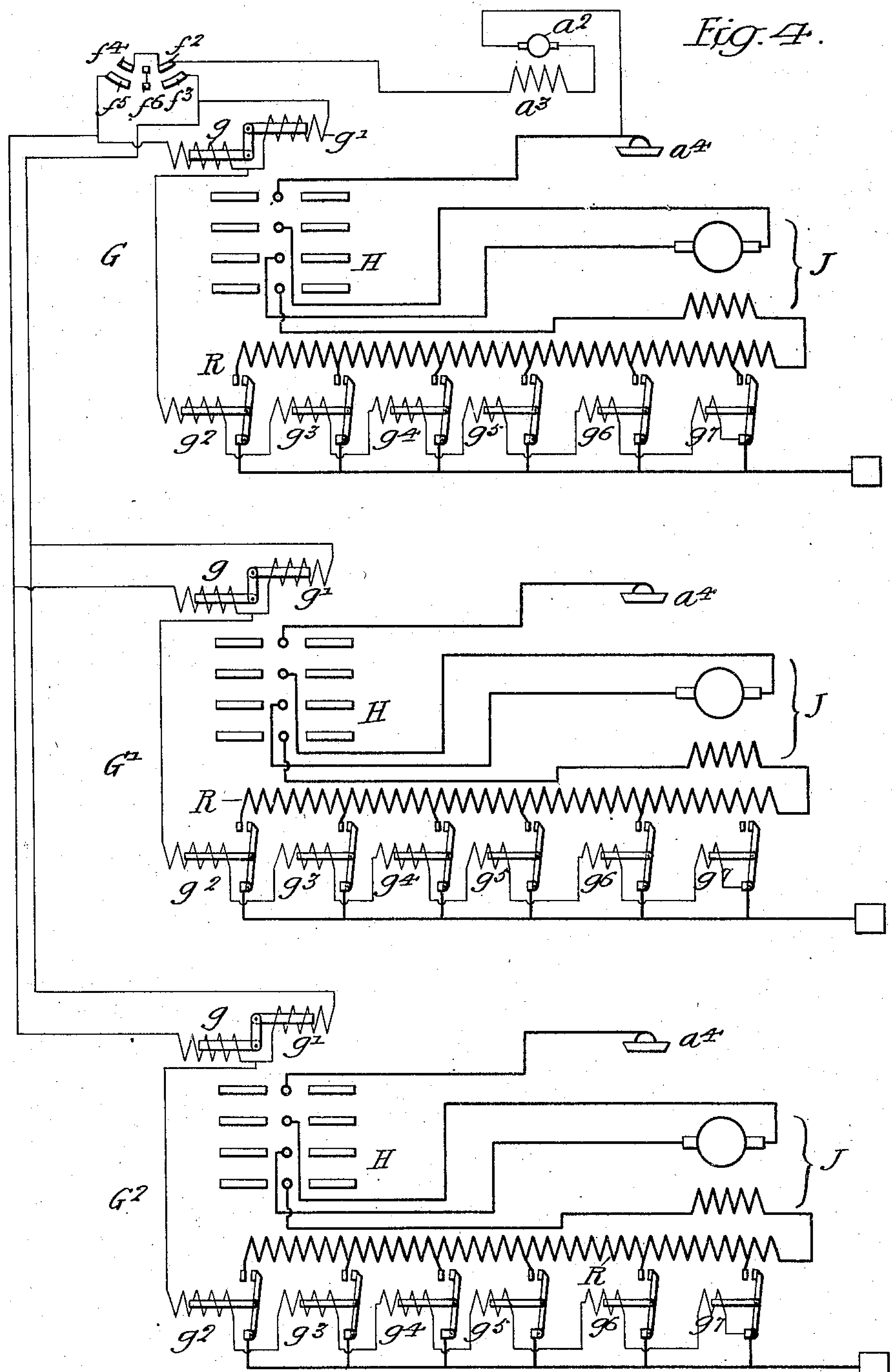
A. C. EASTWOOD.

MOTOR CONTROLLING SYSTEM.

APPLICATION FILED APR. 15, 1905.

3 SHEETS—SHEET 3.

Fig. 4.



Witnesses:

William H. Rivers

Titus H. Irons.

Inventor:

Arthur C. Eastwood,

by his Attorneys,

Howson & Howson

No. 793,570. Patented June 27, 1905.

UNITED STATES PATENT OFFICE.

ARTHUR C. EASTWOOD, OF CLEVELAND, OHIO.

MOTOR-CONTROLLING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 793,570, dated June 27, 1905.

Application filed April 15, 1905. Serial No. 255,741.

To all whom it may concern:

Be it known that I, ARTHUR C. EASTWOOD, a citizen of the United States, residing in Cleveland, Ohio, have invented certain Improvements in Motor-Controlling Systems, of which the following is a specification.

The object of my invention is to provide a combination of apparatus such that by the operation of a manual controlling device through a series of predetermined positions certain definite currents may be caused to flow in a given circuit, the quantity of this current being always the same for a given operating position of said controller irrespective of variations in the voltage of the supply-circuit.

One application of my invention is in connection with the control of electric motors, particularly in installations where a number of motors are to be controlled from a single point—as, for example, in the case of a multiple-unit train. In such systems it is of prime importance that the number of wires running from the point of control to the various individual controlling equipments on the cars be reduced to a minimum, and it is also desirable that each position of the handle or operating-lever of the master-controller should result in a definite combination of connections between the motors and their controlling resistance.

My invention is particularly applicable to a system in which the various circuit connections between the driving-motors and the controlling resistance are effected by means of magnetically-operated switches. In the past the common means of actuating such switches consisted in connecting the solenoid of each switch to a master-controller provided with contacts for energizing the various solenoids in the desired succession. Such a system required the use of a large number of wires and was necessarily objectionable for this reason, as well as on account of the resulting complication. It has also been customary to wind the solenoids of the circuit-controlling switches to respond to different voltages and to so connect the master-controller as to cause it to successively increase the voltage applied to the solenoids. This increase of voltage was secured either by varying the resistance in circuit with the switch-solenoids or in an equivalent manner by energizing the switch-coils from the generator end of a motor-generator, the voltage of the current supplied by said generator being varied at will by the operation of the master-controller. It will be noted, however, that both of these systems depend for their successful operation upon the maintenance of a constant line voltage, which is under conditions ordinarily found a condition almost impossible to fulfil. In railway work particularly it is well known that where the voltage is normally five hundred it actually varies anywhere between three hundred and fifty and six hundred and fifty volts, depending upon the distribution of the load. Hence if the connections of the master-controller be such that its first position will cause only the first switch of a series of controlling-switches to close when the line voltage is at three hundred and fifty a rise of the voltage to six hundred and fifty would result in one, two, or more of the succeeding controlling-switches closing without further operation of the master-controller. As a result the operator has no means of knowing the circuit relations of the motors, nor can he tell when these circuit relations may be altered by fluctuations in the line voltage.

Since a solenoid or electromagnet requires a given number of ampere turns of excitation to cause its plunger to move against a given resistance and since the number of turns of each solenoid is necessarily constant, it is obvious that it is only necessary to deliver a current of definite strength in order to cause actuation of said plunger. Therefore where a number of solenoids or electromagnets are to be successively actuated I so design them that they require progressively greater numbers of amperes of current for their operation and provide means for causing progressive variations in the strength of current delivered to the windings. In other words, I provide a system including a regulating device each of whose positions causes a definite current to flow in the circuit including the solenoid-windings and, moreover, provide means whereby such current-flow is made independent of the variations of the line voltage. For this purpose I take advantage of an inherent characteristic of series-wound motors—namely, the fact that the current-flow through the windings of such a motor depends altogether upon the load and is independent of the voltage of the current supplied to it. Since the speed at which a given load is driven depends on the voltage of the supply-circuit, while the current varies directly as the load, I include a series motor in series with the windings of the solenoids which it is desired to operate, these windings having different numbers of turns. In order to vary the current-flow through this circuit, I supply means for gradually and successively varying the load on the motor by definite amounts, and consequently cause successive operation of the solenoids.

Referring to the drawings herewith, I have shown a form of apparatus for carrying out the invention.

Figure 1 is a side elevation, partly in section, illustrating the detail construction of my master-controller and its connection with a series motor. Fig. 2 is a fragmentary elevation of the face of the controller shown in Fig. 1, illustrating the construction of the master reversing-switch. Fig. 3 is a diagrammatic view illustrating the connections between a series motor, the master-controller, and the solenoids of a series of main reversing and resistance-controlling solenoids; and Fig. 4 is a diagrammatic view illustrating my controlling system in connection with a plurality of motors whose operation it is desired to govern.

In Fig. 1, A is a relatively small series motor, to the shaft of which is connected a friction-disk B. In the present instance this disk is designed to be confined between an auxiliary portion a of the framework A′, upon which the whole structure is carried, and there is a ring c', which is prevented from turning by feathers c holding it to said frame, though permitting its motion toward and from the disk B. This ring is engaged by a second disk c^2, from the center of whose outer face projects a lug c^3, engaged by one arm of a bell-crank lever D. A weighted float d is hung from the second arm of this lever within a container E, connected to a main reservoir E′ through a relatively restricted opening e, in addition to which there is a second opening closed by a check-valve e', so disposed as to freely permit the flow of liquid from the main reservoir to the container E, while preventing its flow in the opposite direction.

Within the main reservoir is a hollow float or cylinder e^2, having connected to it a rod e^3, guided through a suitable opening in the frame A′ and carrying at its upper end a roller e^4. Within the two containers E and E′ is a body of any suitable stable liquid, such as oil or mercury, and the submergence of the float e^2 within this liquid is controlled by means of a cam F, carried on the shaft f, which has attached to it an operating-handle f'.

The above-described mechanism is designed to vary the load upon the motor A by certain definite and constant amounts, for it will be seen that with the motor A in operation and the various parts of the device in the positions shown in Fig. 1 if the handle f be turned the cam F will permit the float e^2 to rise, and a change of level of the liquid in the two containers E and E′ will thereby result, the flow taking place from the container E through the opening e at a definite rate.

If it be assumed that the height of the liquid in the two containers be such that the weighted cylinder d is buoyed up by a force equal to its weight, then this flow of liquid from the container E will cause the said cylinder d to pull down upon the arm of the bell-crank lever D, so as to increase the pressure of the second arm of this lever against the disk c^2, and this by increasing the friction upon the disk will increase the load upon the motor A, which increase in load will be in proportion to the amount of liquid escaping from the container E. It will therefore be seen that if the handle f' be turned through one hundred and eighty degrees without a pause the float e^2 immediately rises to its highest position, and as the liquid gradually flows from the container E into the main reservoir the load upon the motor A will be gradually increased and the current taken by it will correspondingly rise. It will further be understood that the amount of current taken by this motor corresponding to a certain height of liquid in the two containers is always the same for the same position of the operating-handle f', so that if, as in Fig. 3, the motor A is connected in series with the solenoids of a number of resistance-controlling switches, each designed to be actuated by a certain definite current, a relatively simple means is provided for controlling the operation of a number of main motors. In this figure a^2 is the armature and a^3 is the field of the motor A, and this is connected to control the operation of three equipments G, G′, and G². There are two solenoids g and g' for operating each reversing-switch H, to control the direction of rotation of the main motors J, while $g^2, g^4 \ldots g^7$ represent the solenoids of a number of automatic switches for controlling the amount of the resistance R in circuit with said motors. These latter solenoids have different numbers of turns in their windings or may be otherwise constructed, so that they will actuate their attached mechanism under different conditions of current-flow.

As shown in Fig. 2, I preferably arrange means for actuating either of the solenoids g or g' of each reversing-switch H according as to whether the handle f' is moved in one direction or the other, and for this purpose I extend said handle below the shaft f, providing it with a contact f^6, and mount upon a projecting portion of the frame A′ or other support two pairs of segments f^2, f^3, f^4, and f^5, connecting the segments f^2 f^4 to one terminal of the motor A, whose second terminal is connected to a trolley or third-rail shoe a^4. The segment f^3 is connected to one terminal of each of the reversing-switch solenoids g, while the segment f^5 is similarly connected to one terminal of the solenoids g'. The second terminals of each of these solenoids are connected together and to the resistance-controlling solenoids g^2, g^7, which are connected in series. The last solenoid of the series has its free terminal grounded. Under operating conditions current cannot flow through the controlling system until the handle f be operated, and if this be turned through a sufficient distance its extension comes into engagement with the segments f^2 and f^3, for example, and current will flow from the shoe a^4 through the armature a^2 and field-winding a^3 of the motor A, through said switch, the solenoids g of each reversing-switch, and through all of the resistance-controlling solenoids $g^2 \ldots g^7$ of each of the equipments G, &c.

Since the movement of the handle f' has permitted a change in level of the liquid in the container E′, a certain definite load has been put upon the motor A, owing to the fact that liquid has flowed from container E and the support or flotation given the cylinder d has been diminished, so that a current will flow through said motor and through the various solenoids, causing operation of the solenoids g and of the first resistance-controlling solenoids g^2 of each of the three car equipments shown. As a result the main motors J are connected for revolution in a certain direction and the main motor-circuit is completed through all of the controlling resistance R in the manner well known to the art. If the handle f' be moved to its second point, more liquid will escape from the container E, and because of the increased effective weight of the cylinder d there will be an increase of the load upon the motor A, with a resultant increase in the current-flow. This additional current-flow is sufficient to cause operation of the three solenoids g^3, which have more turns than solenoids g^2 and act to cut out a portion of the controlling resistance R from circuit with the main motors. Further movement of the handle f' causes successive operation of the solenoids $g^4 \ldots g^7$, until finally the main motors are brought up to full speed with no resistance in circuit. If at any time the handle f' be turned to its vertical position, the rise of liquid in the reservoir E′ will immediately cause a corresponding rise of liquid in the container E by reason of the opening of the check-valve e', so that the load is taken off of the motor A so quickly that its removal is practically instantaneous, and since the current taken by said motor correspondingly falls all of the apparatus actuated by the solenoids g, $g^2 \ldots g^7$ is automatically returned to its inoperative positions.

It will be seen that as a result of the above-described combination of apparatus in case there should be, for example, an increase in the line voltage when the first two of each series of solenoids have operated the speed of the motor would increase, but the current-flow would remain the same, since there would be no change of load, with the result that no additional switches would be closed. Should the line voltage fall, the motor would merely slow down, though, as before, the current-flow would remain constant. Consequently with my improved system the controlling-solenoids are caused to operate successively, while being altogether independent of the variations in the line voltage.

I claim as my invention—

1. A system including a series of electromagnetic devices constructed to actuate their respective mechanism under different conditions of current-flow, means for rendering the current-flow through said devices independent of variations in the voltage of the source of supply, and means for varying said current-flow at will to cause successive operation of said electromagnetic devices, substantially as described.

2. A system including a series of solenoids having different numbers of turns in their windings, means in circuit with said solenoids for maintaining the current-flow therethrough independent of variations in the voltage of the source of supply, and means for varying said current-flow at will to cause successive operation of said solenoids, substantially as described.

3. A system including a series of electromagnetic devices constructed to actuate their respective mechanism under different conditions of current-flow, a motor in circuit with said solenoids, and a controlling device for varying the load on the motor, substantially as described.

4. A system including a series of windings constructed to actuate their respective mechanism under different conditions of current-flow, a series motor in series with said windings, and means for varying the load on said motor, substantially as described.

5. A system including a series of windings constructed to actuate their respective mechanism under different conditions of current-flow, a motor in circuit with said windings, with means, including a manually-operated device and apparatus controlled thereby, for varying the load on said motor, substantially as described.

6. A system including a series of resistance-controlling solenoids, two reversing-switch solenoids, a series motor, and a controlling device for varying the load on the motor having a switch whereby either one of the reversing-switch solenoids may be placed in circuit

with the resistance-controlling solenoids and the motor, substantially as described.

7. A system including a plurality of independent motor-controlling equipments each having a series of resistance-controlling solenoids constructed to operate under different conditions of current-flow, a series motor in circuit with all of said solenoids, and means for varying at will the load on said motor to cause successive operation of the solenoids of each equipment, substantially as described.

8. A system including a plurality of independent motor-controlling equipments each having a series of resistance-controlling solenoids constructed to operate under different conditions of current-flow, and two reversing-switch solenoids, a series motor in circuit with the solenoids, and a controller for varying the load on the motor, said controller including a switch for supplying current to either of the two reversing-switch magnets, substantially as described.

9. A system including a number of solenoids connected in series and wound with different numbers of turns of wire, a series motor in circuit with the solenoids, with a controlling device having means for varying the load on the motor to cause predetermined currents to flow, and a switch in circuit with the motor and the solenoids, substantially as described.

10. A system including resistance-controlling solenoids operative by different currents, reversing-switch solenoids, a motor in circuit with the solenoids, means for varying the load on the motor, including a handle movable in either of two directions, with a switch controlled by said handle and connected to cause energization of one of the reversing-switch solenoids when moved either way from its off position, substantially as described.

11. A controlling system including a motor, a fluid-actuated device for supplying a load to the motor, and a controller for varying the load so applied, substantially as described.

12. A controlling system including a motor, a fluid-actuated device for applying a load to the motor including a member connected to oppose revolution of the motor-armature, a body of fluid for floating said member, and means for varying the flotation given the member, substantially as described.

13. A controlling system including a motor, a fluid-actuated device for applying a load to the motor including a container, a float therein having mechanism operatively connecting it to the movable member of the motor, a body of fluid in said container, and means for varying at will the quantity of said fluid available to support said float, substantially as described.

14. A controlling system including a motor, a lever having connecting mechanism whereby it may oppose operation of the motor, a weighted float operative on the lever, a container for the float, a reservoir connected to the container, having in it a body of fluid, and means for varying the level of the fluid in the reservoir to vary the support given the float in the container, substantially as described.

15. A controlling system including a motor, a lever having connecting mechanism whereby it may oppose operation of the motor, a weighted float operative on the lever, a container for the float, a reservoir connected to the container, having within it a body of fluid, a plunger for varying the level of the fluid in the reservoir, and a hand-operated device for controlling the position of said plunger, substantially as described.

16. The combination in a controlling system, of a motor and means for governing the load thereon, said means including a disk on the motor-shaft, a fixed member for engaging said disk, a bell-crank lever having one arm operative on the said member, a weight hung from the other arm of the lever, a container having a body of liquid for said weight, and a hand-operated device for varying the amount of flotation given the weight and the load applied to the motor, substantially as described.

17. A controlling system including a motor, a fluid-actuated device for applying a load to the motor including a member connected to oppose revolution of the motor-armature, a body of fluid for floating said member, and means for varying the flotation given the member, said means including a plunger, a cam for moving the same into the body of fluid and a handle for operating said cam, substantially as described.

18. A system including a series of electromagnetic devices constructed to actuate their respective mechanism under different conditions of current-flow, a motor in circuit with said solenoids, means for varying the load on the motor including a controlling-handle, and reversing mechanism having a switch operated by said controlling-handle, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ARTHUR C. EASTWOOD.

Witnesses:
NATHAN L. MILLER,
HENRY A. SHARPE.