No. 716,953. Patented Dec. 30, 1902.

F. J. SPRAGUE.

ELECTRIC ELEVATOR.

(Application filed Oct. 29, 1894.)

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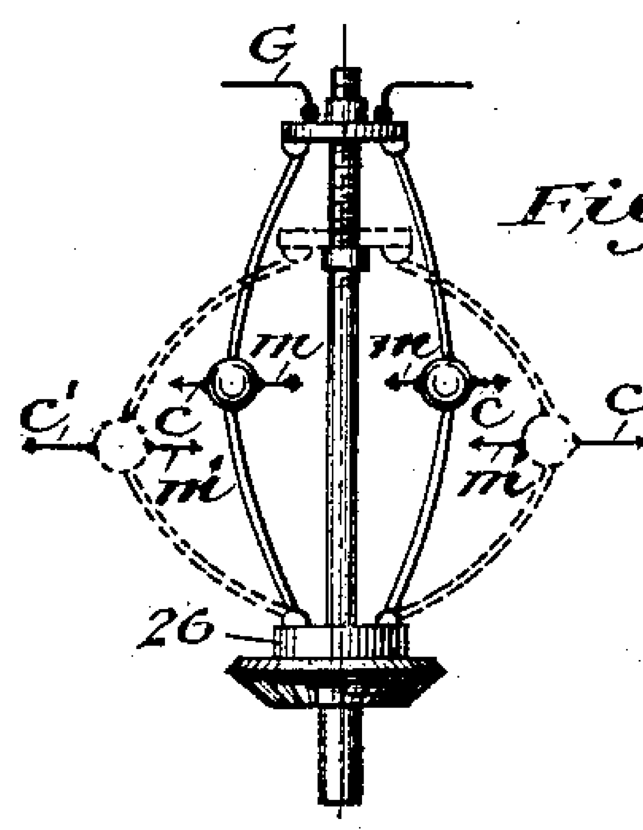
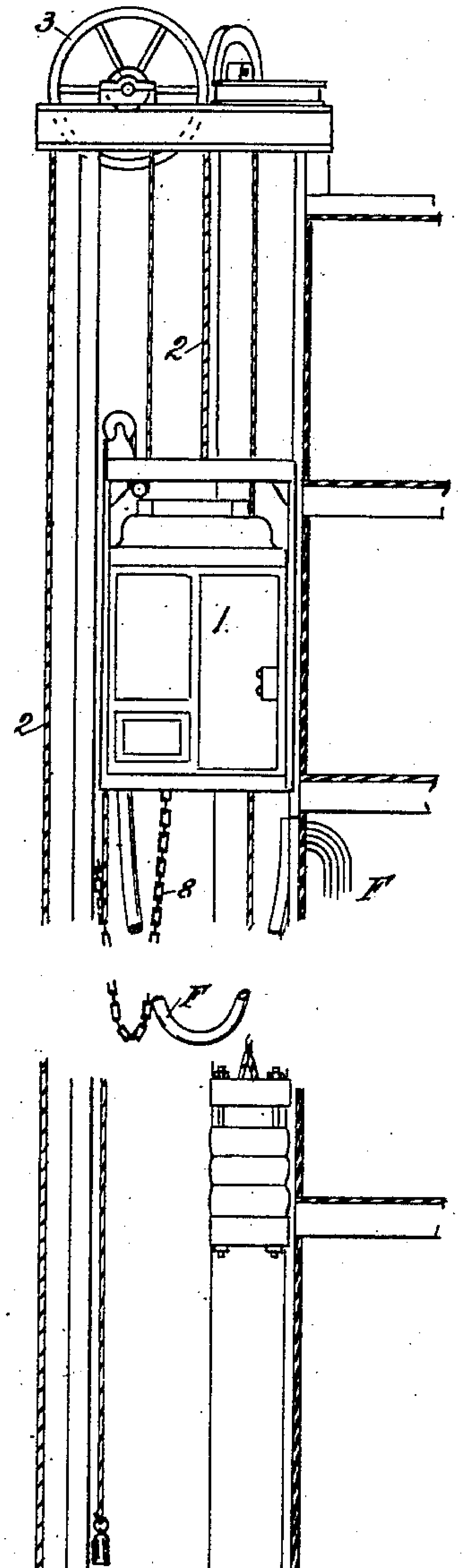


Fig. 2a



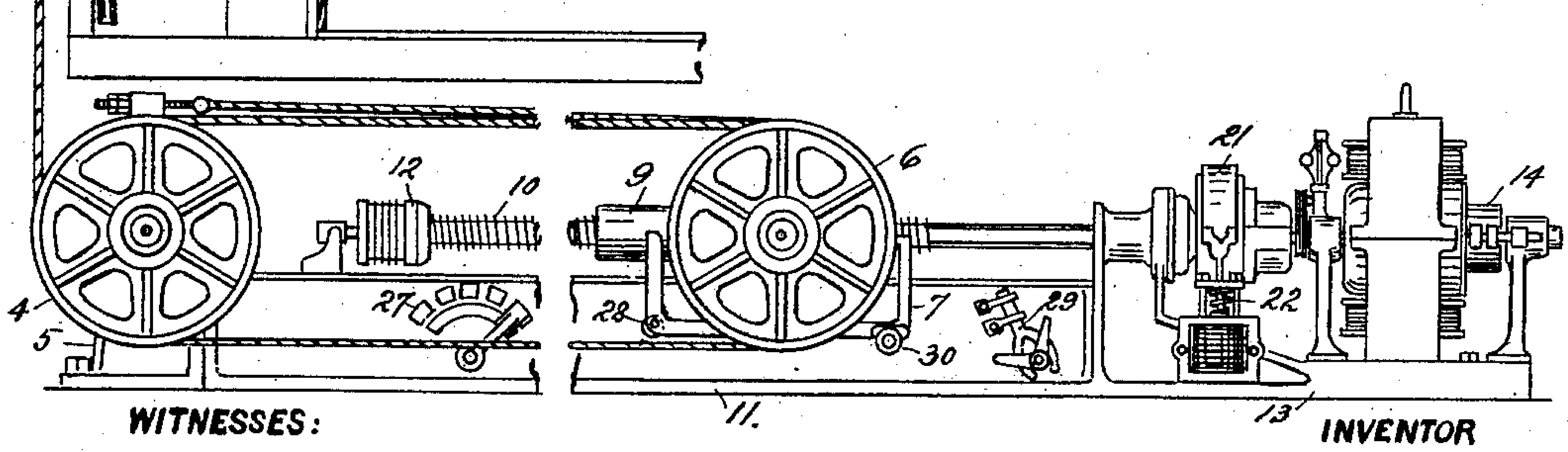


Fig. 1.

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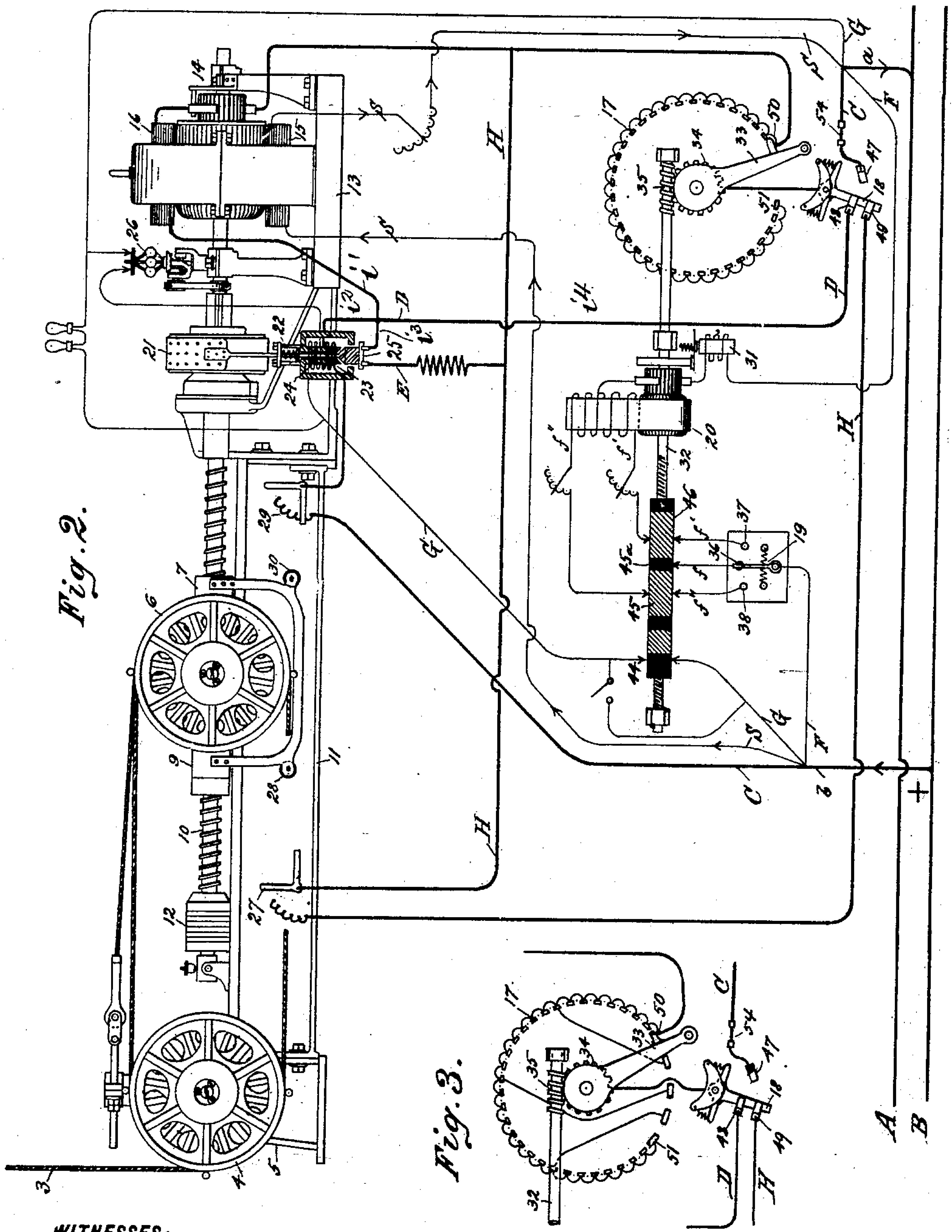

Fig. 2.

Fig. 3.

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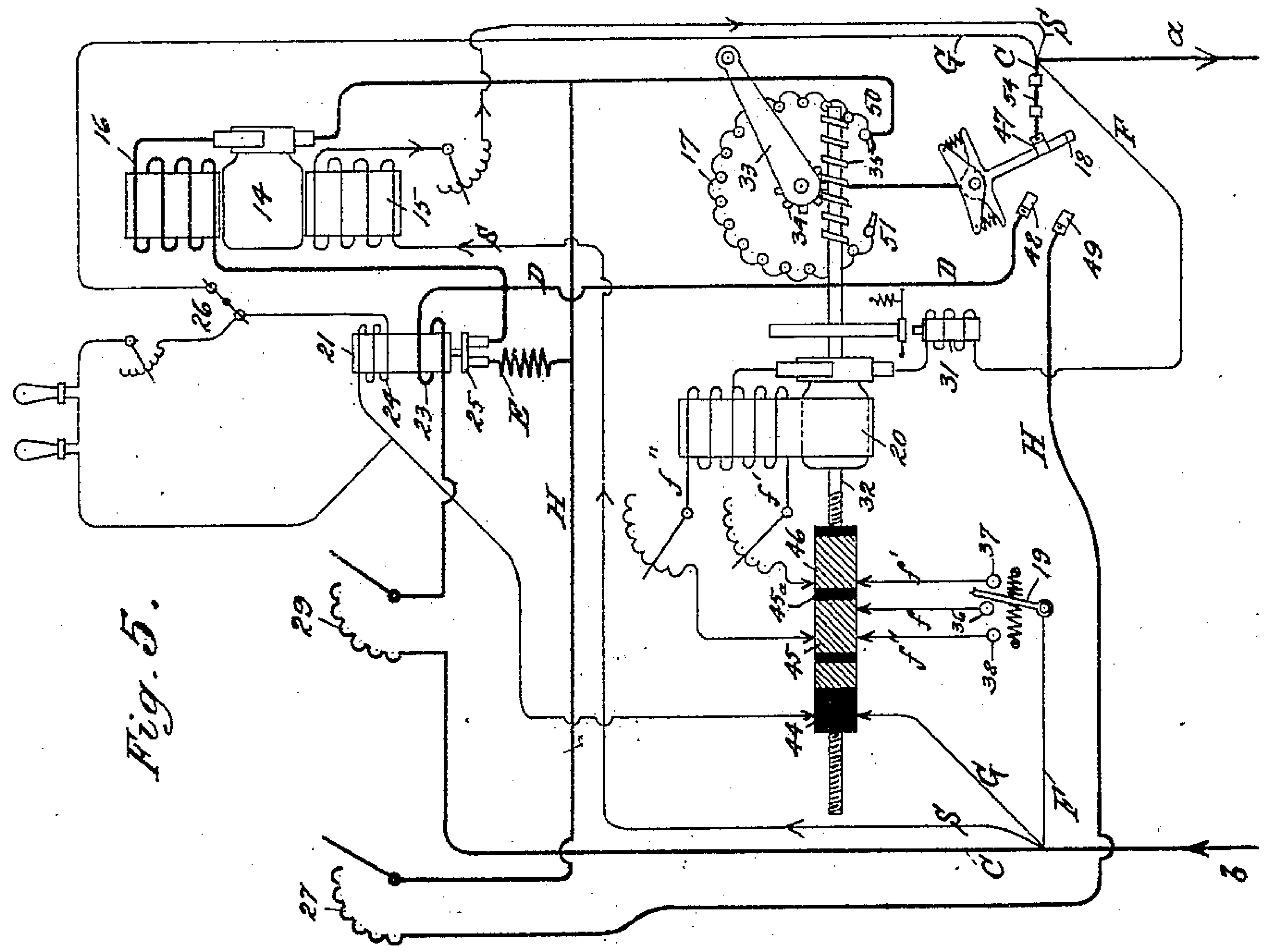

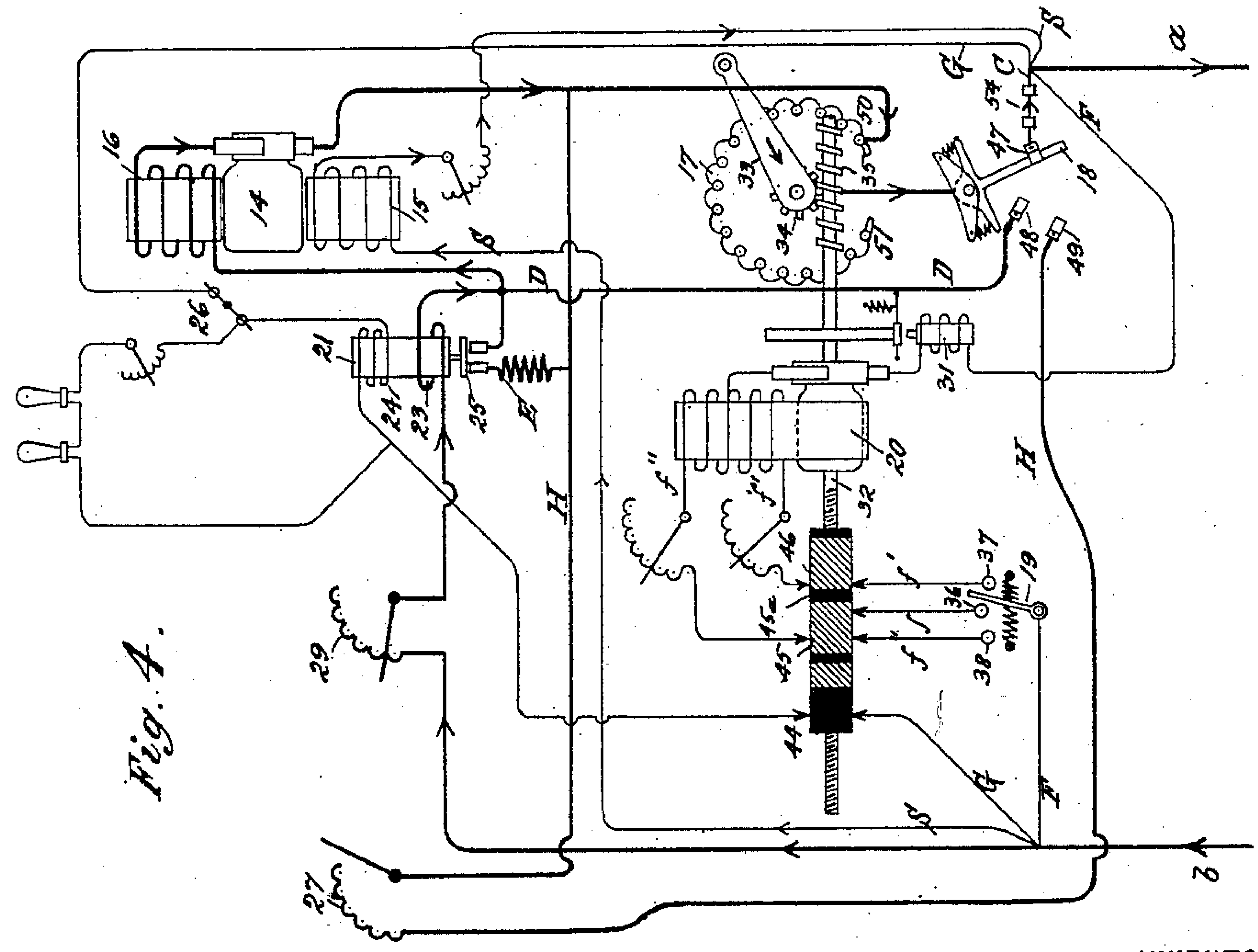

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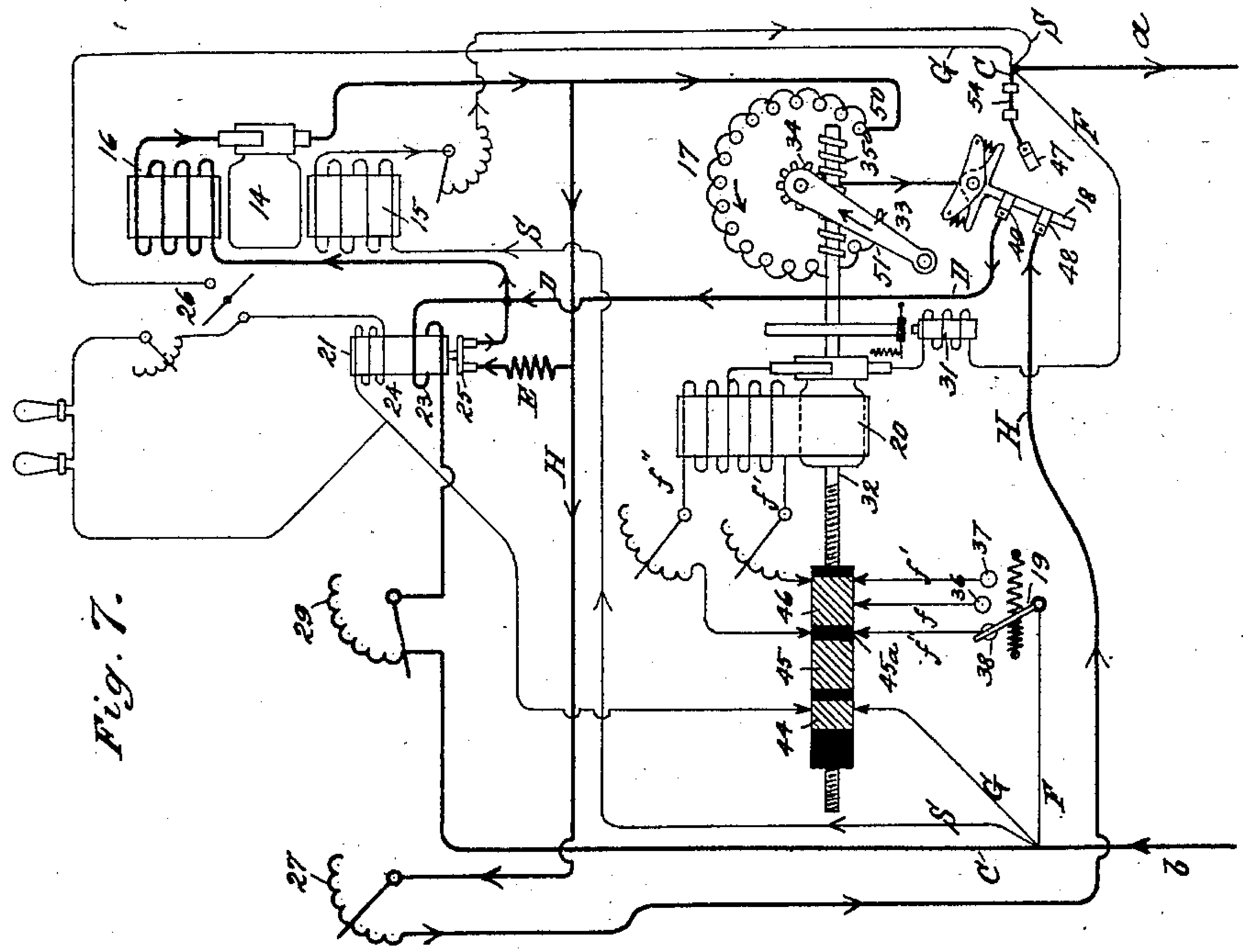

Fig. 7.

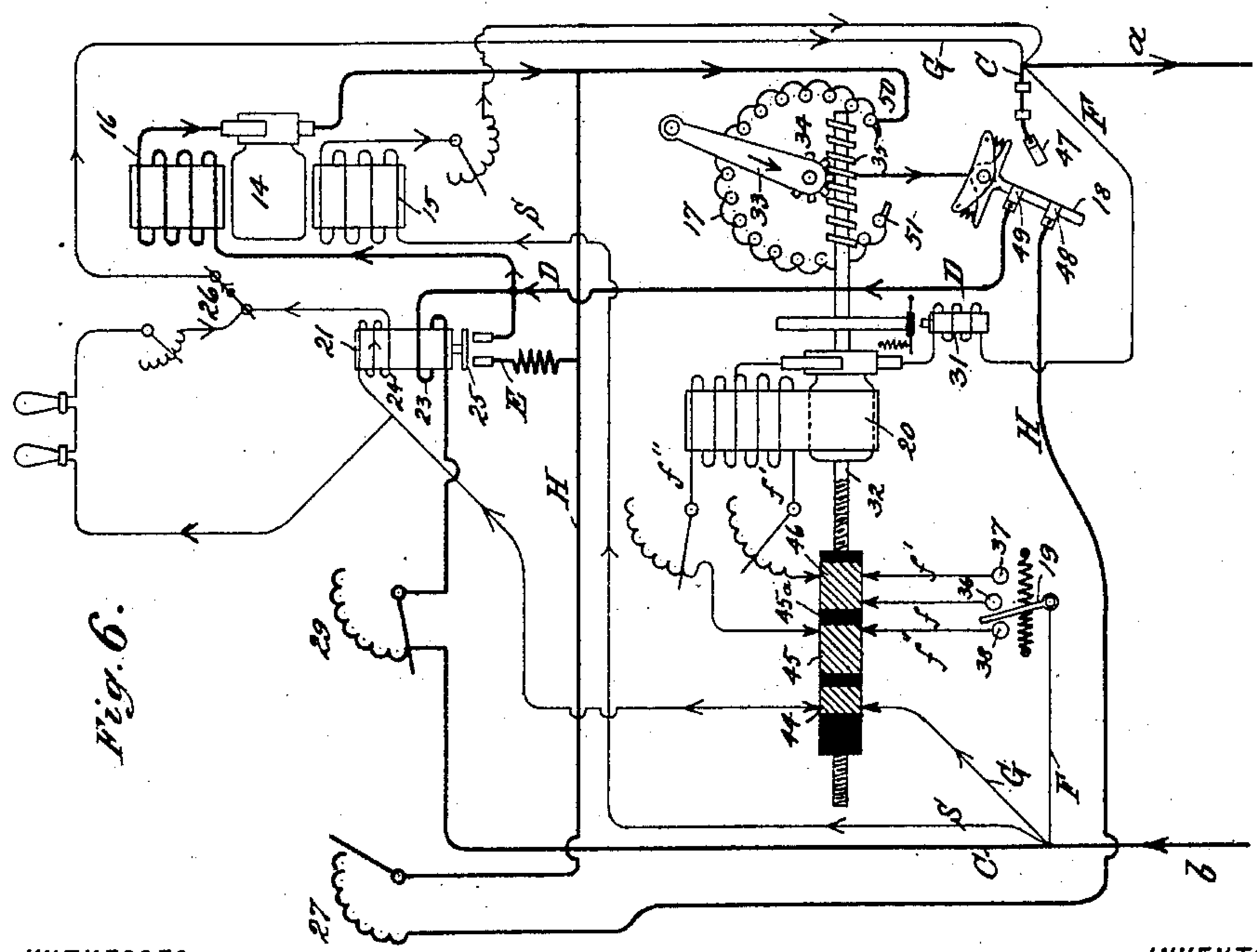

Fig. 6.

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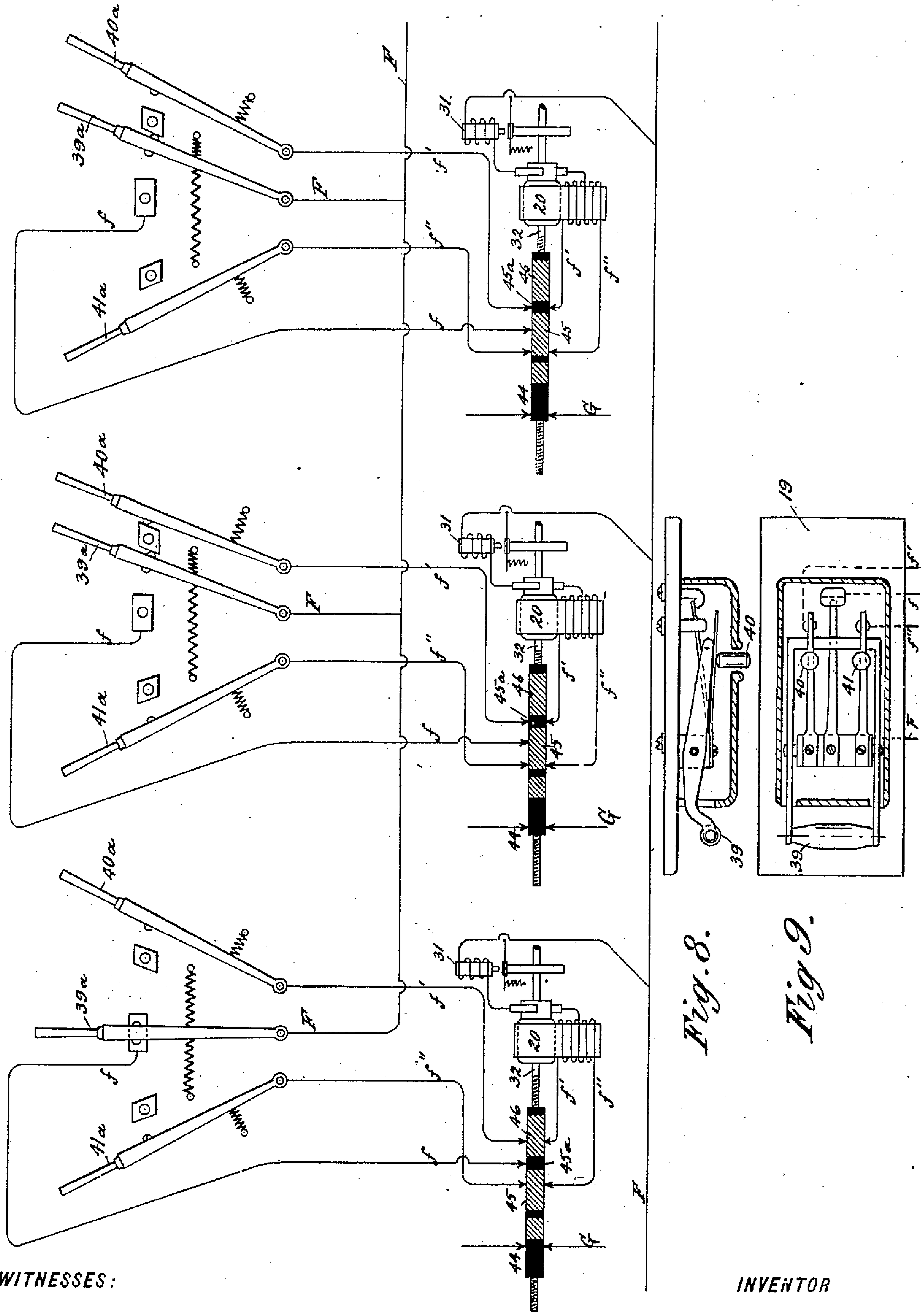

Fig. 10.

Fig. 8.

Fig. 9.

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Fig. 11.

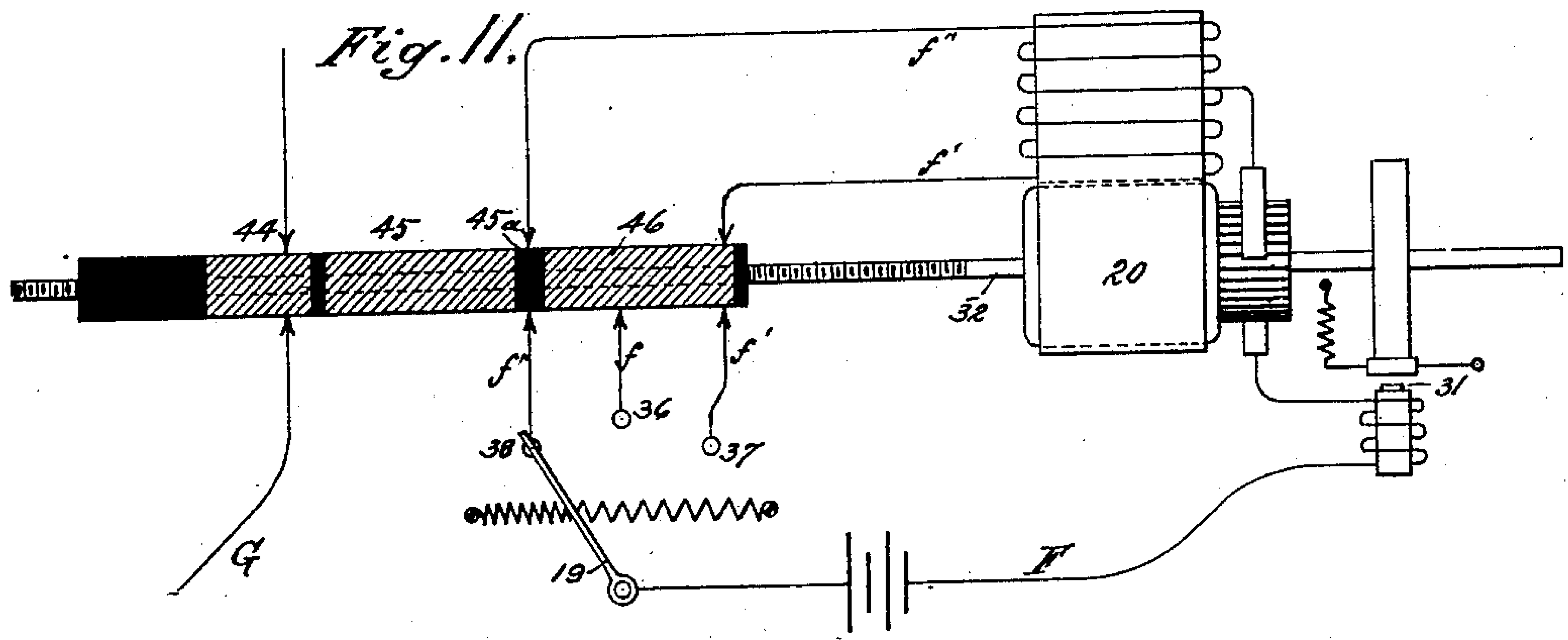


Fig. 12.

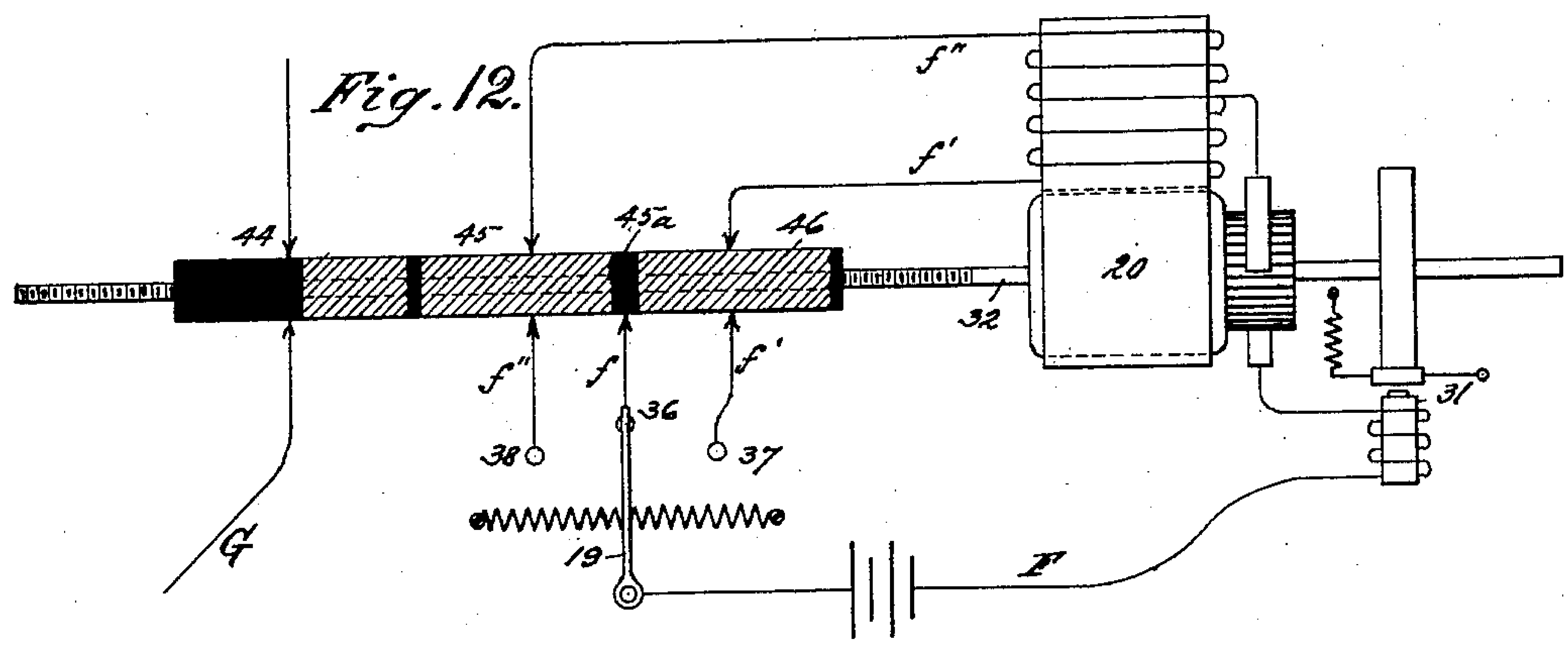
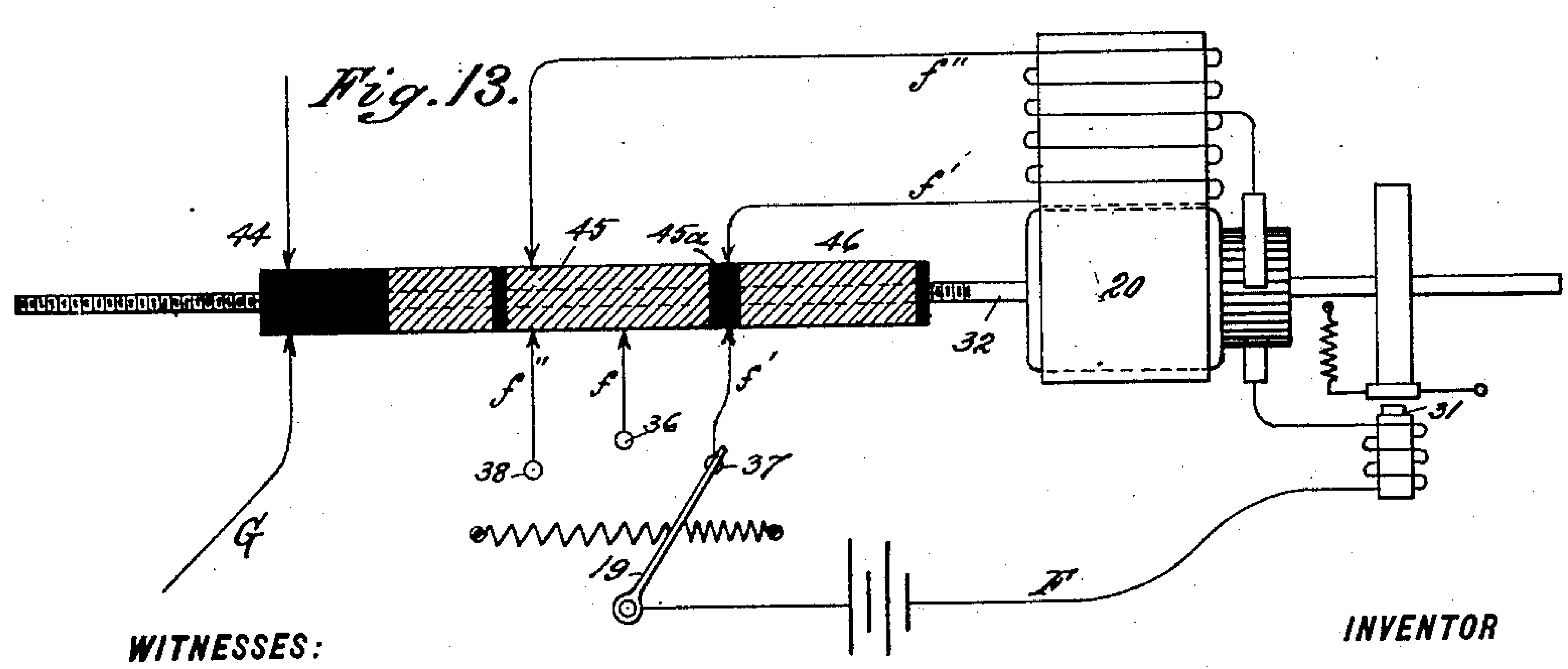


Fig. 13.



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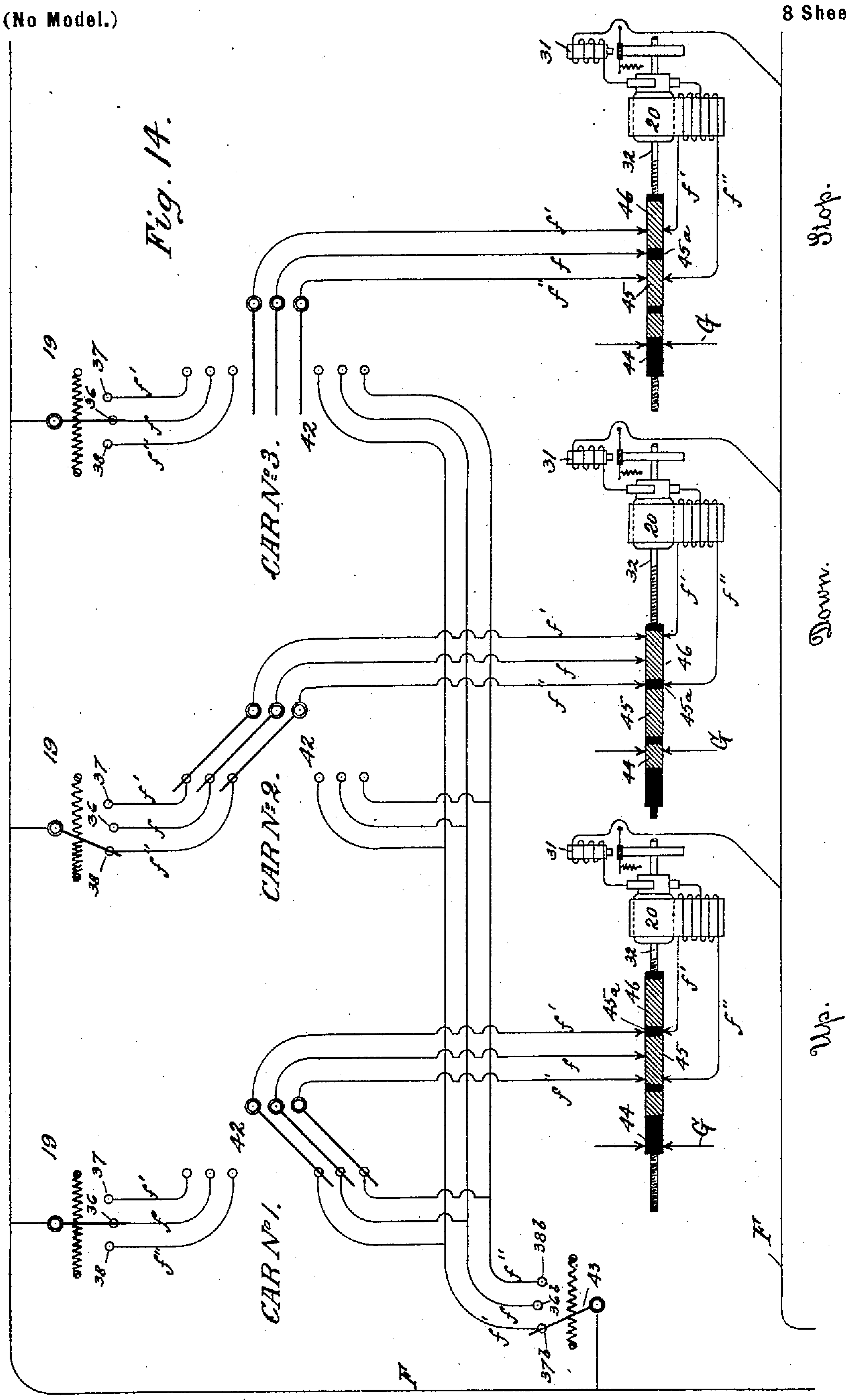

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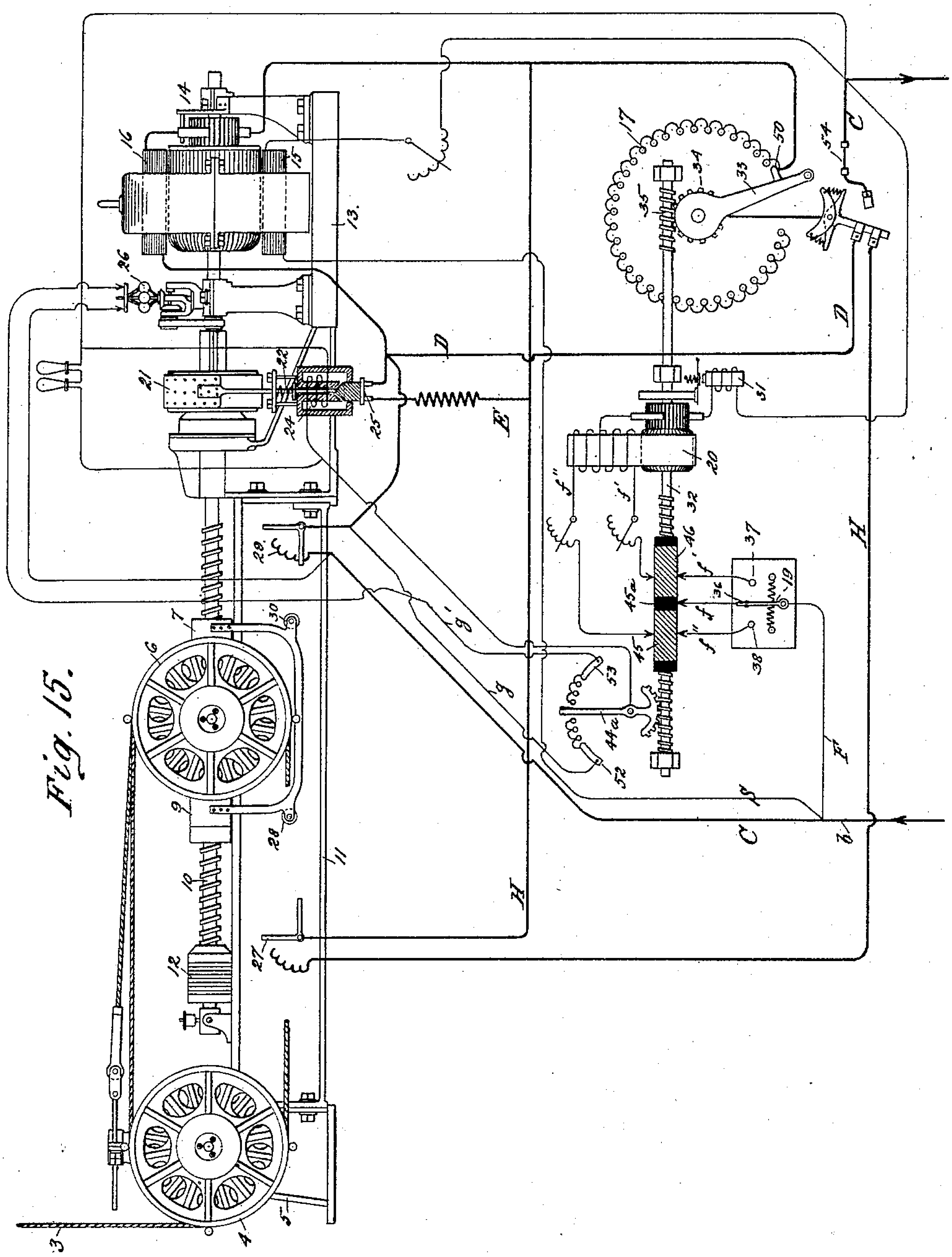

Fig. 15.

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UNITED STATES PATENT OFFICE.

FRANK J. SPRAGUE, OF NEW YORK, N. Y., ASSIGNOR TO THE SPRAGUE ELECTRIC COMPANY, A CORPORATION OF NEW JERSEY.

ELECTRIC ELEVATOR.

SPECIFICATION forming part of Letters Patent No. 716,953, dated December 30, 1902.

Application filed October 29, 1894. Serial No. 527,174. (No model.)

To all whom it may concern:

Be it known that I, FRANK J. SPRAGUE, a citizen of the United States of America, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Electric Elevators, of which the following is a specification.

The invention is an improvement upon the systems shown in United States Patents No. 472,909, dated April 12, 1892, and No. 509,397, dated November 28, 1893. Many of its broad features are described in the *Electrical Engineer*, New York, April 18, 1894, Vol. XVII, No. 311, beginning on page 350 and ending on page 356.

The improvements consist mainly in substituting an improved pilot-motor and circuit for controlling the connections and operation of the main motor, whereby the number of wires carried to the car are reduced to four; the substitution of an improved form of main or working motor; the simplification of the main regulator; the substitution of an electromechanical, for a purely mechanical brake-relieving device; the addition of an entirely new choking-shunt for the working motor, and an entirely new circuit for controlling the brake; and the further modification of the systems shown in the patents named above, and in certain other features of construction and arrangement, as hereinafter fully described and claimed.

In the accompanying eight sheets of drawings, which form a part of this specification, Figure 1 shows the main mechanical parts of the elevator, including the car-hoistway and hoisting mechanism, in about the relations in which they are constructed. Fig. 2 shows the hoisting mechanism, together with a diagrammatic representation of the controlling and regulating mechanism and electrical circuits. Fig. 2^A is a detail of the monitor centrifugal governor for opening the brake-magnet circuit. Fig. 3 is a detail showing a modification of the rheostat. Fig. 4 is a diagram of the circuits as they are when the car is ascending at moderate speed. Fig. 5 shows the circuits of the preceding diagram as modified by the opening of the upper automatic to automatically stop the car at the top of the hoistway. Fig. 6 is a diagram of the circuits as they are when the car is descending at moderate speed, and Fig. 7 shows the circuits of the preceding diagram as modified by the closing of the lower automatic to automatically check the car at the bottom of the hoistway and also the centrifugal opened by high speed and the choking-shunt closed. Figs. 8 and 9 are respectively top and front views of the car-switch as it is preferably constructed. Fig. 10 shows a modified form of car-switch repeated in three positions, together with the pilot-motor and pilot-motor-switch block controlled by it. Fig. 11 shows the same elements enlarged, but with a simpler form of car-switch, the parts being in the position to which they are brought when the down contact is held closed. Fig. 12 shows the same elements in the position to which they are brought by closing the stop-contact, and Fig. 13 shows the position assumed on closing the up contact. Fig. 14 shows the connections of the car-switches of three elevators connected to their pilot-motors through a common-control switchboard. Fig. 15 is a view similar to Fig. 2, but showing a modification of the brake-magnet and its circuit.

General Construction.

The elevator is of a type in which the load is lifted by an electric motor and descends by gravity under control of the same motor, which is reversed in direction and driven by the car as a retarding-dynamo. The car is therefore necessarily heavier than the counterweight, even with the minimum load. It can therefore properly be called an "underbalanced" car. The machine is of the horizontal multiple-sheave type. The sheave and overhead work is of a style common in hydraulic and other plants. The rope multiplication and cross-head movement are similar to the horizontal type of hydraulic elevators. From the car 1 the hoisting-ropes 2 lead over an overhead sheave 3 to the inner of the sheaves 4 on the fixed cross-head 5 of the hoisting-machine and, dividing on either side of the cross-head and screw, lead to the traveling sheaves 6 on the traveling cross-head, pass back and forth between the two sets of sheaves and are anchored to the fixed end of the machine. In practice variable chain counterweights 8, with one end anchored in the hoistway, are used on the car or counterweight to make the pull equal at all points of the hoistway for any given load. The hoisting mechanism has a cross-head and frictionless nut 9, running upon a screw 10, instead of being attached to a piston operating in a water-cylinder, as in the hydraulic elevator. A heavy main girder 11 supports and guides the traveling cross-head and carries the outboard screw-bearing 12. The fixed cross-head is a casting bolted to one end of this girder, and at the other end is the motor bed-frame 13, on which is the brake, the main or working motor, and the thrust-bearing of the screw. The nut and screw are of the general type of that of the United States Patent No. 438,320 and the nut is of the particular form described in United States Patent No. 476,304. The nut is mounted in the cross-head in the manner described in United States Patent No. 448,788. The screw is directly connected to the armature 14 of the working motor. This motor is preferably a multipolar slow-speed motor, with strongly compounded winding, part of the field-coils, hereinafter called the "shunt" field-coils 15, being connected in a shunt-circuit S to the main leads in parallel with the armature, and part of the field-coils, hereinafter called the "series" field-coils 16, being connected in series with the armature. These coils are superimposed on each pole. The working motor is regulated by a rheostat 17 and the main circuit-changing switch, consisting of a movable member 18 and contacts, controlled by a suitable controlling device on the car. As shown, this car device is a switch 19, which controls a pilot-motor 20 and through it controls the rheostat and switch of the working motor.

Like the hydraulic, this elevator always works against gravity. The shunt field-coils are normally connected to the main leads A B through a shunt-circuit S. While hoisting the car, the motor-armature and series field-coils are connected through a feed or hoist circuit C to the main leads and take current therefrom. In lowering the armature the series field-coils are cut off from the main lines and closed on the down regulating-circuit D. The working motor is driven as a dynamo in a reversed direction by the weight of the descending car and acts as a brake on the car in descent. The direction of the current in the field and armature of the working motor is substantially never reversed and the machine never demagnetized, for in hoisting the main line electromotive force predominates and in lowering the direction of the current in the shunt field-coils is unchanged and the reversed electromotive force of the motor-armature is the only active electromotive force in the circuit of the armature and series field-coils; but, as stated, the motor is then being driven in a direction the reverse of that of hoisting and the current developed traverses the armature and series field-coils in the same direction as the hoisting-current traverses them. This current would traverse the series field-coils and excite the field, even if the shunt field-coils were broken. The force which resists gravity while the car is descending is the sum of the friction and inertia of the hoisting mechanism and the torque of the armature due to the current generated therein by its own revolution. The torque exists whether the car be going slow or fast and is practically the same with any given load and a steady speed, whatever be the speed. In this respect this present system is unlike those electric elevators having an approximate balance between the car and counterweight, in which the working motor is connected to the main leads during both ascent and descent and takes current from or gives current to the lines according to the preponderance of weight and the speed of operation. The car 1 is held at rest at any point by an electromechanical brake 21, which holds the screw 10. The brake-band is of steel and is preferably wood-lined. It is anchored at one end on the side of the motor bed-frame away from which the screw turns in lowering, and at the other end is continually drawn down by a powerful spring 22 under compression. The mechanical movement in opposition is effected through the medium of a magnet, which in one form herein shown has a single coil, Fig. 15, and in a second form, Fig. 2, has a double winding. In this latter form of magnet one coil, called the "series" brake-coil 23, consists of a few turns of coarse wire and is in line in series with the working-motor armature and series field-coils and holds off the brake while the car is being hoisted. The other coil, called the "shunt" brake-coil 24, consisting of many turns of fine wire, is directly supplied from the lines through a circuit G, containing a suitably-operated switch, and holds off the brake while the car is being lowered. The brake helps to stop the screw and locks it when at rest. The magnet which controls the brake also controls a coöperating automatic choking-shunt closer 25 in a derived circuit with the armature of the working motor, herein called the "choking-shunt" E. The brake and automatic choking-shunt are not used to vary the car speed, but merely to help stop and hold the screw. The car speed, both in ascent and descent, is controlled by controlling the amount of resistance in circuit with the working motor, and this is true also as to graduating the stop and start of the car. To operate this system, I provide one general regulating device, called herein the "main regulator," which is controlled, as shown, by a pilot-motor through a circuit called herein the "car-circuit" F, in which is a small switch handled by the conductor on the car. This car-switch is provided with hoist, lowering, and stop contacts, and the main regulator is provided with coöperating circuit-controllers included in the car-circuit. The main regulator also has a contact in the hoist or feed circuit, which coöperates with the main rheostat to supply the working motor and main brake from the lines during ascent and also contacts in the down-regulating circuit, which regulates the working motor during the descent of the car, and in a circuit which is called the "brake-magnet" circuit G. This circuit may control the brake during both ascent and descent, as in Fig. 15, or it may control the brake only during descent, as in Fig. 2. In the latter the circuit includes the shunt brake-coil, which controls the electromechanical brake during the descent of the car. In both forms the brake can be applied during descent by means of a switch opened and closed by a circuit-opener, called the "monitor centrifugal" 26, which is driven by the main screw. In both forms this centrifugal applies the brake only during descent. The term "monitor" is used to indicate that the switch warns the conductor if the car runs too fast, but does not limit his control of the car after the car slows down or stops. The term "centrifugal" is used in the broad sense of "speed-governed."

Upon failure of the current, for any reason, whether in ascent or descent, the brake is applied; also to prevent attaining too high a speed on the down run the brake is applied by the monitor centrifugal opening the brake-magnet circuit. This governor may be of the Pickering or any other standard type of speed-governor. Its construction is illustrated in detail in Fig. 2^A^. There are strap-springs carrying governor-balls about midway. These springs are hinged at their lower ends to a fixed collar on the governor-shaft, and at their upper ends they are hinged to a sliding collar. Nuts limit the travel of the sliding collar and so determine the range of travel of the governor-balls to and from the axis. In order that the governor shall act to open at one speed and not close again until a lower speed is reached, it is over compensated. This is effected by having the strap-springs so bent before the governor is assembled that the springs would carry the balls in beyond the axis of the governor if all obstacles were removed. In all positions of the balls when the governor is together the springs will therefore have a deflection from their normal position that is greater than the distance of the balls from the axis. Under these conditions, when a speed sufficient to start the balls out is reached the centrifugal force, which increases, as is well known, proportionately to the distance from the axis, will rise more rapidly than the tension of the springs and the balls will at once fly out to their outer limit, even though the speed of the governor remains constant, and remains there until the speed is checked sufficiently to bring the centrifugal force below the spring tension, when they will return. In Fig. 2^A^ the length of the arrows *m* represent the spring tension tending to hold the balls at their inner positions. The arrows *c* represent a centrifugal just in excess of the springs to start out the balls. The arrow *m'* shows what the spring force will become when the balls reach their outer position. The arrow *c'* shows what the spring force and centrifugal force will become without increase of speed of the governor when the balls reach their outer position. The centrifugal force being, as will be seen, in excess of the spring force, the balls will remain out until the centrifugal falls below the spring force through a reduction of the former by the slackening of the speed.

From the foregoing it will be seen that the governor is constructed to open the switch when the screw exceeds a certain maximum and close it when the speed falls to a certain slower rate or the screw comes to a stop. Attached to the girder, near the outboard end of the screw, is the lower automatic switch 27. This is a rheostat-switch, operated by a roller 28 on the frame attached to the traveling cross-head, to close and gradually cut down the resistance of a shunting-circuit for the working motor when the car reaches its lowest limit. This circuit is called the "lower" automatic shunting-circuit H, or called, briefly, the "lower" automatic circuit. Attached at the other end of the girder is the upper automatic switch 29, which is a rheostatic switch, operated by a roller 30 on the frame of the traveling cross-heads to increase the resistance in and finally open the feed-circuit when the car reaches its upper limit.

The main regulator is independent and self-contained and can be set at any convenient place. It is, in brief, as shown, a pilot-motor 20, with a magnetic brake 31 and having a shaft 32, which is threaded to carry a switch-block; a rheostat 17, composed of cast-iron grids (merely indicated) mounted in a circle or partial circle in a suitable frame (not shown) and connected with contact-clips; a rheostat-arm 33, having teeth 34 engaging with a worm 35 on the pilot-motor shaft, by which the arm is made to travel around the clips and opens and closes the circuit, and the movable member 18, one end of which is in the path of the arm and by it is thrown into contact with contact-points in the hoist and lowering circuits.

Generally speaking, the features of the mechanical construction of the parts are not herein claimed. The description, therefore, of mechanical construction is brief. Many of the features of mechanical construction, however, are novel and will be claimed in other applications.

Switches.

The more elaborate and complicated switches will now be described. This involves a description of the main regulator, which is composed in part of several of the switches.

The car-switch.—The car-switch, which may also be called an "auxiliary" or "subsidiary" controlling-switch, since it controls the pilot-motor which operates the main switch, is operated by the conductor on the car to hoist, lower, and stop the car. It has a stop-contact 36, a hoist-contact 37, and a lowering-contact 38, through which can be closed, respectively, the stop branch f, the hoist branch f', and the lowering branch f'' of the car-circuit F. The contact 36 is called a "stop-contact," because if it is closed and held closed in any position of the system except when the car is already at rest the car will be brought to rest. The contact 37 is called a "hoist-contact," because if it is closed and held closed in any position of the system except when the car is already being hoisted at full speed the system will be brought into position to hoist the car, for should the car be descending continued closure of the hoist-contact while it would first bring the car to rest would cause the car to be hoisted, and contact 38 is called a "lowering-contact," because if it is closed and held closed it will cause the system to be brought into condition to lower the car in the same way that closure of the hoist-contact operates to cause the car to be hoisted. In other words, the operator in order to cause the car to ascend, no matter what may be the condition of the system, has only to close the hoist-contact of the car-switch and hold it closed; in order to cause the car to descend has only to close the lowering-contact and hold it closed, and in order to cause the car to come to a rest has only to close the stop-contact and hold it closed. In fact, as the car-switches are constructed in order to bring the car to rest it is only necessary to let go of the car-switch altogether, whereupon a spring provided for that purpose will operate to close the stop-contact and hold it closed. Three alternative forms are shown. In that shown in Figs. 8 and 9 the stop-contact is opened by pulling a stop-lever 39 held in the fingers, and the other two contacts are closed by pressing push-buttons 40 41 with the thumb. Normally the stop-contact is closed and the other two contacts are open. This is the stop position of the switch and is maintained by the force of springs. When either of the push-buttons is pressed to close the hoist or lowering contact, it will open the stop-contact if the stop-contact is not already opened. The normal operation in starting is to open the stop-contact and then press the hoist push-button, thus bringing the switch into the hoist position, or press the lowering push-button, thus bringing the switch into the lowering position, according as the car is to go up or down, and to hold the stop-contact open and the hoist or lowering contact closed until the main rheostat is brought into the position which corresponds to the desired car speed. The button may then be released and its contact allowed to open, the stop-contact being meanwhile held open. This brings the switch into the steady position—that is, the position of the switch which corresponds to continued uniform movement of the car. As will appear later, there is also provided in the car-circuit a compound automatic circuit-breaker which if a contact of the car-switch is held closed breaks the car-circuit when the main rheostat attains any limiting position, whether of up, down, or stop. The stop-contact must be held open so long as the car is to travel continuously in one direction. An alternative form is shown in Fig. 10. In this are also the hoist, lowering, and stop contacts, with springs to hold the stop-contact closed and the other contacts open. To close the line through the hoist or lowering contacts, the stopping-lever 39^a must first be carried to the right or left to a contact against which the up or down lever 40^a or 41^a is likewise closed, the up and down levers being operated to close with the stop-lever contact with opposite mechanical movements. The features of likeness in these two forms are that they have essentially the same contacts, that the stop-contact is opened and the others closed against a force, shown as a spring tension, and when released the stop-contact closes and the other two open, that to close the line through the hoist or lowering contact the stop-contact must first be opened, and that the stop-contact is operated by a movement distinct from that required to operate the other two contacts.

The third form is that shown in all of the diagrammatic figures. The essential features which it has in common with the other forms are that the switch can be brought into stop, hoist, lowering, or steady position, but is moved from stop position against a force, shown as a spring tension, to close either the hoist or lowering contacts, which can be closed independently of each other, but only on opening the stop-contact, and automatically return to stop position when released. It is obvious that this feature of automatic return to stop position is applicable to car-controlling devices generally, whether they be switches or levers or other devices for operating circuits or valves in electric, hydraulic, or steam elevators. I therefore claim this feature broadly. It will be seen that I have in this car-switch which controls the pilot-motor a switch that may be brought into any one of three positions, in each of which it will close a circuit and cause the pilot-motor to be operated. The switch may be closed through the hoist-contact and will then cause the pilot-motor to run in such direction that the working motor shall cause the elevator to ascend, or it may be closed at the lowering-contact, in which case the pilot-motor will so arrange the connections of the working motor that the elevator shall descend, and the switch can be brought into either of these two positions only when moved out of the third position—that is, when the stop-contact is open, there being a spring provided automatically to close the stop-contact. Moreover, the circuit cannot be closed through the hoist and the lowering contacts at the same time. Whenever the circuit is closed at the stop-contact, the direction in which the pilot-motor has been driven is reversed, and in due course the pilot-motor is brought to rest, whether the hoist-contact or the lowering-contact has been closed.

The common-control switchboard.—When there is in a building a set of two or more elevators each operated by an electrical system such as is herein shown, there is preferably and almost necessarily provided at some convenient point, as in the room occupied by the multiplying machines and regulators, a common-control switchboard, Fig. 14, to which all the car-circuits of the whole set of elevators are connected in multiple and on which is a separate switch 42 for each car. Each switch 42 consists of three levers which are thrown simultaneously, but are insulated from each other, but connected by three contacts to the pilot-motor belonging to the corresponding elevator. In their usual position each connects the stop, hoist, and lowering branches $f\ f'\ f''$ of the car-circuit F to the switch of the pilot-motor for the car, as shown for car No. 2; but each can be thrown, as shown for car No. 1, so as to connect its pilot-motor with a common-control switch 43. In the first-mentioned case the regulator and working mechanism for the car are controlled from the car by the car-switch, and in the second the regulator is controlled in the engine-room by the common-control switch. When any system has its three-lever switch in the middle position, as shown for car No. 3, it is disconnected both from its car-switch and from the common-control switch. The common-control switchboard is used for the purpose of general inspection, cleaning, testing, and manipulating the machines or when undergoing repairs. It is also useful for hoisting safes or for any other purpose when it is desired to run the elevators without a conductor in the cars.

The main regulator.—The entire main regulator is controlled by the operator indirectly through the car-switch or the common-control switch. It comprises contacts in the car-circuit F, herein called the "pilot-motor" switch, contacts in the brake-magnet circuit G, herein called the "brake-magnet" switch 44, and the main circuit-changing switch, which has contacts in all but one of the circuits through the armature of the working motor and which, together with main rheostat, is called the "working-motor" switch. These three switches, which together constitute the main regulator, are all synchronously operated by the pilot-motor, to the shaft of which their movable members are geared. Fig. 2 shows the position of the switches which corresponds to the position of rest for the car. When the switch-block is moved to either side of its stop position, connections are established, as illustrated in positional views and hereinafter explained, which result in establishing the hoist or lowering conditions of the circuits of the system. This is herein described as operation of the switch-block or the switches of the system in opposite senses.

The pilot-motor switch.—The circuits of the pilot-motor are shown in detail apart from all the other circuits of the system in Figs. 11, 12, and 13. On the switch-block are two like insulated plates, which, with coöperating contact-points, control the pilot-motor. The left-hand plate of the two is the lowering-contact plate 45, which, with the coöperating contacts, is called the "lowering" branch of the switch, and the right-hand plate is the hoist-contact plate 46, which, with the coöperating contacts, is called the "hoist" branch of the switch. As to the hoist and lowering branches the switch is merely an automatic circuit-breaker. The third point is the stop-contact point. As to this the switch is an automatic circuit-changer and circuit-breaker. There might be three separate circuit-breakers. As shown, all the breaks, however, occur at a single insulation 45^a, which coöperates with all the contacts. The stop-contact is the middle contact, but is not exactly midway between the other two, being somewhat nearer the lowering than the hoist contact. This is because the main-rheostat arm 33 makes a complete revolution in turning from stop to full-hoist position and less than a complete revolution in turning from stop to full-lowering position, as will hereinafter appear more fully. In the stop position, Fig. 12, the stop-contact rests on the insulation-piece 45^a, where it is out of circuit. In this position the other two contacts are distant from the middle contact less than half the distance from the ends of their respective plates to the stop-contact. As soon as the hoist-circuit is closed and the switch-block starts to move the lowering-plate comes in contact with the stop-contact, and similarly when the lowering-contact is closed the hoist-plate comes in contact with the stop-contact. If the car and pilot-motor switches are closed at the hoist-contacts, the circuit is automatically broken at the pilot-motor switch when the hoist-contact runs off of the hoist-plate. This occurs when the switch-block reaches its extreme position at the right, Fig. 13. In this position the lowering-contact is still closed, because of the unsymmetrical arrangement of the hoist and lowering contacts with reference to their plates above stated. If, on the other hand, the car and pilot-motor switches are closed at the lowering-contacts, the circuit is automatically broken in the pilot-motor switch when the lowering-contact runs off of the lowering-plate. This occurs when the switch-block reaches its extreme position to the left, Fig. 11. In this position the hoist-contact is still closed, because of the unsymmetrical arrangement of the hoist and lowering contacts and plates above stated. The length of the contacts conforms to the intended travel of the rheostat-arm and determines the number of revolutions of the pilot-motor armature. The passage of the current through the pilot-motor armature releases its brake, and when the current is cut off the brake automatically stops the armature from running too far by its momentum.

The car-switch 19 or common-control switch 43 and the pilot-motor switch form a compound switch consisting of two independent branches—to wit, the hoist branch, which controls the start in ascent and the stop in descent, and the lowering branch, which controls the start in descent and the stop in ascent, as will be hereinafter set forth. Each branch has a circuit-closer controlled by the operator, which controlled circuit-closer is the hoist or lowering contact of the car-switch or common-control switch. Each branch has also an automatic circuit-breaker on the pilot-motor switch, the branch being broken when the hoist or lowering contact point of the pilot-motor switch passes off of its plate. With these branches are combined the controlled stop-contact of the car or common-control switch, which the operator can open and close directly at will, and on the pilot-motor switch the stop-contact. In its intermediate position this acts as a circuit-changer to change the circuit from one branch to the other whenever the stop-contact of the car-switch is closed in any but the stop position and as an automatic circuit-breaker to open the circuit when the switch-block returns to the middle or stop position. The stop-contact on the car and pilot-motor switches and the connecting-wire *f* constitute a stop branch of the compound switch. It will be seen that by this arrangement the car-switch is connected in circuit with the pilot-motor without the intervention of relays. The connection is through the pilot-motor switch. The compound switch formed by the car-switch and the pilot-motor switch is directly connected to the pilot-motor. This is of great importance, because in my system the regulator is operated by the pilot-motor, which must therefore respond instantly and with absolute certainty upon the operation of the car-switch. This is insured by the electrical connection shown between the car-switch and the pilot-motor.

The working-motor switch.—The main or working-motor switch is made up of a rheostat and a circuit-changing switch. The rheostat consists of a number of contact-clips arranged to form an arc of a circle and connected to each other in series, with one end of the series connected to the armature of the working motor, and a rheostat-arm 33 electrically connected to the movable member 18 of the circuit-changing switch and pivoted so that it can be revolved around the circle of the rheostat in either direction. The gap between the lowest clip 50, connected to the motor-armature, and the highest clip 51 at the other end of the series prevents the current from passing from any other clip of the series to the lowest clip by any path except through the intermediate clips. The gap between the highest and the lowest clip can be filled with insulated clips connected to intermediate clips of the series, as shown in Fig. 3, so that the arm shall never break contact in the rheostat. The upper end of the movable member of the circuit-changing switch lies in the path of the main-rheostat arm 33 and is moved by the arm between a contact 47 in the hoist-circuit on one side and two contacts on the other side, one of which, 48, is in the down regulating-circuit and the other of which, 49, is in the lower automatic circuit. The movable member is always normally in contact either with the hoist side or the lowering side of this switch and should never be left in the intermediate position. When released from either side, it is thrown by a spring to the other side. As it is a snap-switch, the contact is made and broken quickly.

When the machine is at rest, the circuit-changing switch is preferably closed on the lowering side, with the rheostat-arm on the lowest clip 50, which lies next to the motor armature, so that the resistance of the rheostat is reduced to a minimum. It is not absolutely necessary that this switch should be closed on the lowering side nor that the arm should contact with the lowest clip when the machine is at rest. The circuit-changing switch might be closed on the hoist-contact and the arm might be entirely out of contact with the rheostat, in which case the mere closure of the circuit-changing switch on the hoist side would not close the line. As will be seen hereinafter, it is desirable that in the normal stop position the arm should rest on the lowest clip and the circuit-changing switch be closed on the lowering side, which is the position shown, since this places the apparatus in position when at rest such that the armature is short-circuited at the main rheostat, and the closure of the lower automatic closes a circuit on the working motor which is independent of resistance of the main rheostat. The armature so short-circuited will prevent the car from running away even if the brake is actually removed.

When the pilot-motor is operated to effect the hoisting of the car, it rotates the main-rheostat arm from the lowest clip in the direction of the hands of a watch, which is hereinafter called "right rotation," and so brings it in contact with the highest clip of the rheostat and then closes the hoisting-circuit by closing the circuit-changing switch on the hoist-contact. The arm will then continue its movement in the same direction until the hoist branch of the car-circuit is opened, either manually at the car-switch or automatically at the pilot-motor switch. The positions of the hoist, stop, and lowering contacts of the pilot-motor switch thus determine how far the rheostat-arm can be revolved in either direction from the stop positions. As shown, if the car-circuit is not broken until it is broken automatically at the pilot-motor switch the rheostat-arm will have traveled until it contacts with the lowest clip of the main rheostat. The operator on the car can readily bring the arm to any position which he may wish by holding open the stop-contact and playing the hoist-contact open and shut, thus moving the rheostat-arm step by step until the position is attained which corresponds to the desired car speed, for momentary closure of either branch of the car-circuit starts the rheostat-arm in rotation. When the pilot-motor is operated to slacken the car or stop it, the rheostat-arm is rotated in the opposite direction to the hands of a watch, herein called "left rotation." If the stop-contact of the car-switch is held closed long enough, the arm is brought back to the stop position, and before passing off of the highest clip of the rheostat the arm breaks the hoist-circuit by throwing the circuit-changing switch to the lowering side and acts to check the rotation of the armature. The arm then moves from the highest to the lowest clip.

When the pilot-motor is operated to effect the lowering of the car, the rheostat-arm rotates in left rotation from the lowest clip 50 through a distance which is determined by how long the lowering branch of the car-circuit is held closed. As it travels it throws more and more resistance of the main rheostat into the down regulating-circuit, and if the lowering branch of the car-circuit is held closed until automatically broken at the pilot-motor switch the arm travels until it reaches the highest clip 51 of the main rheostat. On stopping from lowering the arm returns from the highest to the lowest clip without operating the movable member of the main circuit-changing switch.

The rheostat-arm can be rotated from the stop position shown in Fig. 2 almost completely around the circle in left rotation when the car is to descend, in which movement the arm does not operate the movable member, and can be rotated completely around the circle in right rotation when the car is to ascend, in which movement it throws the movable member from the lowering side to the hoist side of the main circuit-changing switch. This difference in the length of travel is due to the difference in the distances from the hoist and lowering contacts to the insulating-piece in the pilot-motor switch. The rheostat-arm can travel in right rotation from the extreme of lowering position on the highest clip back to the stop position on the lowest clip, and continuing in the same direction can travel once again around the whole circuit to the lowest clip 50, this being the extreme of hoist position, throwing the movable member from the down side to the hoist side on passing from stop to hoist. This changes the movement of the elevator from down at full speed to up at full speed. When the rheostat-arm was in the extreme of lowering position on the highest clip 50, the hoist-plate 46 on the pilot-motor switch was in contact with its coöperating contacts in the hoist and stop branches of the car-circuit, and the lowering branch of that circuit was broken at the pilot-motor switch. (See Fig. 11.) During the described movement of the arm the lowering plate 45 contacts with its coöperating contacts in the lowering circuit, and the stop-circuit is first broken at the insulation 45[a] (see Fig. 12) and is then transferred to the lowering branch, and finally the hoist branch is broken by the hoist-plate moving out of contact with its coöperating contacts in the hoist-circuit, this being position for hoist at extreme speed. (See Fig. 13.) The rheostat-arm can travel from the extreme of hoist on the lowest clip in left rotation once around the circle to the stop position, and then continuing in the same direction pass to the extreme of lowering at the highest clip, throwing the movable member from the hoist to the lowering side on passing from the hoist to the stop position, the contacts in the car-circuits being made and broken in the reverse order to that before described. In any of these movements it will be understood that the rheostat-arm can be stopped at any intermediate position on the rheostat by merely opening the car-circuit at the car or common-control switch. These intermediate positions of the rheostat-arm correspond to intermediate rates of speed of ascent or descent and are called "steady positions." Fig. 4 shows the steady position of ascent at moderate speed, and Fig. 6 shows the steady position of descent at moderate speed. As the conductor approaches a floor and wishes to stop he can slow down the speed by bringing the arm to successive steady positions, corresponding to slower and slower speeds, by simply holding the stop-contact open and playing the button which corresponds to movement in the opposite direction to that in which he is traveling or by leaving both buttons open and playing the stop-contact open and shut.

The brake-magnet switch.—Two forms are shown—a down brake-magnet switch (shown in Fig. 2 and certain other figures) and an up and down brake-magnet switch. (Shown in Fig. 15.) The former will be described first. On the left end of the main switch-block, Fig. 2, is a plate 44, which, with coöperating contact-points, constitutes the down brake-magnet switch. The switch is closed during descent and open when the car is at rest and during ascent. There is also provided a shunt around this switch, in which is a circuit-closer that can be operated manually to relieve the brake when the machine is at rest.

In Fig. 15 the brake-magnet switch is represented as a pivoted member 44[a], connected to line and having teeth engaging with a worm on the pilot-motor shaft, whereby it is moved to right and left. The switch has an intermediate stop position, in which the circuit is broken in the switch, and a hoist-plate 52 and resistances and a lowering-plate 53 and resistances, the resistances being intended to prevent the current from being turned on too quickly.

Reviewing the entire main regulator, it is seen to be made up of the pilot-motor switch, the brake-magnet switch, and the working-motor switch. All the foregoing parts, except the car-switch and, perhaps, the source of supply, are preferably placed in the engine-room. The three switches of the main regulator have common stop, hoist, and lowering positions—that is, their movements are coördinated and interrelated, so that by operating the car or common-control switch they can all be brought at once each to its stop or hoist or lowering position. The open position is both the stop and the hoist position of the brake-magnet switch shown in Fig. 2.

While I have shown the regulator mounted in the car under the direct manual control and in the reach of the hands of the conductor in the car, I do not limit my invention, which I claim broadly, to any specified location of the regulator or any specified means of control thereof.

The Circuits.

Speaking somewhat broadly, there are five circuits provided, four of which are connected to the source of supply of electricity. The circuits are (1) the shunt field-circuit S to supply to the working motor a field which is independent of the main switch; (2) the feed-circuit C, also properly called the "main" circuit, the "hoist-circuit," or the "up" regulating-circuit, to control the working motor, choking-shunt, and brake during ascent; (3) the brake-magnet circuit G to control the brake and closure of the automatic choking-shunt for the working motor in descent, Fig. 2, or in both ascent and descent, Fig. 15; (4) a circuit to control the entire system, so as to place the hoisting, lowering, and stopping of the car under normal operation at the will of the operator, called the "car-circuit" F. These are connected to the source of supply. Circuits numbered 2, 3, and 4 may be called "operative-line" circuits, and 5 a "compound" circuit, made up of the two branches, herein called the "down" regulating-circuit D and the "lower" automatic circuit H, which are in parallel with each other. Neither of these branches is under any circumstances connected with the source of supply. They are closed only during descent, when they control the speed of the car by controlling the output of the working motor, which the descending car drives as a dynamo. This compound circuit can be called the "brake" or "braking" or the "retarding" circuit. The term "brake-circuit" is herein used because in United States Patent No. 472,909 it is applied to an analogous circuit, and certain generic claims of that patent are drawn in the general form adopted in more specific claims of the present application. In that patent a mechanical brake was used to hold the main screw. The adoption of an electromechanical brake in the present case gives rise to the danger of misunderstanding of the term "brake-circuit." It is therefore explicitly stated that, as shown, the circuit herein called the "brake-circuit" in no way and under no conditions controls the electromechanical brake for the main screw; but its branches control the speed of the working motor during descent. This statement is not intended as a limitation of the invention, but is inserted merely to avoid possible confusion of terms.

The feed-circuit and brake-circuit together constitute a compound circuit, which may be broadly called the "working-motor" circuit. In addition to the foregoing circuits there is provided an automatic choking shunt and resistance E, which is electrically operated. When closed, it shunts the armature and series coils of the working motor, but not the brake-magnet, and is so connected that it is independent of the working-motor switch. It is controlled by a contact opened and closed by the brake-magnet. It is a part of both the feed-circuit and the brake-circuit.

The shunt field-circuit S is normally closed. The car and feed circuits are used in hoisting. The other circuits are always open in hoisting, except that in Fig. 15 the "up" side of the brake-magnet is closed. The car, down brake-magnet, and the brake-circuits are used in lowering. The other circuits are always open in lowering. In the stop position, which is assumed when the machine is stopped by the operation of the car-switch, the down regulating-circuit and the automatic choking-shunt are closed; but the other circuits of the system are opened. If the car is stopped by arriving at the lower limit without operating the car-switch, the down regulating brake-magnet and lower automatic circuits are closed and the other circuits are open. If the car-switch is then brought to stop position, the condition is established in which the down regulating and lower automatic retarding-circuits and the automatic choking-shunt are closed and the other circuits of the system are open.

At the bottom of the diagram of Fig. 2 are two main or general bars A B, herein called "bus-bars," to which are connected all the elevator systems and the dynamo or other suitable source of electricity belonging to the outfit of the building. One elevator system is shown connected to the bars; but others can be connected in parallel therewith.

Following up either of the leads *a b* there will be found a point in each where the wire divides into four branches. These four branches are the four circuits above described as connected to the source of supply. They can be connected, if desired, each to an independent source of supply.

One of the leads of each dynamo or other source of electricity includes, in series with the hoist-contact of the working-motor switch, a fuse 54 or other suitable overload circuit-opener to open the circuit in case of overload of the circuit throughout or locally. As shown, the lead branches between this fuse and the bus-bar into three wires. One of these wires is in the shunt field-circuit, a second is in the car-circuit, and the third is in the brake-magnet circuit. These three branches are not affected by blowing the fuse. As will be seen more fully hereinafter, the purpose of this connection, whereby these branches are independent of the fuse, is to enable the operator to lower and control the car in case the fuse is blown. By the arrangement shown the car cannot be hung up between landings by blowing the fuse, but though disabled for hoisting can be normally lowered.

The different circuits will now be described and such description given of the parts included therein as may be necessary.

The shunt field-circuit.—The shunt field-circuit S contains only the shunt field-coils and a rheostat-switch, by which it can be opened and closed, and its resistance, and hence the strength of the shunt-field, can be varied. These coils have a steadying effect on the working-motor field, particularly when the motor is driven as a dynamo in descent. It is shown as normally closed while the system is in operative condition; but I do not limit my claims to a normally closed shunt field-circuit. Variation of the field can be made to determine in part the hoisting and lowering speeds, weakening it increasing the speed with any given load and position of the rheostat-arm. These shunt field-coils differ from the shunt field-coils of an ordinary compound-wound or shunt-wound motor, because the connections of this shunt field-circuit are independent of the other connections of the motor.

The feed-circuit.—The feed, main, hoist, or up-regulating circuit C includes the upper automatic snap-switch and rheostat, the working-motor armature and the series field-coils thereof, the main rheostat, the hoist side of the working-motor switch, and the fuse above referred to, and in the construction of Fig. 2 the series brake-coil. At the moment of closing this circuit the armature and series field-coils are shunted through the automatic choking-shunt, which consists of a rheostat, preferably of greater resistance than that of the armature and series field-coils. The moment the brake-magnet is energized and the brake lifted this circuit is opened at a low potential, and consequently without sparking, and remains open until the current is interrupted. In the construction of Fig. 2 the armature and series field-coils should be connected to the working-motor switch independently of the series brake-magnet coils, but not independently of the automatic choking-shunt, so that the armature and series field-coils can be divided off from the series brake-coils and connected independently thereof in the brake-circuit during descent, but without disturbing the connections of the automatic choking-shunt. By reference to Fig. 2 it will be seen that this is accomplished by branching the wire i^4, which is led from the contact 48 on the down side of the working-motor switch, into three branches—one, branch i', going to the series field-coils and armature, another, i^2, to the series brake-coil, and the third, i^3, to the automatic choking-shunt circuit-opener. This choking-shunt is closed whenever for any cause the current fails in the feed-circuit in ascent or in the down brake-magnet in descent, in the construction of Fig. 2, and whenever the current fails in the brake-magnet circuit of Fig. 15. It is closed and shunts the working motor whenever the car stops, except, as will be seen, in the single instance when the car is stopped at the lower limit without operating the car-switch, in which case it remains open until the car-switch is closed at the stop-contact. It is closed to shunt the working motor and helps to bring it to rest under seven conditions—to wit, during hoisting on failure of the current from any cause, as, first, when the circuit is opened in normal stop; second, when the circuit is opened at the upper automatic; third, when the safety-fuse is blown in the main circuit, (not true of Fig. 15;) fourth, on total failure of current in the leads and, during lowering, on failure of the current in the brake-magnet circuit from any cause, as, first, when the circuit is opened in normal stop; second, when the circuit is opened by the centrifugal; third, when for any reason there is failure of current in the safety-circuit or in the leads.

The brake-magnet circuit.—This circuit is shown in two forms. In one, shown in Fig. 2 and certain other figures, it is a down brake-magnet circuit only, the brake-magnet being controlled during ascent by the feed-circuit. In the other form (shown in Fig. 15) it is an up-and-down brake-magnet circuit. Referring first to the form shown in Fig. 2, the down brake-magnet circuit G is intended in the normal operation of the system to lift off the brake from the main screw and open the contact of the automatic choking-shunt when the car is to start down, to maintain this condition so long as the car runs down at a speed which does not exceed the established maximum, and to apply the brake and close the choking-shunt on the working motor when the car is to stop normally. It also contains a circuit-opener operated by a centrifugal governor to apply the brake and shunt the working motor when the car runs down too fast. The automatic circuit-opener is of the construction before described and is driven from the shaft of the working motor and is opened whenever the main screw rotates too rapidly. It should be set to open at one determined speed and close at a lower speed or when at rest. The circuit also includes coils of the brake-magnet, herein called the "shunt-coils." There is a large number of turns in these coils and in order to reduce the spark due to these turns when the safety-circuit is opened and also to delay and soften the brake operation, a shunt around it is provided, which is adjustable and, as shown, consists of lamps through which the coils can discharge. Should the car acquire too fast a speed in descending, the down brake-magnet circuit is opened by the centrifugal governor; but it will merely be necessary for the speed of the car to be slowed down to the determined limit or the car to be stopped by the strap-brake and choking-shunt to enable the operator by operating the car-switch in the ordinary way again to relieve the brake and open the choking-shunt, Fig. 7. In hydraulic elevators there are no centrifugal safeties except those operating the catches on the car, and to avoid the annoyance of operation from temporary excess of speed these are frequently set for so high a speed as to be inoperative when required. This additional monitor centrifugal safety, herein described, does not interfere with the use or operation of car centrifugal catches. The essential point of the modification of Fig. 15 is that a single-coil brake-magnet is substituted for the double-coil brake-magnet of Fig. 2. The hoist-plate 52 of the brake-magnet switch 44^a is connected directly to the line on the motor side of the upper automatic switch, so that the hoist branch g of the brake-magnet circuit shall include this upper automatic switch and the brake-magnet shall be deënergized when the upper automatic switch is opened. The lowering-plate 53 of the switch is connected to the line on the line side of the upper automatic switch, but through the centrifugal circuit-opener, so that the lowering branch g' of the brake-magnet circuit shall be independent of the upper automatic and shall be opened to demagnetize the brake-magnet by the centrifugal circuit-opener. In this system the monitor centrifugal circuit-opener is not in operation during ascent—that is, in both forms there is a compound brake-magnet circuit having one branch which includes the upper automatic switch and another branch which includes the monitor centrifugal circuit-opener. This single-coil brake-magnet is introduced merely to enlarge the scope of the invention, so that the claims, which do not specify a double-coil brake-magnet, shall be broadly construed.

If the monitor centrifugal circuit-opener is omitted from either form of brake-operating circuit, the circuit will become a mere brake-operating and motor-shunting circuit. If the automatic choking-shunt feature is omitted, the circuit will become a mere brake-operating circuit. I use the terms "brake-magnet" circuit and "brake-operating" circuit in a broad sense.

The car-circuit.—The car-circuit F is provided with instrumentalities intended to put it in the power of the car-conductor or the engineer to rotate the arm of the main rheostat in either direction and to bring it to rest and hold it as long as desired at any point on the rheostat, and it is also provided with instrumentalities which automatically bring it to rest at or near opposite ends of the rheostat when the car is being hoisted or lowered and at stop position when the car is stopped. With this object the car-circuit includes the armature of the pilot-motor and the electromagnet of a magnetic brake to prevent the pilot-motor armature from spinning, and thus unduly shifting the switch-block and rheostat after the current is cut off. The circuit divides into two branches, which traverse the field-magnet of the pilot-motor in opposite directions. Changing the circuit from one branch to the other reverses the direction of rotation of the pilot-motor by reversing the polarity of the field. This method of reversal of direction of the pilot-motor is novel, being a departure from the ordinary method of reversing the current in the armature or in a single field-circuit. Instead there are two field-coils wound in opposition. The two coils are never used together. A modification of this method would be to use two oppositely-wound coils in series, one or the other of which is short-circuited when thrown into line, according to the direction of rotation required.

One branch of the car-circuit, herein called the "hoist" branch f', includes a rheostat-switch, the hoist-contact of the pilot-motor switch, and the hoist-contact of the car-switch. The other branch, herein called the "lowering" branch f'', includes a rheostat-switch, the lowering-contact of the pilot-motor switch, and the lowering-contact of the car-switch. The operating position of the car-circuit to start the elevator up or down is with the stop-contacts open and the hoist or lowering contacts closed. The steady position is with the stop-contact and at least one of the other contacts of the pilot-motor switch closed, but with all the contacts of the car-switch open, and hence with all branches of the car-circuit open. Closing the stop-contact of the car-switch except when the pilot-motor switch is at the stop position changes the car-circuit from one of the branches to the other, and thus reverses the pilot-motor, and if the stop-contact is closed long enough brings the switch to stop position, at which point the circuit is automatically opened at the stop-contact of the pilot-motor switch.

It will be seen that the lowering branch f'' of the car-circuit controls the starting of the car down from "Stop" and the stopping of the ascending car, for in order to move the rheostat and circuit-changing switch from, say, the position shown in Fig. 4, which corresponds to ascent of car, to the position shown in Fig. 2, which corresponds to the stopping of the car, it is necessary to turn the rheostat-arm in left rotation, and this is effected by closing circuit through the lowering-contact 38 or the stopping-contact 36, the lowering-plate 45, and the corresponding field-winding of the motor, these parts being in the position shown in Fig. 4 in the lowering branch f, and that the hoist branch controls the starting of the car up and the stopping of the descending car, for in order to move the rheostat-switch from, say, the position shown in Fig. 6 (descent of car) to the position shown in Fig. 2 (car stopped) it is necessary to turn the rheostat-arm in the right rotation, and this is effected by closing circuit through the stopping-contact 36 or the hoist-contact 37, the hoisting-plate 46, and the corresponding field-winding of the motor, these parts being in the position shown in Fig. 6 in the lowering branch f'. It is desirable that these two branches should be independently adjustable, particularly with an underbalanced car, for when the car starts down the main rheostat-arm can be operated very quickly and the car quickly got under way without jar on account of the mechanical conditions of the down movement, and when the car stops in ascent the current can be cut off very promptly and the car allowed to stop in the height determined by the gravity equivalent without jar. Therefore the lowering branch of the car-circuit should rotate the pilot-motor armature and through it the main rheostat-arm rapidly; but if the car stops in descending too rapidly there results a jerk on the ropes and a strain on the machine, besides an unpleasant personal experience in the passengers, and if the current is put on to hoist too quickly the increase of current affects unpleasantly other translating devices in circuit, such as lamps, as well as unnecessarily straining the machine and shaking up the passengers. Therefore the two fields of the pilot-motor are in shunt to each other and independently adjustable, each having its own rheostat, as shown, and they are wound so as to give the highest permissible speed when the rheostats are cut out.

The brake-circuit.—The brake, braking, or retarding circuit has two branches which are in multiple with each other. One branch, which is the lowering or down regulating-circuit D, includes the armature and series field-coils of the working motor, a switch to control the speed of the car in descending, preferably, but not necessarily, the main rheostat, and one point on the lowering side of the working-motor switch. This branch is closed when the lowering-contact of the car-switch is closed. The other branch, which is the lower automatic circuit H, includes the contact 49 on the lowering side of the working-motor switch and the lower automatic switch 27. This switch is automatically closed through its entire resistance and its resistance gradually cut out when the car approaches its lowermost position, as already described. This so far short-circuits the working motor that the car can scarcely drive the motor, and it is brought automatically and gradually very nearly to a stop. It comes to a full stop when the operator lets his controlling-switch go to "Stop" or the traveling cross-head 7 is stopped by the buffer-nut at the end of the screw 10.

All these various circuits and branches of circuits are independent of each other. The shunt field-circuit is obviously not influenced by the other circuits. The feed-circuit would operate to hoist the car independently of any operation of the car-circuit if, as above suggested, the main regulator were operated mechanically. The down regulating-circuit and lower automatic circuit are similarly independent of the car-circuit, and the feed and brake and feed and down brake-magnet circuits are mutually independent of each other, because each is open when the other is closed, so that they cannot interfere, and the brake-circuit is independent of the brake-magnet circuit, since it and the brake-magnet circuit in both forms each has a separate switch. The brake-circuit can be used alone to lower the car if the brake is operated mechanically instead of magnetically. The car and brake-magnet circuits obviously perform their functions independently of each other and of any other circuits of the system. By operating the monitor centrifugal manually the car can be lowered without using the car-circuit, for by opening and closing the brake-magnet circuit the brake can be lifted off and applied and the descent thus regulated. This can also be accomplished without a brake-magnet circuit if the brake is operated mechanically. This, however, of course differs from the normal method of regulating the descent by the resistance in the circuit with the working motor. In specifying operation of the brake I include also mechanical operation of the circuit-closer of the choking-shunt.

A consideration of the foregoing description will make it clear that this is a gravity-elevator system with an underbalanced car in which there is substantially no reversal of the current in any of the circuits. The current always flows in the same direction through each branch of the car-circuit, through each branch of the brake-magnet circuit of Fig. 15, through the shunt field-circuit, and through the feed-circuit and the two branches of the brake-circuit, and, as already explained, the current is not reversed through the motor on changing from the feed-circuit to the brake-circuit. When, however, the car in traveling up opens the upper automatic, thereby cutting off the line-current and closing the automatic choking-shunt for an instant while the car continues to rise, a reversed current is developed which traverses the armature and series field coils and the choking-shunt.

It is well at this point to indicate a few broad features of the invention, which will be clear from the foregoing full description. The pilot-motor is connected to the car-switch without the intervention of relays. The car-switch and the pilot-motor switch together constitute a compound switch with two branches, in each of which is a controlled circuit-closer—namely, the hoist and lowering contacts of the car-switch—in combination with a circuit-changer—namely, the stop-contact of the car-switch and the corresponding connection on the pilot-motor switch—acting to change the circuit from one branch to the other. In the invention herein disclosed this circuit-changer acts to change the circuit from either branch to the other, according to the position of the pilot-motor switch, and there are provided means for automatically opening the circuit at the limit and stop contacts on the pilot-motor switch. There are also means for automatically operating the circuit-changer, such means being the springs which return the car-switch to stop position when it is released. When the car-switch is brought thus automatically to the stop position, one of the branches is opened and the other is closed. By this it is not meant that the other contact of the car-switch is closed, but that the corresponding branch leading from the pilot-motor switch to the pilot-motor is closed through the stop-contact of the car-switch, and if we consider the rheostat as a part of the combination there is provided means for operating it—namely, the pilot-motor and connections—a suitable circuit for controlling the rheostat-operating means—namely, the car-circuit and the connections with the pilot-motor—a circuit-changer operating to bring the rheostat to a definite position—namely, the stop or initial position—and means for automatically operating the circuit-changer, as above explained, together with the automatic circuit-openers, whereby the rheostat can be brought to certain other definite positions—namely, the full-hoist or full-lowering position.

In certain of the claims I use the term "current-controller" as a generic term to cover either a simple rheostat or any form of circuit-varying switch to control the driving-motor. The term thus covers a series multiple switch or a reversing-switch.

Operation.

The operation of the complete system will now be described, reference being made only to the regulator and brake-magnet circuit shown in Fig. 2 and to the car-switch and not to the common-control switch and to that form only of the car-switch illustrated in Figs. 8 and 9. Assuming that the car 1 is at rest at some point between the extreme points of travel along the hoistway and the conductor wishes to go up, the circuits at stop are then as shown in Fig. 2. All the circuits are open except the shunt field-circuit S, the choking-shunt E, and the down regulating-circuit D. The conductor opens the stop-contact 36 and closes the hoist-contact 37 of the car-switch 19. This closes the hoist branch f' of the car-circuit F through the pilot-motor 20 and the pilot-motor switch. The pilot-motor drives the main-switch block to the right and rotates the rheostat-arm 33 of the main rheostat 17 in right rotation. The rheostat-arm contacts with the highest clip 51 of the rheostat, and the hoist-circuit C is then closed by the movable member 18 of the circuit-changing switch, which is thrown by the arm from the lowering-contacts to the hoist-contact 47. The line-current then traverses the feed-circuit C, including the whole of the main rheostat and momentarily including the automatic choking-shunt E. The brake 21 is then lifted off and the choking-shunt is opened. If the hoist-contact of the car-switch is held closed, the main-rheostat arm travels on in right rotation, cutting out more and more of the rheostat. All the circuits of the system are open except the shunt field-circuit S and the feed-circuit C, which must be closed, and the car-circuit F, both branches of which may be open or which may be temporarily closed in either branch f' or f'' to move the rheostat-arm forward or backward, and thus control the rate of ascent. This is the condition throughout an uninterrupted hoisting unless the hoist-contact of the car-switch is held closed until the main-switch block is pushed far enough to the right to break the hoist branch f' at the pilot-motor switch. In this position the rheostat-arm will rest upon the lowest clip 50, the main rheostat will be entirely cut out, and the rate of ascent will be the maximum permitted speed, and when the parts are in this position the hoist branch f' of the car-circuit cannot be closed. As soon as the current through the pilot-motor is cut off by opening the car-circuit at the car-switch 19 or pilot-motor switch, or both, the magnetic brake 31 stops its armature, and the main-switch block and main-rheostat arm are stopped. The position illustrated in Fig. 4 is that in which the hoist branch of the car-circuit is opened at the hoist-contact 37 of the car-switch before the car-circuit is automatically broken at the pilot-motor switch and before the entire resistance of the rheostat is cut out of the hoist-circuit C. This is a position of steady speed of ascent slower than the maximum speed of ascent permitted. When the conductor of the car wishes to slow down before stopping, he plays the stop-contact 36 of the car-switch open and shut, or holding this open plays the lowering-contact 38 open and shut, thus reversing the connection in the car-circuit from the hoist to the lowering branch and moving the rheostat-arm in left rotation, and thus throws in more and more of the resistance of the rheostat. Momentarily the circuits are as they would be in Fig. 6 if in that figure the car-switch were closed at the stop or lowering contacts. The main-switch block is then brought by the pilot-motor to stop position, where either branch of the car-circuit when closed through the stop-contact is automatically broken.

During this backward movement the rheostat-arm travels back along the rheostat, gradually throwing in more and more resistance and finally breaking the feed-circuit C by throwing the movable member 18 of the main circuit-changing switch from the hoist to the lowering side and then passing off of the highest clip of the rheostat. This is the position of the parts shown in Fig. 2. Opening the hoist-circuit in any way causes the brake 21 to be applied and the working motor to be shunted by the automatic choking-shunt E. In every case the armature is thus shunted when the brake is applied. The working motor and the car stop. If instead of being stopped during ascent in the manner indicated the car is allowed to travel to the top of the shaft, the roller 30 of the traveling cross-head will throw open the upper automatic switch 29. This opens the feed-circuit C, and thereby closes the choking-shunt E on the working motor and applies the brake 21, thus stopping the motor and the car. If the upper automatic is thus operated when the car is ascending at something short of the maximum speed permitted, the parts will be in the position shown in Fig. 5. When it is desired to lower the car, the lowering-contact 38 of the car-switch is closed. This drives the main-switch block to the left. The down brake-magnet circuit G is closed. The brake 21 is lifted and held off, and the choking-shunt E is opened and held open. The main-rheostat arm 33 is rotated in left rotation and gradually cuts more and more of the resistance of the rheostat 17 into this circuit G. The car starts downward, impeded by the torque and inertia of the working-motor armature 14. The upper automatic 29 is closed, and the parts assume the position of Fig. 6. All the circuits are open, except the shunt field-circuit S, the down regulating-circuit D, and the car-circuit F, which latter may be open in both branches $f' f''$ or temporarily closed in either branch to operate the main-rheostat arm. In starting down the mechanical conditions of revolving the screw by pressure of the nut and the inertia of the armature render a sudden start with the limited force of the car-weight impossible and insure a gradual acceleration independently of the dynamo action. The speed attained by the car with any given weight and strength of field up to the maximum speed permitted will depend on how long the lowering-contact of the car-switch is closed, for this determines how much of the resistance of the rheostat is in the down regulating-circuit. When the car starts down, with the rheostat-arm stationary on any clip, the speed increases until the current generated in the working motor becomes large enough to prevent further increase with the given load. If the rheostat-arm is moved so as to increase the resistance in the down regulating-circuit D, this momentarily cuts down the current generated, and the car will increase its speed until the increased motor electromotive force acting through the increased resistance generates the normal current to give about the same torque. This then prevents further increase of speed. Roughly speaking, with any given load the speed, motor electromotive force, and resistance vary in the same ratio and the current remains nearly the same for any steady rate of speed. If the lowering-contact 38 of the car-switch is closed long enough, the main-switch block will be carried the full distance to the left, as shown in Fig. 11, when the lowering branch f'' of the car-circuit will be automatically opened as the lowering-contact of the pilot-motor switch passes off of the lowering-plate 45. When this lowering branch of the car-circuit is opened, the pilot-motor is cut out of circuit and the switch-block stops. When it is desired to slow down the car, the stop or hoist contact is or may be played open and shut to first slow down the speed in the manner described above of playing the stop or lowering contact in coming to a stop during hoisting. To stop the car, the stop-contact 36 is closed. This brings the switch-block back to stop position and automatically breaks the car-circuit. The down brake-magnet circuit G is also broken. Opening the down brake-magnet circuit causes the working motor to be shunted at the choking-shunt and the brake to be applied. The working motor and car stop. If, however, the stop-contact of the car-switch is held open until the car approaches nearly to the lowest limit of travel, the roller 28 on the traveling cross-head closes the second branch H of the brake-circuit at the lower automatic 27 therein. The working motor is thereby gradually short-circuited and the car brought to travel at slowest speed until stopped at the buffer-nut. The position of the parts is now that illustrated in Fig. 7. Closing the stop-contact of the car-switch will bring the system to the neutral or stop position illustrated in Fig. 2, except that the lower automatic will remain closed until the car starts upward. Should the car during descent attain speed greater than the maximum permitted, the down brake-magnet circuit G will be opened by the centrifugal governor 26. This will cause the brake 21 to be applied and the working motor to be shunted, thus bringing the car to a stop, or at any rate slowing it down until the centrifugal falls to the speed at which it again closes the down brake-magnet circuit G. The condition of the circuits when the centrifugal governor 26 has opened the down brake-magnet circuit while the car is descending at more than the maximum permitted speed is illustrated in Fig. 7. Should the overload-fuse 54 in the feed-circuit be blown, thus opening the connection of the working motor back to the dynamo or other source of supply, the current from the leads cannot be reëstablished through the feed-circuit C until this brake is closed, but the car-circuit and the down brake-magnet circuit G, which are connected to the main dynamo around the fuse so as to be independent thereof, can still be operated so the car can be fully controlled in descent, and since the working motor is in part separately excited by the shunt field-coils being connected up directly to the leads and independently of the other connections of the motor the motor will have some field independent of that generated by its own rotation. It would be possible, however, to lower the car even if there were no shunt-field, the motor being in part self-exciting, and if the main fuse is not blown the car can be hoisted with the series field-coil alone. The automatics will all work, although some of them not so effectively.

It is obvious that many changes can be made in my system without departing from the spirit of the invention.

Therefore, without limiting myself to the precise details shown or described, what I claim, and desire to secure by Letters Patent of the United States, is—

1. The combination of a working motor, one or more operative line-circuits, and an electrically-controlled choking-shunt for the working motor automatically closed on failure of an operative line-circuit, substantially as described.

2. The combination of a working motor and working mechanism, an electrically-controlled automatic choking-shunt for the working motor, and an electromechanical brake for the working mechanism operating simultaneously with the choking-shunt, substantially as described.

3. The combination of a working motor and an electrically-controlled automatic choking-shunt therefor operated by a double-coil magnet one coil being operative during hoisting and the other during lowering, substantially as described.

4. The combination of a working motor, one or more operative line-circuits, an electrically-controlled choking-shunt for the working motor, and an electrically-controlled brake for the working motor, the shunt being automatically closed and the brake being automatically applied on failure of an operative line-circuit, substantially as described.

5. A switch having three circuit-closing contacts, two of which can be closed independently of each other, but only on opening the third, and means for automatically closing the third contact and opening whichever one may be closed of the other two, substantially as described.

6. A switch having three positions in which it will close a circuit, and connections and means for operating the switch such that it can be brought into either of two of these positions only when moved out of the third position, and means for automatically bringing the switch into said third position, together with operative circuits through the switch when in the first two positions, and a stop or reversing circuit through the switch when in the third position, substantially as described.

7. The combination of driving mechanism, a main switch to control it, an auxiliary switch, and means controlled by the auxiliary switch for operating the main switch, the main switch having two positions corresponding to opposite movements of the driving mechanism, and a stop position corresponding to the condition of rest in the driving mechanism, the auxiliary switch having positions corresponding to those of the main switch, and means for automatically bringing the auxiliary switch when released to the position which corresponds to the stop position of the main switch, substantially as described.

8. A switch having a stop, hoist and lowering position and composed of a hoist branch and means for breaking it, and a lowering branch and means for breaking it with contacts such that the two branches are independent of each other, a stop-contact which can be connected in either of these branches, a coöperating stop-circuit breaker, and means operative in all positions of the switch for closing the circuit through any contact, excepting a contact which rests upon a circuit-breaker, substantially as described.

9. A switch having steady and extreme stop, hoist and lowering positions and composed of a hoist branch and means for breaking it, a lowering branch and means for breaking it, with contacts such that the two branches are independent of each other, a stop-contact which can be connected to either of these branches, and a coöperating stop-circuit breaker, and means for closing it through any contact, excepting a contact which rests upon a circuit-breaker, substantially as described.

10. A switch having stop, hoist and lowering contacts and placed in a circuit composed of a hoist branch and means for breaking it, and a lowering branch and means for breaking it, the stop-contact being adapted to be connected to either of these branches, and a motor connected in circuit with this switch in such manner that it can be controlled through the switch, substantially as described.

11. A compound switch consisting of two parts, and having two branches in each of which is a controlled circuit-closer forming one part of the switch, in combination with an electric motor for driving the other part of the switch and included in both branches of the switch, and a circuit-changer acting to change the circuit from one branch to the other, substantially as described.

12. A compound switch consisting of two parts, and having two branches in each of which is a controlled circuit-closer forming one part of the switch, in combination with an electric motor for driving the other part of the switch and included in both branches of the switch, and a circuit-changer acting to

change the circuit from one branch to the other, and means for automatically opening the circuit-changer, substantially as described.

13. A compound switch with two branches in each of which is a controlled circuit-closer, in combination with an intermediate branch and a circuit-changer acting to change the circuit of the intermediate branch from one branch to the other, and means for automatically operating the circuit-changer, substantially as described.

14. A compound switch with two branches in each of which is a controlled circuit-closer and an automatic circuit-breaker, in combination with an intermediate branch and a circuit-changer acting to open the circuit between the intermediate branch and one of the branches and close the other, and means for automatically operating the circuit-changer, substantially as described.

15. The combination of a current-controller, means for operating it, a suitable circuit for controlling the controller-operating means, a circuit-changer operating to bring the controller to a definite position, and means for automatically operating the circuit-changer, substantially as described.

16. The combination of a current-controller, means for operating it, a suitable circuit for controlling the controller-operating means, a circuit-changer operating to restore the controller to initial position, and means for automatically operating the circuit-changer, substantially as described.

17. The combination of a current-controller, means for operating it, a circuit in which are one or more controlled circuit-closers and one or more automatic circuit-openers, whereby the controller can be moved from initial position to one or more definite positions, a circuit-changer operating to restore the controller to initial position, and means for automatically operating the circuit-changer, substantially as described.

18. A compound switch consisting of two independent branches, in each of which is a controlled circuit-closer and an automatic circuit-breaker, in combination with a controlled circuit-changer coöperating to change the circuit from one of the independent branches to the other, substantially as described.

19. A compound switch consisting of two independent branches, in each of which is a controlled circuit-closer and an automatic circuit-breaker, in combination with a controlled circuit-closer, a circuit-changer and an automatic circuit-breaker coöperating to change the circuit from one of the independent branches to the other and automatically open it at a desired point, substantially as described.

20. A compound switch having stop, hoist and lowering positions, and composed of a hoist branch and a lowering branch which are independent of each other and in each of which is an automatic circuit-breaker and a controlled circuit-closer, a stop branch which can be connected to either of the other branches and in which is an automatic circuit-breaker and a controlled circuit-closer, and means operative in all positions of the switch for closing any one of the branches excepting a branch which is open at its circuit-breaker, substantially as described.

21. A compound switch having steady and extreme stop, hoist and lowering positions, and composed of a hoist branch and a lowering branch which are independent of each other and in each of which is an automatic circuit-breaker and a controlled circuit-closer, a stop branch which can be connected to either of the other branches, a stop automatic circuit-breaker and controlled circuit-closer, and means for closing any one of the branches when the switch is in steady position, and means operative in all positions of the switch for closing any one of the branches excepting a branch which is open at its circuit-breaker, substantially as described.

22. A compound switch consisting of two independent branches, in each of which is a controlled circuit-closer and an automatic circuit-breaker, in combination with a controlled circuit-changer operating to change the circuit from one of the independent branches to the other, the compound switch being directly connected to a motor which is controlled through the switch, substantially as described.

23. The combination of a working motor, a feed-circuit containing in series field-coils and the armature of the motor, an automatic choking-shunt, and means for opening the shunt when the circuit is charged and closing it when the current fails, and connections whereby the field-coils the armature and choking-shunt will be in series when the latter is closed, substantially as described.

24. The combination of a working motor, a feed-circuit containing in series the armature thereof and a brake-operating coil, an automatic choking-shunt, means for opening the shunt when the circuit is charged and closing it when the current fails, and connections whereby the armature and choking-shunt when the latter is closed will be in series in a circuit in which the brake-operating coil is not included, substantially as described.

25. The combination of a working motor, a feed-circuit which contains in series a brake-operating coil and field-coils and the armature of the motor, an automatic choking-shunt, and means for opening the shunt when the circuit is charged and closing it when the current fails, and connections whereby field-coils, the armature and the choking-shunt when the latter is closed will be in series in a circuit in which the brake-operating coil is not included, substantially as described.

26. The combination of a working motor, and a feed-circuit containing in series a brake-operating coil and field-coils and the armature of the motor, an automatic choking-shunt,

means for opening the choking-shunt when the circuit is charged and closing it when the current fails, and a switch and connections whereby the armature and field-coils can be cut off from the brake-operating coil and leave them connected in series with each other and the choking-shunt, substantially as described.

27. The combination of suitable working mechanism, an electromechanical brake therefor, a suitable circuit and a monitor centrifugal circuit-opener to apply the brake, substantially as described.

28. The combination of a working motor, a suitable circuit and electromechanical brake, a monitor centrifugal circuit-opener, so constructed as to open at one speed and close at another speed, substantially as described.

29. In an electric-elevator system, an upper automatic switch, a centrifugal circuit-opener, and a compound brake-magnet circuit having one branch connected to line through the upper automatic and another branch through the centrifugal circuit-opener, substantially as described.

30. The combination of working mechanism, an electric working motor and working-motor circuit, and a down brake-magnet circuit containing a monitor centrifugal circuit-opener and an electromechanical brake for the working mechanism, substantially as described.

31. The combination of working mechanism, an electric working-motor circuit and switch, an electromechanical brake for the working mechanism, a down brake-magnet circuit controlled by a monitor centrifugal circuit-opener and by a switch which coöperates with the working-motor switch, substantially as described.

32. The combination of a working motor, an automatic choking-shunt therefor, working mechanism, an electromechanical brake therefor, a suitable circuit, and a monitor centrifugal circuit-opener, substantially as described.

33. The combination of a working motor, an automatic choking-shunt therefor, working mechanism, an electromechanical brake therefor, a suitable circuit, and a monitor centrifugal circuit-opener, so constructed as to open at one speed and close at another speed, substantially as described.

34. The combination of a current-controller, a pilot-motor for operating it, a circuit for controlling the pilot-motor in which are one or more controlled circuit-closers, whereby the controller can be moved from initial position, a circuit-changer operating through the pilot-motor to restore the controller to initial position, and means for automatically operating the circuit-changer, substantially as described.

35. The combination of a current-controller, a pilot-motor for operating it, a circuit in which are one or more controlled circuit-closers, and one or more automatic circuit-openers, whereby the controller can be moved from initial position to one or more definite positions, a circuit-changer operating to restore the controller to initial position, and means for automatically operating the circuit-changer, substantially as described.

36. The combination of a working motor, and a pilot-motor for controlling the working motor, and a two-branch car-circuit in each branch of which is included the armature and part of the field-coils of the pilot-motor, substantially as described.

37. The combination of a working motor, and a pilot-motor for controlling the working motor, and a two-branch car-circuit, in each branch of which is a rheostat and the armature and a part of the field-coils of the pilot-motor, substantially as described.

38. The combination of a two-branch car-circuit, in which is included a compound switch consisting of two automatic circuit-breakers and two controlled circuit-closers, and a controlled circuit-changer and a circuit-closer operating to change the circuit from one branch of the car-circuit to the other, in combination with a compound motor having two sets of field-coils, one set of field-coils and the armature being included in each branch, substantially as described.

39. The combination of a car-circuit having a hoist branch and a lowering branch, a motor having its armature and a part of its field-coils in each of the branches, a separate rheostat in each of the branches, and a compound switch having a controlled circuit-closer and an automatic circuit-breaker in each of the branches, substantially as described.

40. The combination of a car-circuit having a hoist branch and a lowering branch, a motor having its armature and a part of its field-coils in each of the branches, a separate rheostat in each of the branches, and a compound switch having a controlled circuit-closer and an automatic circuit-breaker in each of the branches, and a controlled circuit-changer operating to change the circuit from one of the branches to the other, and an automatic circuit-breaker coöperating therewith, substantially as described.

41. The combination of a compound working motor, hoisting mechanism connecting the car and motor and driving the motor as the car descends, and a two-branch brake-circuit, each branch including the motor-armature and series field-coils, and a circuit-closer, and being operated independently of the other branch, substantially as described.

42. The combination of an electric motor partly series wound and partly separately excited as to field, a car, hoisting mechanism connecting the car and motor, and driving the motor as the car descends, a down regulating-circuit, a switch for connecting the motor in this circuit and gradually varying

the resistance therein, to control the speed of the car in descending, substantially as described.

43. The combination of an electric working motor and circuits, and a choking-shunt connected around the motor independently of the working-circuit connections, a circuit-closer in the choking-shunt and means for closing the circuit through the choking-shunt whenever the current fails, substantially as described.

44. The combination of an electric working motor, hoisting mechanism connecting the car and motor and driving the motor as the car descends, and a two-branch brake-circuit, each branch including the motor-armature and a circuit-closer, a choking-shunt, the shunt and branches being operated independently of each other, substantially as described.

45. The combination of an electric working motor, hoisting mechanism connecting the car and motor and driving the motor as the car descends, and a compound brake-circuit, which includes a circuit-closer and rheostat to regulate the speed of the car in descent, a circuit-closer and rheostat to slow down the car automatically at the bottom of the shaft, and a circuit-closer and rheostat operating to close the circuit whenever the current fails, substantially as described.

46. In a gravity-elevator system a compound working motor and a working-motor circuit, a shunt field-circuit, series field-coils in the working-motor circuit with the armature, a main regulator and connections such that it can be brought into hoist, stop and lowering positions without reversal of the current in the motor-armature and series field-coils, substantially as described.

47. In a gravity-elevator system a compound working motor and working-motor circuit, a shunt field-circuit, series field-coils, a working-motor switch and connections such that the armature and series field-coils can be connected in series to the line or closed on themselves, substantially as described.

48. In a gravity-elevator system a compound working motor and working-motor circuit, a shunt field-circuit, series field-coils, a main regulator, and connections such that the main regulator can be brought into hoist, stop and lowering positions and the armature and series field-coils be connected to line or closed on themselves, without reversal of the motor, substantially as described.

49. The combination of an electric working motor, an up circuit, a down circuit, and connections whereby the motor can be connected in the up circuit or down circuit at will, an automatic choking-shunt for the working motor connected independently of the up and down circuits, and a circuit-opener which closes the circuit through the choking-shunt whenever the current fails, substantially as described.

50. The combination of a car, working mechanism, a working motor, an up regulating-circuit, an electromechanical brake, and a compound brake-operating circuit to control the brake during hoisting and lowering, substantially as described.

51. The combination of a car, working mechanism, an electromechanical brake therefor, a working motor, a choking-shunt therefor, and a compound circuit to control the brake and shunt, substantially as described.

52. The combination of a car, working mechanism, a working motor, a feed-circuit, a down brake-magnet circuit, and a brake for the working mechanism controlled by the feed-circuit during ascent and by the down brake-magnet circuit during descent of the car, substantially as described.

53. The combination of a car, working mechanism, a working motor, a feed-circuit and a down brake-magnet, a choking-shunt for the working motor controlled by the feed-circuit during ascent and by the down brake-magnet circuit during descent of the car, substantially as described.

54. The combination of a car, a working motor, a feed-circuit and a down brake-magnet circuit, a choking-shunt for the working motor and a brake for the working mechanism, both controlled by the feed-circuit during ascent and by the down brake-magnet circuit during descent of the car, substantially as described.

55. In an elevator system a feed-circuit having a double-coil magnet, one coil of which is in the feed-circuit and lifts the brake during hoisting, and a separate circuit which includes the other coil of the magnet, to lift the brake during lowering, substantially as described.

56. In a gravity-elevator system the combination of an electric motor, which is in part series wound and in part separately excited as to its field, hoisting mechanism controlled thereby, a feed-circuit, a brake-circuit, means for connecting the motor in the feed-circuit, and for connecting the motor in the brake-circuit, according as the elevator is to ascend or descend, substantially as described.

57. In a gravity-elevator system the combination of an electric motor which is in part series wound and in part separately excited as to its field, hoisting mechanism controlled thereby, an up regulating-circuit, a down regulating-circuit, and means for connecting the motor in the up regulating-circuit, and gradually varying the resistance therein, and for connecting the motor in the down regulating-circuit and gradually varying the resistance therein, according as the elevator is to ascend or descend, substantially as described.

58. The combination of an electric motor, hoisting mechanism controlled thereby, an up regulating-circuit, a switch therein including a series of graduated resistances, a down regulating-circuit, including the same switch and graduated resistances, and means for operating the switch in opposite senses to connect

the motor in the up regulating-circuit and gradually varying the resistance therein when the car is to ascend, and to connect the motor in the down regulating-circuit and gradually varying the resistance therein when the car is to descend, substantially as described.

59. The combination of a car-circuit, a compound brake-magnet circuit, and a monitor centrifugal circuit-opener operating in descent, substantially as described.

60. The combination of an electric motor, working mechanism connecting the car and motor, a car-circuit, a down brake-magnet circuit, and a centrifugal circuit-opener and magnet in the down brake-magnet circuit for controlling the car in descent, substantially as described.

61. The combination of an electric working motor, working mechanism connecting the car and motor, a car-circuit, a down brake-magnet circuit, a centrifugal circuit-opener, and a brake-magnet in the down brake-magnet circuit, and suitable switches, whereby the car-circuit controls the down brake-magnet circuit, except when it is opened by the centrifugal circuit-opener, substantially as described.

62. The combination of a working motor, a choking-shunt therefor, and a compound circuit for controlling this shunt, substantially as described.

63. The combination of a working motor, a choking-shunt therefor, and a compound circuit for controlling this shunt with a monitor centrifugal circuit-opener therein, substantially as described.

64. The combination of a working motor, a down regulating-circuit, an electromechanical brake, a down brake-magnet circuit, and a magnet therein to control the brake, substantially as described.

65. The combination of a working motor, a down regulating-circuit, an electromechanical brake, a down brake-magnet circuit, a magnet therein to control the brake, and a monitor centrifugal circuit-opener therein, substantially as described.

66. The combination of a working motor, a down regulating-circuit, an electromechanical brake, a down brake-magnet circuit, a magnet therein to control the brake, and a monitor centrifugal circuit-opener operating to apply the brake, so constructed as to open and close the down brake-magnet circuit at different speeds, substantially as described.

67. The combination of a working motor, a down regulating-circuit, a choking-shunt, an electromechanical brake, and a down brake-magnet circuit for controlling the choking-shunt and the brake, substantially as described.

68. The combination of a working motor, a down regulating-circuit, a choking-shunt, an electromechanical brake, a down brake-magnet circuit, and a centrifugal circuit-opener therein, to control the choking-shunt and the brake, substantially as described.

69. The combination of a working motor, a down regulating-circuit, a choking-shunt, a lower automatic circuit, all being in multiple with each other, and a circuit to control the choking-shunt, substantially as described.

70. The combination of a working motor, a down regulating-circuit, a lower automatic circuit, an electromechanical brake, a down brake-magnet circuit, and a centrifugal circuit-opener therein to apply the brake, substantially as described.

71. In an electric elevator system the combination of a working motor, a down regulating circuit, a lower automatic circuit, a choking-shunt, an electromechanical brake, a down brake-magnet circuit with a centrifugal circuit-opener therein to control the brake and the choking-shunt, substantially as described.

72. The combination of a working motor, an up regulating-circuit, a down regulating-circuit, an electromechanical brake, and a compound brake-magnet circuit to control the brake in ascent and descent, substantially as described.

73. In a gravity-elevator system with underbalanced car the combination of a working motor, a feed-circuit, a down regulating-circuit, an electromechanical brake, and a down brake-magnet circuit, substantially as described.

74. In a gravity-elevator system with underbalanced car the combination of a working motor, an up regulating-circuit, a down regulating-circuit, an electromechanical brake, a magnet in the up regulating-circuit to control the brake during hoisting, a down brake-magnet circuit, and a magnet therein to control the brake during lowering, substantially as described.

75. The combination of a working motor, and an electromechanical brake having a compound magnet, an up regulating-circuit, the armature of the working motor and series brake-coils therein, means for connecting this circuit during ascent to the source of supply, a down regulating-circuit, and means for closing the down regulating-circuit during descent, in combination with a down brake-magnet circuit in which are shunt brake-coils, and means for closing it during descent, substantially as described.

76. The combination of a working motor, an up regulating-circuit, a down regulating-circuit, an electromechanical brake, a magnet in the up regulating-circuit to control the brake in ascent, a down brake-magnet circuit, and a speed-controlled circuit-opener and magnet therein to control the brake in descent, substantially as described.

77. The combination of a working motor, an up regulating-circuit, a down regulating-circuit, a choking-shunt, an electromechanical brake, a down brake-magnet circuit, and a magnet therein to control the choking-shunt and the brake, substantially as described.

78. The combination of a working motor, an

up regulating-circuit, a down regulating-circuit, a choking-shunt, an electromechanical brake, a down brake-magnet circuit, and a centrifugal circuit-opener therein to control the choking-shunt and brake, substantially as described.

79. The combination of an electric working motor, an up regulating-circuit, a down regulating-circuit, and a choking-shunt in multiple with respect to the up and down circuits, and an independent circuit to control the choking-shunt, substantially as described.

80. The combination of an electric working motor, an up regulating-circuit, a down regulating-circuit, a choking-shunt, and a down brake-magnet circuit, the choking-shunt being controlled by the up regulating-circuit during ascent, and by the down brake-magnet circuit during descent, substantially as described.

81. The combination of an electric working motor, an up regulating-circuit, an automatic circuit-opener therein, to open the circuit when the car reaches the highest point of travel, a down regulating-circuit, a lower automatic circuit to close on the motor when the car reaches the lowest point of its travel, a choking-shunt, and an independent circuit to control the choking-shunt, substantially as described.

82. The combination of an electric working motor, an up regulating-circuit, a down regulating-circuit, a choking-shunt in multiple with respect to the other two, an electromechanical brake, and an independent down brake-magnet circuit, the electromechanical brake and the choking-shunt being controlled by the up regulating-circuit during ascent, and by the down brake-magnet circuit during descent, substantially as described.

83. The combination of an electric working motor, an up regulating-circuit, an upper automatic circuit-opener therein, a down regulating-circuit, a lower automatic circuit, a choking-circuit in multiple with respect to the foregoing circuits, an electromechanical brake, and an independent brake-magnet circuit to control the choking-shunt and the brake, substantially as described.

84. The combination of a working motor, an up regulating-circuit, an upper automatic circuit-opener therein, a down regulating-circuit, a lower automatic circuit, a choking-shunt in multiple with respect to the foregoing circuits, an electromechanical brake, an independent compound brake-magnet circuit to control the choking-shunt and brake, and a monitor centrifugal circuit-opener, the brake-magnet circuit including on its up side the upper automatic, and on its down side the centrifugal circuit-opener, substantially as described.

85. The combination of a source of supply of electricity, a working motor, and an electromechanical brake having a compound magnet, an up regulating-circuit, the armature of the working motor and series brake-coils therein, means for connecting the up regulating-circuit during ascent to the source of supply, a down regulating-circuit and means for closing it on the motor during descent, in combination with a down brake-magnet circuit containing a speed-controlled circuit-opener, and shunt-coils of the brake-magnet, and means for connecting it to the source of supply, substantially as described.

86. The combination of a working motor, a car, hoisting mechanism connecting the car and motor and driving the motor as the car descends, an electromechanical brake, a source of supply, an up regulating-circuit, and means for connecting the circuit during ascent to the source of supply, a down regulating-circuit, and means for closing it on the motor during descent, a choking-shunt in multiple with the foregoing circuits, a compound brake-magnet circuit containing a speed-controlled circuit-opener operating only in descent, and means for connecting the brake-magnet circuit to the source of supply, the brake and choking-shunt being controlled by the brake-magnet circuit, substantially as described.

87. The combination of a working motor, a car, hoisting mechanism connecting the car and motor and driving the motor as the car descends, an electromechanical brake, a source of supply, an up regulating-circuit having an upper automatic circuit-opener therein, and means for connecting the circuit during ascent to the source of supply, a down regulating-circuit, and means for closing it onto the motor during descent, a lower automatic circuit, a choking-shunt in multiple with the foregoing circuits, a compound brake-magnet circuit containing a speed-controlled circuit-opener, and means for connecting it to the source of supply, the electromechanical brake and the choking-shunt being controlled by the brake-magnet circuit, substantially as described.

88. The combination of a working motor, a car, working mechanism connecting the car and motor, a feed-circuit, a brake-circuit, a compound brake-magnet circuit, and a car-circuit which controls the other circuits, substantially as described.

89. The combination of a working motor, a car, working mechanism connecting the car and motor, a feed-circuit, a brake-circuit, a compound brake-magnet circuit, and a car-circuit which controls the other circuits through switches which have coördinated stop, hoist and lowering positions, substantially as described.

90. The combination of an electric working motor and switch, a feed-circuit which includes an overload circuit-breaker, and a car-circuit independent of the circuit-breaker to control the motor-switch, substantially as described.

91. The combination of an electric working motor, a source of supply, a circuit connecting the motor with the source of supply through an overload circuit-breaker, and con-

trolling-circuits for lowering the car which are independent of the overload circuit-breaker, substantially as described.

92. The combination of an electric working motor, a feed-circuit, a down brake-magnet circuit, a car-circuit to control the other circuits, and an overload circuit-opener in the feed-circuit, of which the car and down brake-magnet circuits are independent, substantially as described.

93. The combination of an electric motor, a car, hoisting mechanism connecting the car and motor and driven by the motor during ascent and driving the motor during descent of the car, an up regulating-circuit, a brake-circuit, and a down brake-magnet circuit, the up regulating-circuit including an overload circuit-breaker, and the down brake-magnet circuit and brake-circuit being independent of this circuit-breaker, substantially as described.

94. The combination of an electric motor, a car, hoisting mechanism connecting the car and motor, a feed-circuit, an overload circuit-opener therein, a brake-circuit, a down brake-magnet circuit, and a car-circuit for controlling all the other circuits, the brake and down brake-magnet and car circuits being independent of the circuit-opener in the feed-circuit, substantially as described.

95. The combination of a set of elevators, a car-circuit for each elevator, these circuits being arranged in multiple, a common-control switchboard, a separate switch thereon for each car, a common-control switch for all of the cars, and connections from each of the separate switches by which it can be connected to one of the car-circuits or to the common-control switch, as preferred, substantially as described.

96. The combination of a set of elevators, working mechanism and regulators therefor, a car-circuit to control the working mechanism of each elevator through the regulator thereof, these car-circuits being arranged in multiple, a common-control switchboard, a separate switch thereon for each car, a common-control switch for all of the cars, and connections from each of the separate switches by which it can be connected to one of the car-circuits or to the common-control switch, as preferred, substantially as described.

97. In a rheostat a number of clips arranged in an arc of a circle and connected in series by resistance, the gap between the end clips being filled by insulated clips connected to intermediate clips, substantially as described.

Signed by me in New York city this 23d day of October, 1894.

FRANK J. SPRAGUE.

In presence of—
CHAS. M. SPRAGUE,
JAMES LEITCH.