No. 719,325. PATENTED JAN. 27, 1903.

E. GRAY.

ELECTROMECHANICAL GOVERNOR.

APPLICATION FILED NOV. 6, 1899.

NO MODEL. 2 SHEETS—SHEET 1.

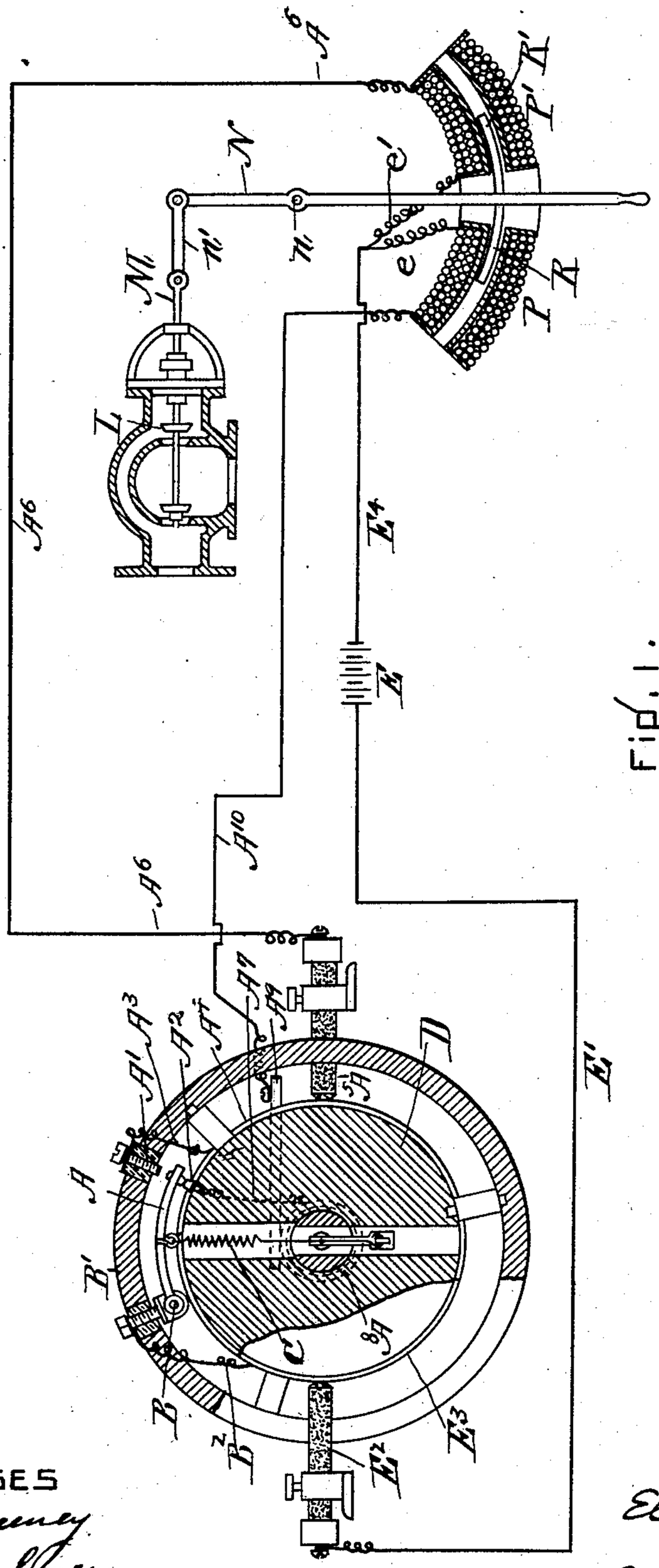

Fig. 1.

WITNESSES
C. M. Sweeney
J. M. Espenschied

INVENTOR
Elisha Gray
by his Attys
Clarke & Raymond

No. 719,325. PATENTED JAN. 27, 1903.

E. GRAY.

ELECTROMECHANICAL GOVERNOR.

APPLICATION FILED NOV. 6. 1899.

NO MODEL. 2 SHEETS—SHEET 2.

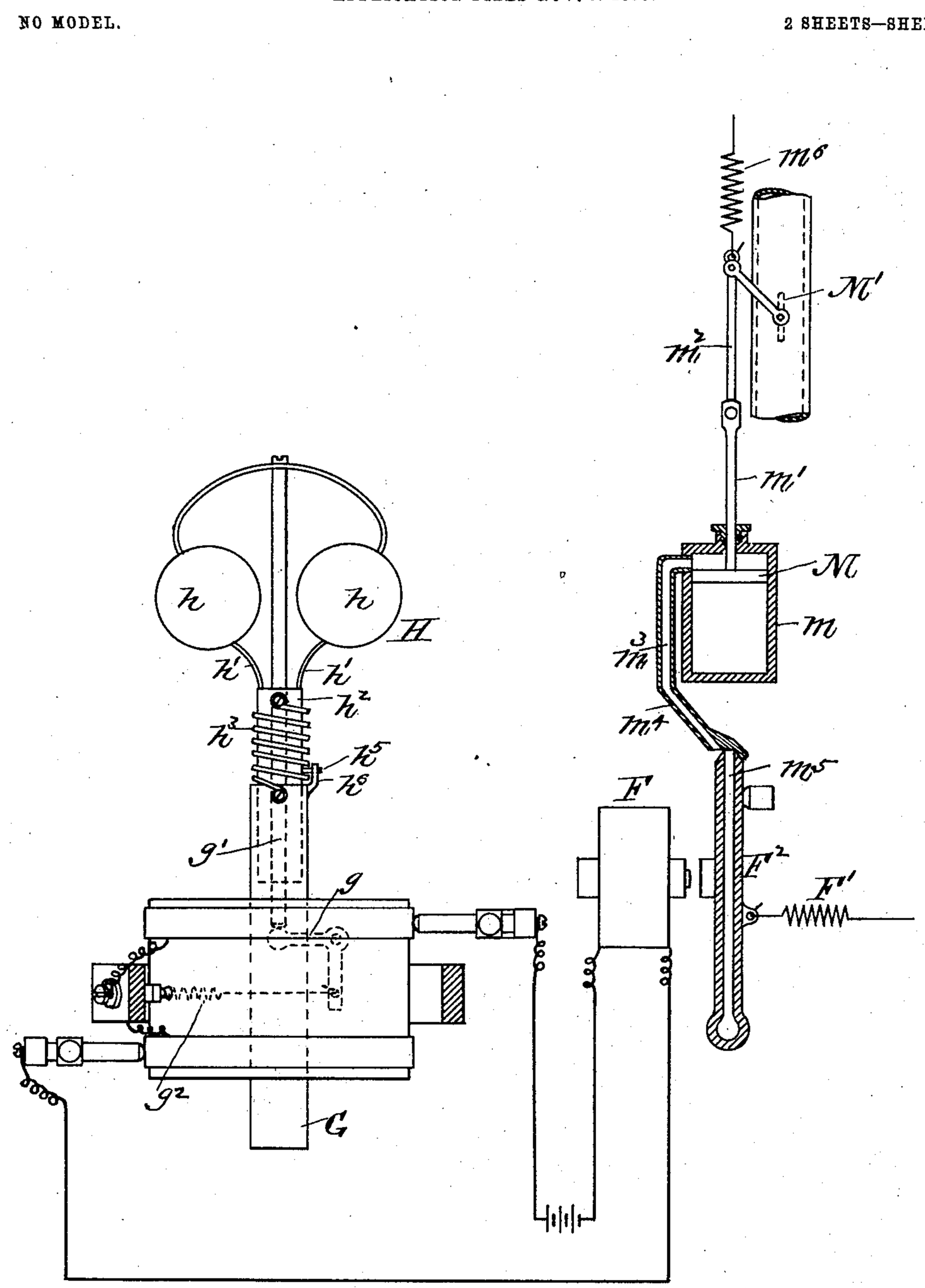

Fig. 2.

WITNESSES

C. M. Sweeney.

J. M. Copenhaver.

INVENTOR

Elisha Gray

by his attys

Clarke & Raymond

UNITED STATES PATENT OFFICE.

ELISHA GRAY, OF HIGHLAND PARK, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE GRAY TELEPHONE COMPANY, OF WATERVILLE, MAINE, AND BOSTON, MASSACHUSETTS, A CORPORATION OF MAINE.

ELECTROMECHANICAL GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 719,325, dated January 27, 1903.

Application filed November 6, 1899. Serial No. 736,036. (No model.)

To all whom it may concern:

Be it known that I, ELISHA GRAY, a citizen of the United States, and a resident of Highland Park, in the county of Lake and State of Illinois, have invented certain new and useful Improvements in Electromechanical Governors and in Devices for Carrying the Same into Effect, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification, in explaining its nature.

My invention consists in the application of the governor device described and claimed in my application for Letters Patent of the United States for transmission of sound, filed June 23, 1899, Serial No. 721,672, to the automatic controlling of steam and similar power.

In the drawings, Figure 1 is a diagrammatic view illustrating my invention. Fig. 2 is a view of a similar character, showing a modification, to which reference will be hereinafter made.

The governor in the main is like in construction that described in the said application. It varies from it in that both contact-points against which actuating-lever comes into contact at the end of its throw in each direction may be in circuit instead of one of them, although this is not absolutely essential.

In Fig. 1 I have represented the governor as adapted to regulate automatically the flow of steam or other power through a pipe by means of a valve in the pipe, which is operated by the governor to maintain a practically uniform or constant flow of steam or other medium through the pipe at the pressure required for actuating uniformly an engine or motor.

In the drawings, L is a steam-valve of ordinary construction, arranged so that it is balanced when under steam or other pressure. It may be the main operative valve or it may be an auxiliary or supplemental valve. It is represented as provided with movements which open and close or partially open and close the passage in the valve by the solenoids P P′, which are adapted to be electrically energized, as hereinafter indicated, and are alternately operated upon the valve stem or rod M through the lever N, which is pivoted at *n* and is preferably connected with the rod by a link *n*′. The solenoids are arranged one on each side of the lever at or near its outer end, sufficient space being provided between them for the movement of the lever. The lever has mounted upon it two soft-iron cores R and R′, one for each solenoid. I prefer that the solenoids be curved to the arc described by the movement of the iron cores and that the cores be correspondingly curved and that they extend within the curved holes in the solenoids without making contact with either. The energizing of one solenoid will cause the valve L to be moved in one direction and the energizing of the other solenoid in the opposite direction. The governor controls the energizing of the solenoids and in the following manner:

A is the governing-lever. It preferably is exceedingly light and not over an inch in length. It is pivoted at B by an insulated connection to the ring B′. This ring is mounted on a rotating disk or drum D, from which it is insulated and between which and the ring is a space within which the lever A may have a slight movement. The outer end of the lever plays or moves between the outer contact-point A′ and the inner contact-point A^2, and when in contact with either it forms a part of an electric line or circuit, the current reaching it from the line B^2. The lever is moved in an outward direction to make contact with the point A′ by centrifugal force and in the inward direction to make contact with the point A^2 by the light spring C. The tension of this spring may be varied at any time, either by hand or automatically, as hereinafter described. The former way is shown and described in my said application. The latter is represented in Fig. 2 of the drawings. It should be understood that the lever A of the governor is arranged upon the plane of rotation of the drum or disk, so that its pivotal end and the end making contacts are upon the same or substantially the same plane of rotation; that the moving end of the

lever makes a very slight movement for establishing either contact; that it is rotated generally at a high rate of speed; that it is set to operate after a certain speed has been reached, and that upon the reaching of said rate of rotation it immediately becomes as sensitive to an increase as any highly-organized or sensitive instrument like, for instance, a barometer or thermometer can be, responding instantly to any variation in centrifugal force at a high rate of rotation. This is due to a number of things—the lightness of the lever and its centripetal spring, its arrangement in the plane of rotation, and the short movement of its outer end required for making or breaking the contact. This sensitiveness of the lever insures an almost, if not quite, absolutely perfect automatic control of the valve, the part which it is designed that it shall operate or cause the operation of, for when the rate of rotation has arisen which causes it to become mobile it then may be said to be traveling in the air between the points, or to be making a rapid contact with one or the other of them, of such exceeding quickness and fineness as is best adapted for the use and control of the electric current in producing instantaneous results. The contacts thus established through the contact-point A′ permit the current to pass from the lever through the contact-point, line A^3, ring A^4, brush A^5, line A^6 to the solenoid P′. The contacts establish with the contact-point A^2 a line A^7, extending to the insulated ring A^8 in the drum D, brush A^9, line A^{10} to the solenoid P.

E is the battery or other source of electric energy. It is connected by line E, branching at *e e′*, with the solenoid P P′. It is connected by line E′ with the lever A through brush E^2 and ring E^3, which ring is connected with the lever by the line B^2.

From the above description it will be seen that the governor when operative supplies and controls the supply of electric current energizing the solenoids in an extremely delicate, sensitive, and rapid way, at one instant energizing one solenoid and causing it to move the valve-lever toward it, at the next instant energizing the other, deënergizing the first and causing the second to move the valve-lever in a reverse direction. The ordinary action of the governor and solenoid upon the valve-lever will be such as to keep the valve-lever and the valve at the time when automatic regulation or control of the motor is desired upon what might be called "a more or less continuous rapid vibratory action." It will readily be seen that whenever the load of the engine changes the valve will be moved to a position which will admit more or less steam to the engine, as may be desired and according as the load is increased or decreased.

In Fig. 2 I have represented the governor as automatically regulated to effect the variation in the action of the valve which it governs. I shall describe it as applied to locomotive-engines for the purpose of preventing the driving-wheels from slipping on the track when a train is started up or a heavily-laden freight-train is running up a grade; but I do not wish to be understood as confining this modification of the invention to such use. The governor is of the construction already described, and it operates to control the electric current energizing the controlling-magnet in the same way, and its construction and line connections need not be further described, it being sufficient to say that the magnet is lettered F and is adapted to be energized to actuate the valve of the locomotive, as above described. It may operate in opposition to a spring F′, as represented in Fig. 2, upon an armature F^2, connected with the valve, or in lieu of the spring another magnet may be employed, in which case practically the magnet construction of Fig. 1 would be used. The governor is mounted upon a shaft G, which may be turned by any rotating or moving part of the locomotive and may have continuous connection therewith or may be connected therewith when it is desired that the governor be used. When the latter construction is desired, the connection between the shaft and one of the driving-wheels or other part of the locomotive may be established by a lever and intermediate connections. The shaft G carries, in addition to the governor which I will call the "primary" governor, a secondary governor H, and this is of any usual type of centrifugal governors. The one represented has the balls *h*, which are mounted upon the spring-arms *h′*. It is carried by the section h^2 of the governor-shaft, which, however, is not fastened to the shaft, but is free to have limited rotation thereon, the extent of the rotation being controlled and limited by a spring h^3, fastened at one end to the shaft-section h^2 and at the other end to the shaft G. Stops h^5 h^6 prevent the primary governor from running slower than the secondary governor. If, however, the revolutions of the shaft G are suddenly increased, the primary governor will instantly respond to the increase, while the secondary governor, because of its construction and weight and because of the manner in which it is connected with the shaft G, will be slower to respond. Attached to and operated by the secondary governor is the spindle or pin *g′*, supported by the section h^2 of the shaft and having its inner end in contact with the spring-adjusting lever *g* of the governor. This spindle or pin *g′* instead of being hand-operated to adjust the governor, as above referred to, is automatically moved inward or outward by the secondary governor, being moved inward as the governor-balls are more rapidly rotated and outward upon the reverse movement of the balls. When the governor is rotated, the balls are thrown outward by centrifugal force. The distance to which they are thrown depends upon speed of rotation. The effect of the outward movement of the balls is to straighten out the flat

spring h', upon which they are mounted and to cause an inward movement of the pin. It should be remarked in this connection that the pin rotates with the whole system, whereas the hand-adjusted pin does not. It will be seen that the inward movement of the pin will increase the tension of the main governor-spring g^2 and that the tension will be gradually increased as the speed of the governor increases. In this combination the movement of the pin against the lever g is so related to the governor-spring that at all speeds of revolution the governor-spring will be a little stronger than the centrifugal force of the governor-lever, which also increases as the speed increases. The governor when applied to a locomotive may be driven by a friction-wheel, that may be set down upon the top of one of the driving-wheels by means of a lever when it is desired to throw the governor into use, which will usually be at the time of starting of a train. It will be seen that the speed of the governor will thus depend directly upon the speed of the driving-wheel. It often happens when starting up a heavily-laden train that the driving-wheels will slip upon the track and run at a high rate of speed until the steam is shut off. This governor is so designed that the governor-lever will only be thrown against the outer contact-point when there is a sudden acceleration of speed in the driving-wheels, and this only occurs when the wheels slip upon the track.

The operation is as follows: When a locomotive-engine is started up and no slip occurs between the driving-wheels and the track, it will gradually move faster and faster until the maximum speed has been reached. Under these conditions the governor-lever will not be thrown against the outer contact-point as its centrifugal power increases, because the balls of the secondary governor will cause the pin g' of the primary governor to be moved inward against lever g, and thus gradually increase the tension of the governor-spring and its stress upon the governor-lever. If, however, the wheels at any point should slip upon the track, causing a sudden acceleration of speed, the primary governor will then run ahead of the secondary governor and unwind the spring h^3. This sudden acceleration of speed of the primary governor will cause its centrifugal lever to be thrown out for a short time, because the secondary governor controlled by the balls will not then immediately act to increase the tension of the governor-spring. The length of time that the circuit will be closed will depend upon the size of the balls of the secondary governor and the power of the spring h^3. If the balls are light and the spring is strong, it will soon catch up with the primary governor. It will be seen, then, by what has been said that whenever a slip occurs between the driving-wheels and the track the steam will be suddenly shut off by means of the operation of the magnet F or its equivalent; but immediately the driving-wheels slack or as soon as the secondary governor overtakes the primary governor the circuit will be opened and the steam turned on. These parts may be so related as to allow the steam to be turned off from a very small fraction of a second to a whole second or even longer, as circumstances may demand. The valve operated by the governors may be the throttle or valve which is operated by the engineer or it may be a supplemental and independent valve. I prefer the latter construction. All the engineer has to do in starting up is to push down a lever which will bring the governors into action, and when the train is up to normal speed if he so chooses he can detach the governors from the driving-wheel by lifting the lever. This attachment to a locomotive will not only save work for the engineer, but will save the wear and tear of the engine and track due to friction when the engine races, and what is more important it will save the expenditure of energy in loss of steam whenever a slip between driving-wheel and track occurs. The slip will be practically prevented, because the steam is shut off before the driving-wheel has moved many inches at the accelerated speed due to slip. I would say that the balls may be of such weight and so hung as to reach the limit of their action at any desired speed at which it is desired to run the two and that beyond this speed the primary governor would automatically act to prevent an acceleration of speed, as it would then be uncontrolled by the secondary governor. The means by which the magnet F and spring or their equivalent are connected with the valve to operate it are immaterial. I have represented in Fig. 2 a construction which involves the use of a piston M, contained in the cylinder m, connected with the valve M' by a piston-rod m' and link m^2. The cylinder is adapted to receive compressed air, steam, or other power supplied it by a passage m^3 in the pipe m^4, and which is adapted to be connected with a passage m^5 in the armature-lever F^2. All compressed air or other power passes through the passage in the armature-lever when said passage by the movement of the armature-lever is brought into line with the passage m^3. This admits power to the cylinder and causes the piston to be moved and operate the valve. A spring m^6 serves to move the valve in a reverse direction when the power has been cut off. The end of the armature-lever closes into a rubber cap or pocket when out of line with the passage m^3, and thus prevents the flow of air or other power at such time.

I do not broadly claim herein the governor described in my said application.

Having thus fully described my invention, I claim and desire to secure by Letters Patent of the United States—

1. The combination of a valve, magnets for moving the valve in both directions, a cen-

trifugal lever of the character specified, contact-points limiting the movement of the lever electrically connected with the magnets, a battery, or other source of electric energy, connected with the magnets and with the centrifugal lever, as and for the purposes set forth.

2. The combination of a motor, a primary governor connected therewith to control the operation thereof, and a secondary governor to check the operation of the first governor.

3. The combination of a motor, a primary governor for preventing undue acceleration of the motor, and a secondary governor connected with the primary governor to control the same except upon undue acceleration of the motor.

4. The combination of a motor, a means for checking undue, or undesired, acceleration thereof, comprising a primary governor adapted to be inactive during the desired operation of the motor and a secondary governor operated upon the acceleration or undesired action of the motor to cause the primary governor to then act, as and for the purposes set forth.

5. The combination of a motor, means for governing the same, comprising a primary governor and a secondary governor, operative for a restricted period to prevent the action of the primary governor except upon an aberration of the motor and after said restricted period no longer operative upon the primary governor and whereby the primary governor may then act to check the unaberrated speed of the motor.

6. The combination of a centrifugal governor adapted to make and break one or more governing electric circuits and an automatic secondary governor for controlling the action of the first-named governor.

7. The combination of a shaft, a centrifugal lever mounted thereon, one or more electric circuits with which said lever is adapted to be brought into contact, a secondary governor mounted upon said shaft to have a restricted independent rotation and slower in operation than said first-named governor and means connecting said secondary governor with the primary governor whereby the said secondary governor controls and permits the action of the said first-named governor.

ELISHA GRAY.

Witnesses:
F. F. RAYMOND, 2d,
J. M. DOLAN.