No. 821,697. PATENTED MAY 29, 1906.

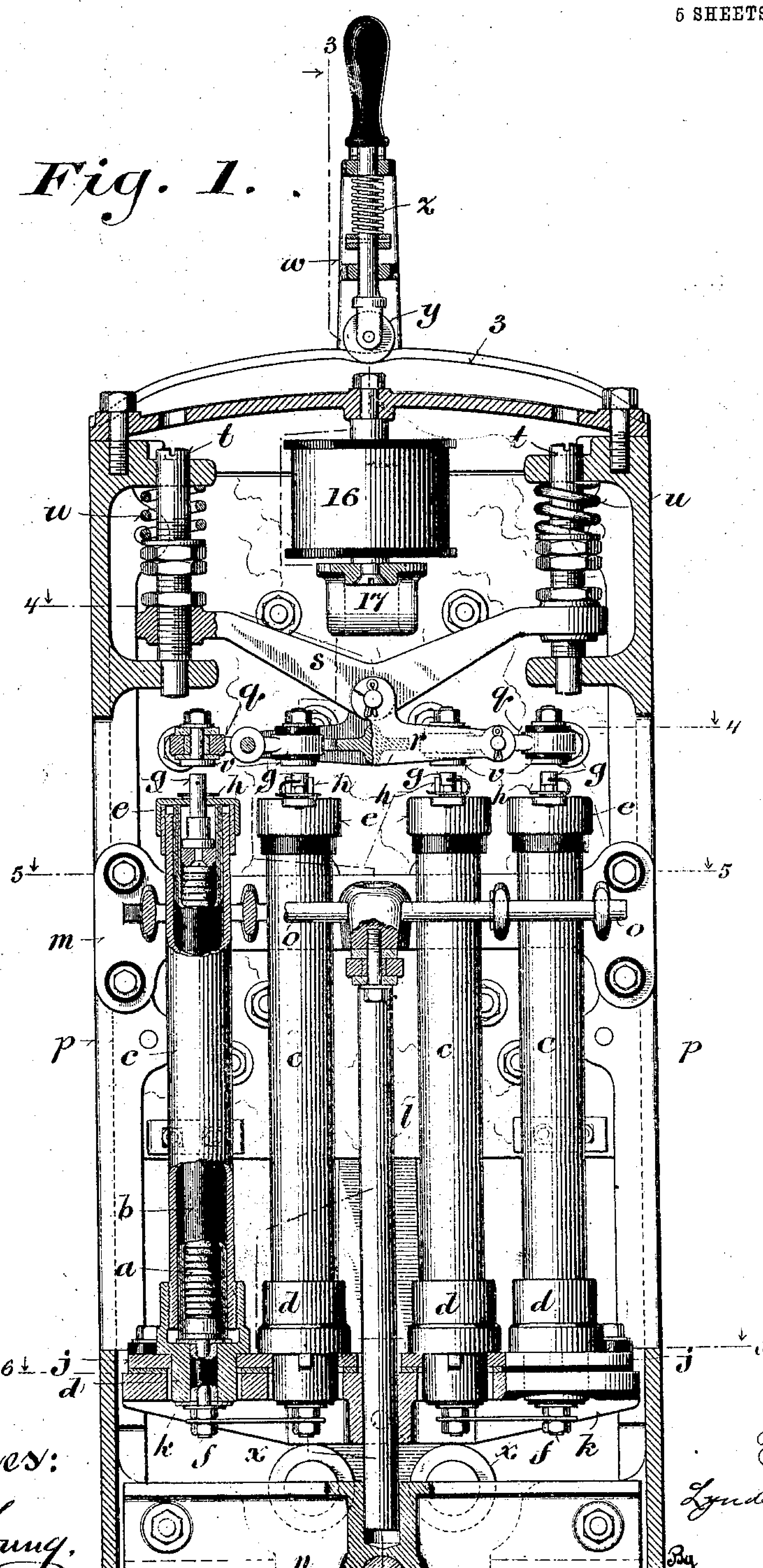
L. BRADLEY.

ELECTRIC CURRENT CONTROLLER.

APPLICATION FILED JUNE 9, 1904.

5 SHEETS—SHEET 1.

Fig. 1.



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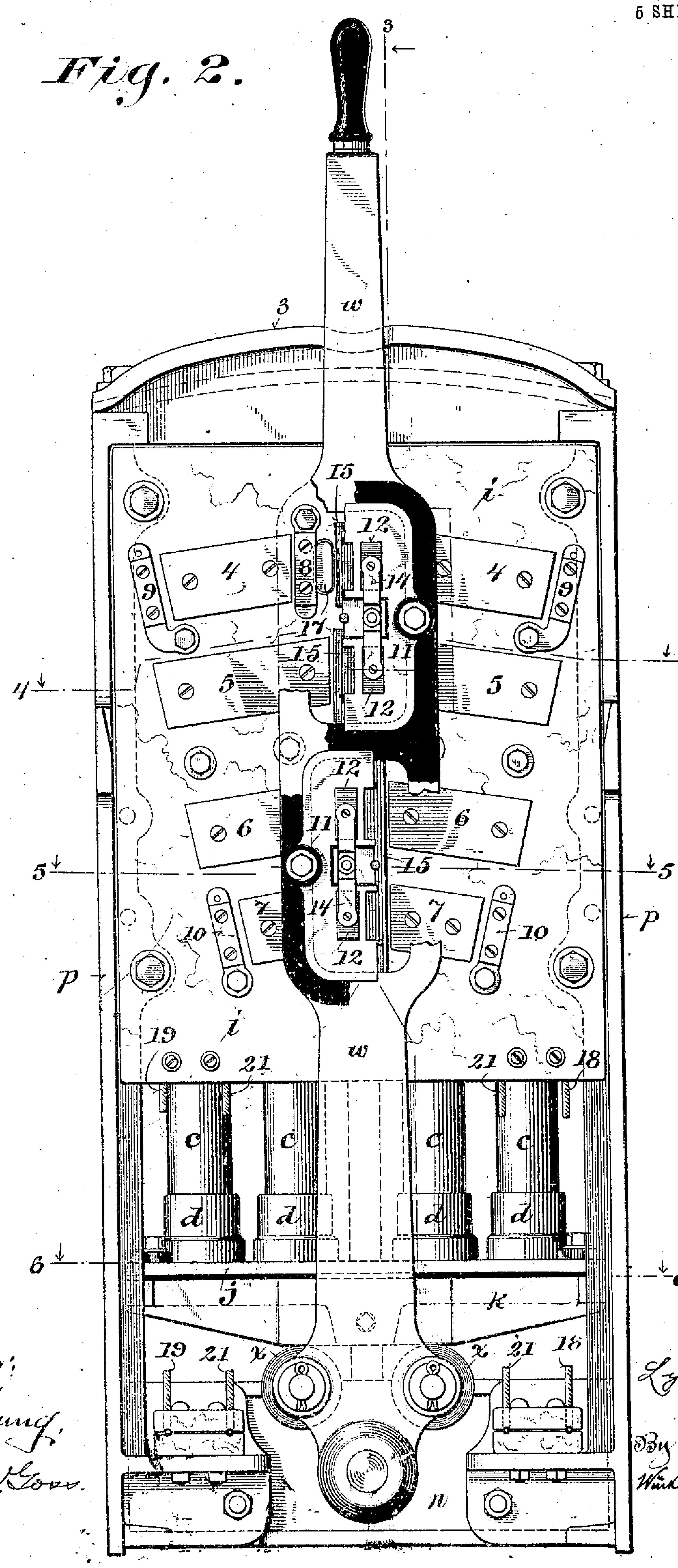
5 SHEETS—SHEET 2.

Fig. 2.



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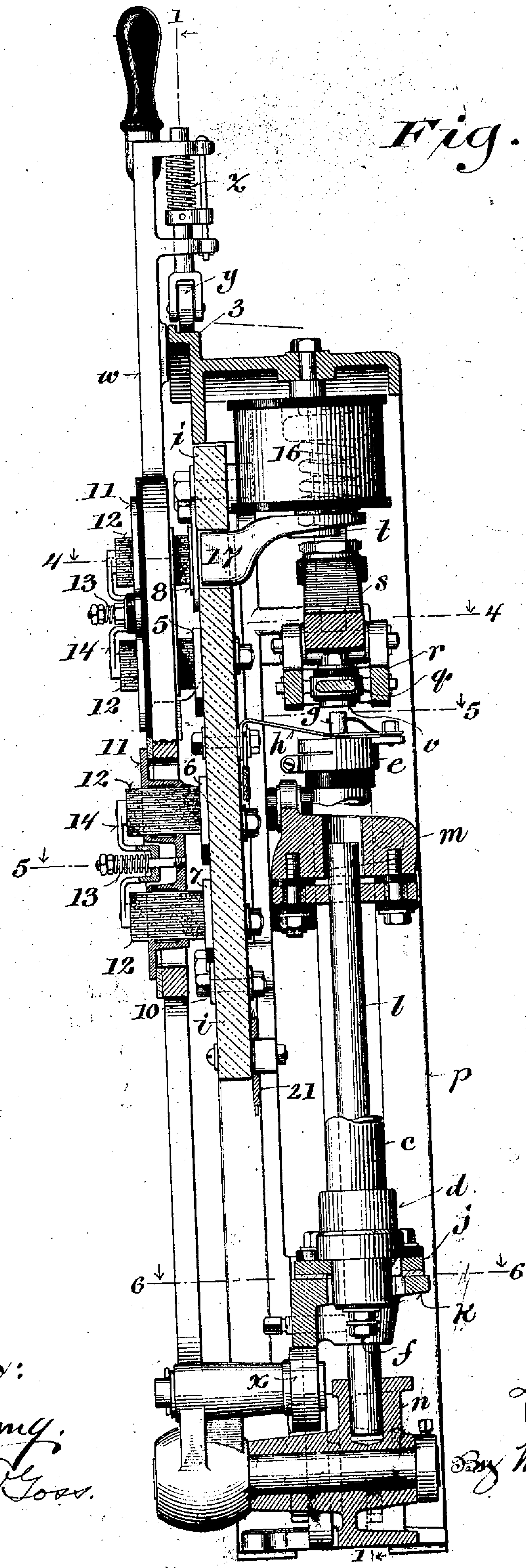
5 SHEETS—SHEET 3.

Fig. 3.



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5 SHEETS—SHEET 4.

Fig. 4.

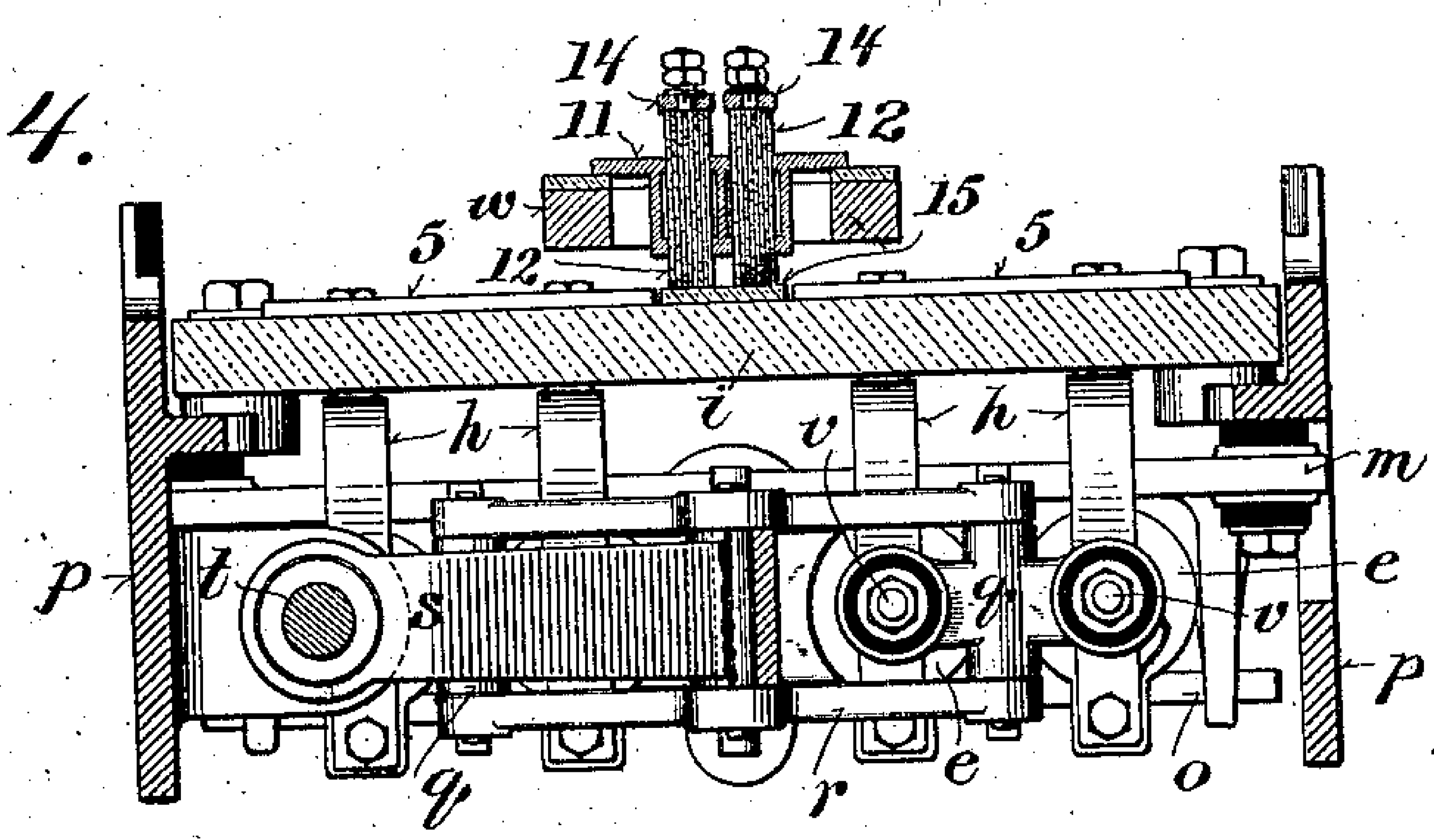


Fig 5.

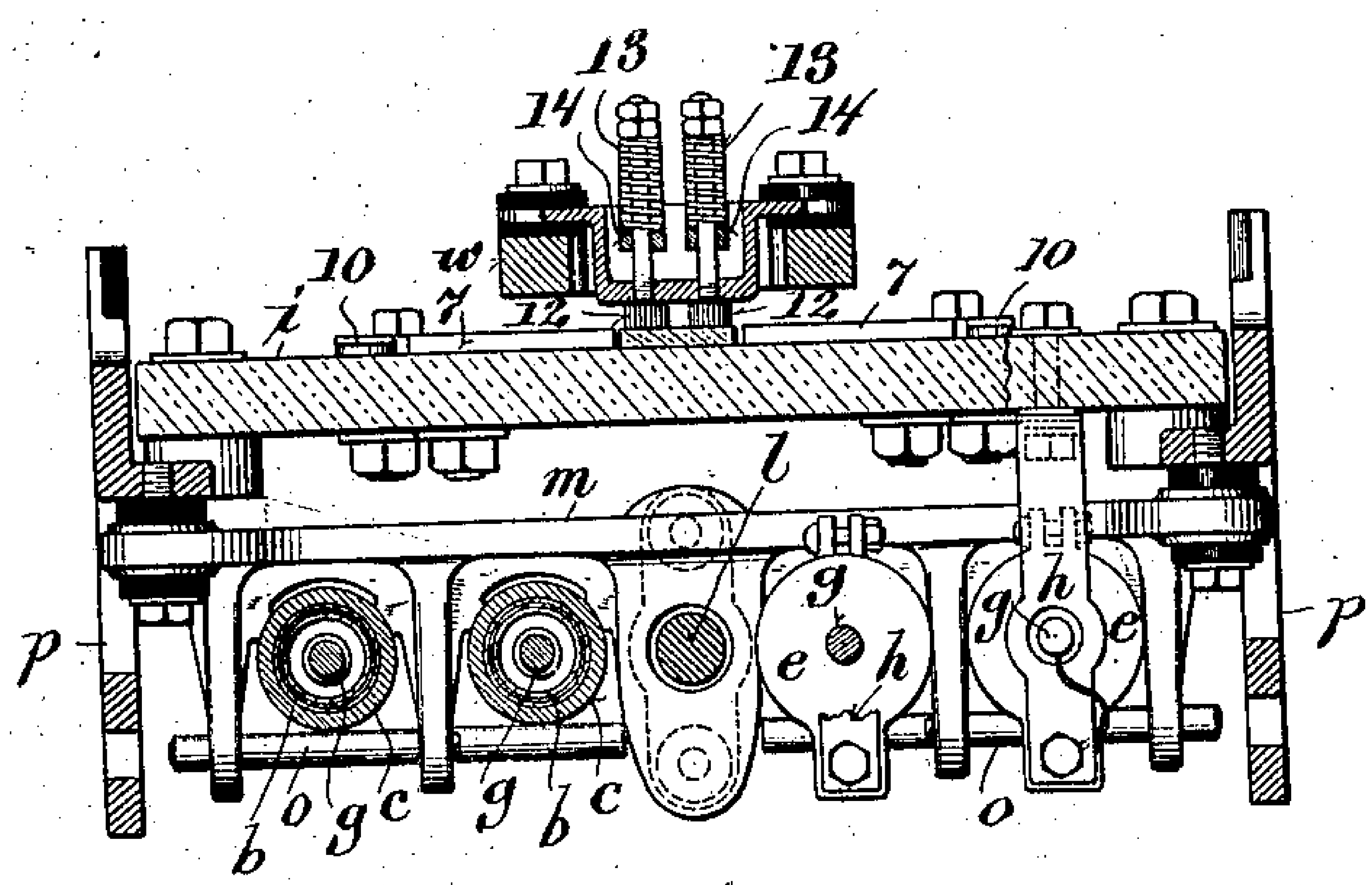
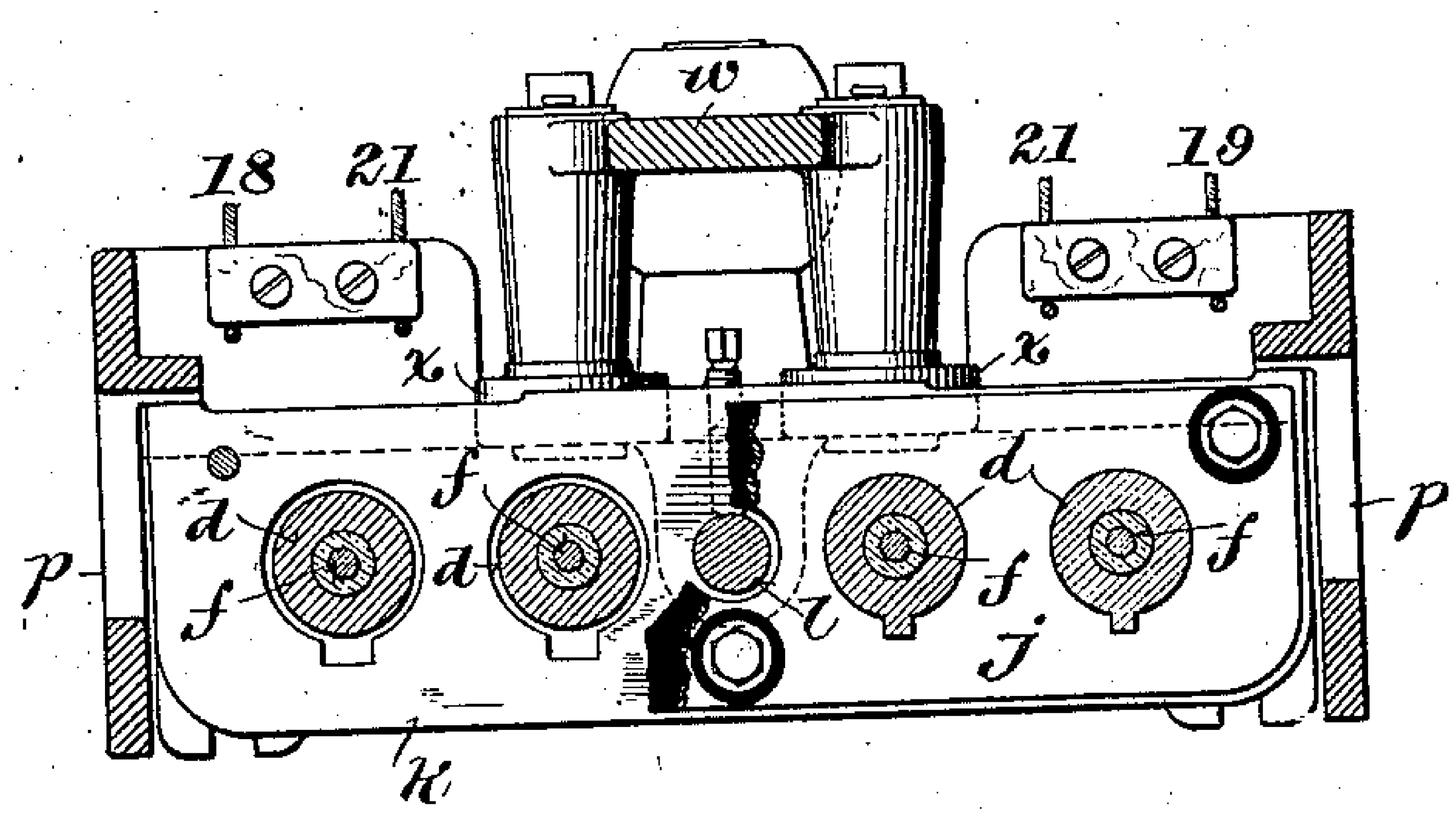


Fig. 6.



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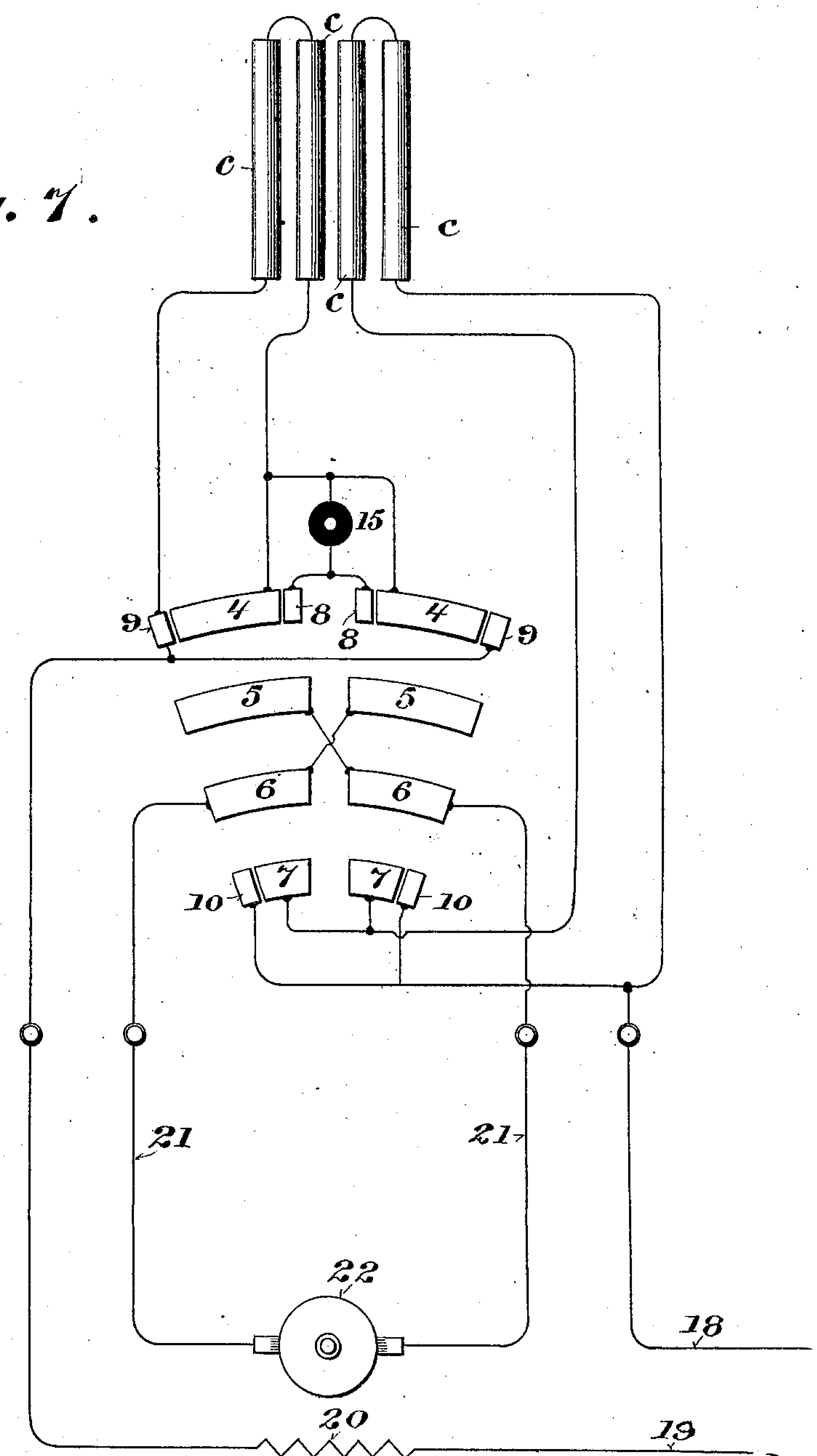
5 SHEETS—SHEET 5.

Fig. 7.



Witnesses

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UNITED STATES PATENT OFFICE.

LYNDE BRADLEY, OF MILWAUKEE, WISCONSIN, ASSIGNOR TO COMPRESSION RHEOSTAT COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

ELECTRIC-CURRENT CONTROLLER.

No. 821,697. Specification of Letters Patent. Patented May 29, 1906.

Application filed June 9, 1904. Serial No. 211,742.

To all whom it may concern:

Be it known that I, Lynde Bradley, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Electric-Current Controllers, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

This invention relates to controllers of the class for which United States Letters Patent No. 723,817 were issued to me March 31, 1903, and in which a compressible resistance medium is subjected to a variable pressure to gradually change its electrical conductivity and regulate the flow of current.

The main objects of the present invention are to equalize and reduce the manual effort required to operate the controller by increasing the power of the compressing mechanism as the reaction of the resistance medium is augmented by increased compression, to restore and maintain the normal resistance or low conductivity of the resistance medium when it is relieved from pressure, to effectively avoid or stop arcing and prevent injury to the switch contact-pieces and other parts of the controller when the circuit is broken, to provide for the quick and easy removal and renewal of the resistance units and other parts of the controller, and generally to improve the construction and operation of controllers of this class.

It consists in certain novel features of construction and in the peculiar arrangement and combinations of parts, as hereinafter particularly described, and defined in the claims.

In the accompanying drawings like characters designate the same parts in the several figures.

Figure 1 is a generally vertical section in a broken or irregular plane indicated by the line 1 1, Fig. 3, and an elevation showing particularly the construction and arrangement of the resistance units and of the compressing mechanism in a controller embodying my invention. Fig. 2 is an elevation of the reverse side of the controller, showing particularly the switching mechanism constituting a part of the controller. Fig. 3 is a vertical section of the controller in a plane indicated by the lines 3 3, Figs. 1 and 2. Figs. 4, 5, and 6 are horizontal sections of the controller in planes indicated by the lines 4 4, 5 5, and 6 6, respectively, on Figs. 1, 2, and 3; and Fig. 7 is a diagram illustrating the circuit connections of the controller.

The operation of the controller to which my present improvements relate depends upon the fact that the resistance of divided or disintegrated electrical conducting substances varies according to the pressure to which they are subjected. This is true in a very marked degree with carbon, and for this reason this material is preferably employed as the resistance medium in my improved controller.

For the purpose of illustrating and explaining the improvements constituting my present invention I have shown and will particularly describe a series reversible controller, although the invention is applicable to other types of controllers by such changes in the arrangement of parts and in the electrical connections as will be obvious to persons skilled in the art to which the invention pertains.

The carbon which serves as the resistance medium is formed into plates or disks which are arranged, as shown in Fig. 1, in piles or columns *a*. Each pile or column is inclosed and insulated by a tube *b*, preferably formed of loosely-wrapped asbestos-paper without glue, paste, or other binder. This has been found to be the most effective, durable, and satisfactory insulation for the carbon columns. For protection and support the columns thus covered and insulated are inclosed in metal tubes or cases *c*, which are threaded at their lower ends and provided with perforated caps *d*. At their upper ends they are provided with perforated caps *e*, which are clamped with insulating-bushings in place, as shown in Figs. 1 and 3.

Each carbon column terminates at the ends with copper-plated carbon blocks, which are thicker than the intermediate disks and bear against metal studs or plugs *f* and *g*. The studs *f* pass through and are insulated from the caps *d* at the lower ends of the tubes, and they are electrically connected in pairs or otherwise by metal plates or conductors, as shown in Fig. 1.

The studs or plugs *g*, which for the sake of lightness are preferably made of aluminium, so as to exert normally little pressure on the carbon columns, are secured by screws or otherwise to the upper copper-plated blocks, as shown in Fig. 1, thus forming carbon-tipped electrodes and insuring good electrical contacts and connections at the upper ends of the carbon columns, and they pass loosely through and are movable up and down in the caps e, with which they are connected by flexible conductors, said caps being also connected by flexible metallic bands h or other suitable conductors with binding-posts on the back of the slate panel or switch-base i. The carbon piles or columns constitute the resistance units of the controller.

Air being excluded from the tubes c, except what may enter through the small openings at their upper ends in the caps e around the plugs g, disintegration and consumption of the carbon, even if heated to a high temperature, are prevented. Whatever air may remain in or enter the tubes is expelled and displaced by carbon-dioxid gas, which is produced by heat developed in the operation of the controller and which, as is well known, prevents oxidation or combustion.

The caps d, formed with reduced extensions at their lower ends, are loosely fitted in openings in a plate j, which is mounted upon and insulated from a carriage or vertically-movable support k. This carriage is fastened to a vertical rod l, which is guided at its upper and lower ends by bearings in the frame of the controller, the upper bearing being attached to and insulated from the tube-rack m and the lower bearing being formed in the bottom girder or cross-piece n of the frame. The tube-rack m, in which the upper ends of the tubes c are guided and held in place by removable rods o, is attached at its ends to and insulated from the sides p of the frame. By simply withdrawing the rods o and detaching the electrical connections at the upper ends of the tubes said tubes can be readily removed from the controller and replaced.

The extensions on the caps d, which enter the openings in the plate j, are formed, as shown in Figs. 1, 3, and 6, with lugs, and the openings in said plate are formed on one side with corresponding notches to receive said lugs and insure the tubes c, with the electrical connections at their upper ends, being placed and held in the controller in their proper positions. Openings in the carriage k to receive the extensions on the lower ends of the plug d, are made somewhat larger than the corresponding openings in the plate j, so as to insure the insulation of the tubes c from the carriage.

Above the tubes c the controller is provided with a yielding equalizer by which the pressure exerted upon the several resistance units is equally distributed between them, crushing of the carbon is prevented, variation in the length of the columns a, due to expansion and contraction under varying temperatures, is allowed, and a sufficient range of movement of the operating-lever is permitted for practical operation of the controller. This equalizer comprises rockers q q, centrally pivoted to the ends of a rocker r, which is in turn centrally pivoted to a cross-bar s. The bar s is adjustably secured at its ends on rods t t, which are guided in bearings on the sides p p of the frame in lines parallel with the guide-rod l of the carriage k. The equalizer is yieldingly held in its normal position toward the carriage by springs u u bearing at their lower ends against nuts and interposed washers on the rods t and at their upper ends against lugs on the frame. The rockers q q are provided above and in line with the studs or plugs g with insulated abutments or bearings v. The downward movement of the equalizer is limited by the engagement of shoulders on the rods t with the lower guiding-lugs on the frame.

The guide-rods t t are threaded in the bar s, which is secured therein by jam-nuts, and the upper ends of said rods are slotted and accessible through holes in the top of the controller-frame for the purpose of turning them with a screw-driver and adjusting the equalizer toward and from the resistance units. The tension of the springs u u is readily adjusted by turning the nuts at their lower ends up or down on said rods.

The operating-lever w is fulcrumed at its lower end to the girder or cross-piece n of the frame and is provided on opposite sides of its axis near its fulcrum with rollers x x, upon which the carriage k normally bears, as seen in Figs. 1 and 2. At its upper end this lever is provided with a suitable handle and also with a roller y, which is movably mounted thereon and yieldingly held by a spring z against a curved track or runway 3 on the top or upper part of the frame. This runway is formed with a central depression in which the roller y rests when the operating-lever is in its initial and neutral position, as shown in Figs. 1 and 2. For a short distance on each side of this depression the runway is formed to a curve approximately concentric with the fulcrum of said lever, and then it gradually approaches said fulcrum toward its ends, the radius of the curve becoming shorter.

In connection with the variable resistance and compressing and equalizing devices of the controller, the following switch mechanism for turning the current on and off from the resistance, progressively short-circuiting the resistance in sections when the full current is on, and reversing the current is provided. Upon the plate panel or other suitable insulating-base i are mounted in pairs contact-plates 4, 5, 6, 7, 8, 9, and 10, the two plates of each pair being arranged on opposite sides of the central or neutral position of the operating-lever. Upon the operating-lever are mounted two insulated brush-holders 11, each of which is provided with two pairs of carbon or other brushes or contact-pieces 12, movably held therein and yieldingly pressed toward the fixed-contact-plates on the base *i* by springs 13, acting upon and through yokes 14, one set of brushes being arranged to span and electrically connect the contact-plates 4, 8, or 9 with the plates 5 and the other set to connect the contact-plates 6 with the plates 7 or 10 on either side of the center, according to the direction in which the operating-lever is turned. The contact-plates 5 and 6 are for the purpose of reversing the current, the contact-plates 9 and 10 are for progressively short-circuiting or cutting out the resistance medium in sections when the full current is on, and the contact-plates 8 are made separate and insulated from the contact-plates 4 for the purpose of renewal and for connecting a blow-out magnet in series with the plates 4 and 8, so that said magnet will be included in the circuit only with the full resistance or when the least current is flowing through the controller. Between the two sets of contact-plates on each side of the controller the panel *i* or switch-base is provided with fiber or other insulating plates 15 of the same thickness on which the brushes 12 bear when the operating-lever is in its central position. The blow-out magnet 16 has a forked pole-piece 17 projecting through openings in the slate panel *i* adjacent to the inner edges of the contact-plates 8 to concentrate the magnetic lines of force at the most effective points for extinguishing arcs when the circuit is broken.

Referring to Fig. 7, illustrating the electrical connections for a series reversible controller like that herein shown and described, the resistance units *c c* are connected with each other at one end in pairs. One of the units is connected at the other end with the contact-plates 4, while the other unit of the same pair is connected with the contact-plates 9. One unit of the other pair is connected with the contact-plates 7, while the other unit of this pair is connected with the contact-plates 10 and with one main or supply conductor 18. The plates 9 are connected with the other main or supply conductor 19 through the field 20 of the motor. The plates 5 and 6 are cross-connected, and the plates 6 are connected by conductors 21 with the armature 22 of the motor. The coil of the blow-out magnet 15 is connected with each of the plates 4 and 8 around or across the spaces between them. Of course it will be understood that the arrangement of the parts of the controller and their electrical connections may be varied to adapt the controller to motors of different types and for different kinds of work.

My improved controller herein shown and described operates as follows: Assuming that the main or supply conductors 18 and 19 are connected with a source of electricity and that the controlling-lever is in its middle and neutral position, as shown in Figs. 1 and 2, no current will flow through the motor or controller. If now the operating-lever *w* is turned in either direction from its central position sufficiently to carry the brushes 12 into engagement with the contact-plates—for example, if it is turned to the left, as shown in Fig. 2—the roller *y* will be carried out of the central depression in the track 3 upon a raised portion thereof, thereby further compressing the spring *z*, and the circuit will be closed through the controller, current flowing from the line 19 through the field 20 of the motor, as shown in Fig. 7, thence through the left contact-plate 9, one pair of the resistance units *c*, the blow-out magnet 15, the left contact-plate 8, the left upper pair of brushes 12, the left contact-plate 5, the right contact-plate 6, thence through the armature 22 of the motor back to the left contact-plate 6, through the lower left pair of brushes to the left contact-plate 7, thence through the other pair of resistance units *c* to the line 18. The continued movement of the lever in the same direction will operate, through the roller *x* at the right, as seen in Fig. 2, to lift the carriage *k* with the resistance units until the plugs *g* at their upper ends are brought into engagement with the bearing-pieces *v* of the equalizer. The resistance medium, consisting of the columns *a*. of carbon disks, will then be gradually compressed, the pressure being equally distributed by the rockers *q* and *r* between the several resistance units. As the lever is moved farther to the left the springs *u* will be compressed, the cross-bar *s* with the rockers will yield upwardly, and the pressure on the carbon columns will be gradually increased, thereby reducing their resistance to the flow of current. As the pressure upon the carbon is increased and its resistance reduced it reacts with augmented force upon the operating-lever, tending to carry it back to its initial position; but the power stored in the compressed spring *z*, acting through the roller *y* upon the track or runway 3, tends to turn the lever away from its central position with a gradually-increasing force, according to the pitch or inclination of the runway 3, which is so designed that the force exerted by the spring *z* through said roller *y*, tending to turn the lever in one direction, will approximately equalize the reaction of the compressed resistance medium, tending to move the lever in the opposite direction. The power required to operate the controller is thus distributed over the entire traverse of the operating-lever, and the compression of the resistance medium is effected with the expenditure of much less effort or energy than would otherwise be required. As the operating-lever approaches the outer limit of its movement the lower brush 12 passes off from the contact-plate 7 upon the contact-plate 10, thus cutting out or short-circuiting the resistance units *c* connected with the plate 10. The upper brush thereupon passes from the contact-plate 4 upon the plate 9, cutting out or short-circuiting the rest of the resistance units after they have been compressed to the fullest extent and their resistance to the current reduced to a minimum. When the lever is in its final or extreme position with the brushes resting on the contact-plates 9 and 10, the current will flow from the main 19 through the motor-field 20, thence through contact-plate 9, brushes 12, contact-plates 5 and 6, armature 22, contact-plate 6, brushes 12, contact-plate 10, to line 18 without passing through any of the resistance units *c*. As the lever is moved back to its middle position and the upper brushes pass over the contact-plate 8 the circuit is closed through the blow-out magnet 15, when the resistance units, relieved of pressure, have again assumed their normal condition of high resistance. As the last brush passes off from the contact-plate 8 any arc that may be formed will be instantly extinguished by said magnet. The blow-out magnet, connected as herein shown and described, carries only the starting or minimum current, and therefore may be wound to work with much greater efficiency than if it was made to carry the full-load current, since it is required to extinguish arcs only when the circuit is broken with the full resistance included therein. The contact-plates 8 at which the circuit is broken being most liable to injury from arcing or sparking are made separate from the plates 4, so that they may be easily renewed, besides affording means of cutting the blow-out magnet 15 out of circuit except when the full resistance is included therein. During the return movement of the operating-lever to its middle position the spring *z* is recompressed as the roller passes over the higher portion of the track or runway 3, and power is thus stored to compress or aid in compressing the resistance medium, when the circuit is again closed through the controller and the lever *w* is moved a sufficient distance in either direction from its middle or neutral position, as above explained. When the roller passes over the crest on either side of the central depression in the track upon either of the sloping sides of said depression, the spring *z* reacts to bring the lever *w* instantly to its central position, thus making a simple and effective quick-break switch. This automatic centering function of the spring-actuated roller *y* also operates to bring the carriage *k* and the upwardly-moving roller *x* on the operating-lever together with sufficient force to jar the resistance units and restore them to their normal condition of high resistance. This feature of the device is of great advantage, since the carbon columns are apt to become compacted with continued use of the controller and will not then of themselves regain their original condition of high resistance when they are relieved from pressure. It will be observed that when the operating-lever is turned in either direction from its middle position and approaches the outer limits of its movement the leverage of the rollers *x* on the carriage *k* increases as pressure upon and reaction of the resistance medium is augmented. Thus the arrangement of these rollers coöperates with the spring-actuated roller *y* and the curved track 3 to overcome the reaction of the resistance medium when subjected to pressure. By turning the operating-lever to the right, as seen in Fig. 2, the current will be reversed through the armature of the motor, and the resistance will be gradually reduced and finally cut out of the circuit in the manner hereinbefore explained.

The number of the resistance units may be varied, and they may be variously grouped and connected according to the requirements of varying conditions, so as to cut out or short-circuit more or less of them at a time by means of the separate switch-contact pieces 9 and 10—as, for example, with the four units shown in the drawings, three instead of two may be connected with the contact-pieces 10 and only one with the contact-pieces 9. They are, however, preferably arranged, as shown, in a single row, so as not to increase the depth of the controller in a direction perpendicular to the plane in which the operating-lever moves.

Various changes in the details of construction and arrangement of parts and electrical connections may be made without departing from the principle and intended scope of the invention.

I claim—

1. In an electric-current controller the combination of a resistance medium and mechanically-operated means adapted to subject said medium to pressure and to act with augmented power as the pressure upon said medium is increased, substantially as described.

2. In an electric-current controller the combination of a resistance medium whose electrical conductivity is increased when it is subjected to pressure, and manually-operated means adapted to exert an increasing pressure upon said medium with a substantially constant expenditure of energy, substantially as described.

3. In an electric-current controller the combination of a compressible resistance medium whose conductivity is increased by pressure, and mechanically-operated means adapted to exert a gradually-increasing pres-

sure upon said medium as its reaction under augmented pressure increases, without the application of correspondingly-increasing energy, substantially as described.

4. In an electric-current controller the combination of a resistance medium whose electrical conductivity is increased by pressure, a manually-operated lever adapted to exert pressure upon said medium, and means for increasing the power exerted by said lever as the reaction of said medium is augmented by increased compression, substantially as described.

5. In an electric-current controller the combination of a resistance medium whose electrical conductivity is varied by pressure, means for compressing said medium and means for storing the power exerted by the reaction of said medium upon said compressing means and for applying such stored power to the operation of said compressing means, substantially as described.

6. In an electric-current controller the combination of a compressible resistance medium whose electrical conductivity is increased by pressure, a lever arranged to compress said medium and means for storing the power exerted by the reaction of said medium upon said lever when moved in one direction and for applying such stored power to the operation of said lever when moved in the other direction to compress said medium, substantially as described.

7. In an electric-current controller the combination of a compressible resistance medium, means for subjecting said medium to a variable pressure to gradually change its electrical conductivity and means tending to equalize the power applied to operate the controller for different degrees of compression, substantially as described.

8. In an electric-current controller the combination of a resistance medium, a lever arranged to gradually compress said medium and provided with a roller movably mounted thereon, a track or runway for said roller and means holding said roller with yielding pressure against said track or runway, which has a varying curvature or inclination constructed and arranged to hold said lever at rest in any position in which it may be left, substantially as described.

9. In an electric-current controller the combination of a resistance medium, a lever arranged to gradually compress said medium and provided with a roller movably mounted thereon, a runway gradually approaching the fulcrum of said lever toward the end opposite the initial or neutral position of the lever, and means tending to force said roller against said runway, substantially as described.

10. In an electric-current controller the combination of a compressible resistance medium whose electrical conductivity is varied by pressure, a lever arranged to gradually compress said medium and provided with a roller movably mounted thereon, a track or runway for said roller having a depression, and means yieldingly pressing said roller against said track and adapted to automatically complete the return movement of said lever to its neutral position, substantially as described.

11. In an electric-current controller the combination of a compressible resistance medium whose electrical conductivity is varied by pressure, a lever arranged to gradually compress said medium and provided with a roller movably mounted thereon, a track or runway having a depression, switch-contact pieces, one of which is carried by said lever, and means yieldingly pressing said roller against said track and adapted to automatically complete the return of said lever to its neutral position and to quickly break the circuit, substantially as described.

12. In an electric-current controller the combination of a resistance medium, a lever arranged to gradually compress said medium and provided with a roller movably mounted thereon, a runway having a depression and gradually approaching the fulcrum of said lever as it recedes from said depression, and means holding said roller against said runway and tending to move the lever away from said depression with gradually-increasing power, and to quickly complete its return movement to the neutral position when said roller is carried to one side of said depression, substantially as described.

13. In an electric-current controller the combination of a carriage, a compressible resistance medium mounted upon and movable with said carriage, an abutment against which said medium is arranged to be compressed, a lever adapted to move said carriage toward said abutment and provided with a roller movably mounted thereon, a track having a depression, and means yieldingly holding said roller against said track and adapted to quickly complete its return movement when the roller reaches said depression and to jar said resistance medium as the carriage is brought to a stop, substantially as described.

14. In an electric-current controller the combination of a resistance medium whose electrical conductivity is varied by pressure, means for exerting a variable pressure upon said resistance medium, and means for restoring and maintaining the normal resistance of said medium, substantially as described.

15. In an electric-current controller the combination of a resistance medium whose electrical conductivity is increased by pressure, means for subjecting said medium to a variable pressure, and means for jarring said

medium whereby it is restored to its original state of high resistance, substantially as described.

16. In an electric-current controller the combination of a movable resistance medium whose electrical conductivity is increased by pressure, an abutment or bearing, and means for subjecting said medium to a variable pressure by moving it with more or less force against said abutment and for jarring said medium and restoring its normal resistance in moving it back to its initial position, substantially as described.

17. In an electric-current controller the combination of a suitable frame, provided with an abutment, a movable support, a case mounted upon said support and movable therewith toward said abutment, a compressible resistance medium inclosed in said case and means for moving said support with said case and resistance medium toward said abutment and gradually compressing said resistance medium, substantially as described.

18. In an electric-current controller the combination of a carriage or movable support, a number of resistance units mounted upon and movable with said carriage, a yielding equalizer toward and from which said resistance units are movable, and means for moving said carriage to and pressing said resistance units with more or less force against said equalizer, substantially as described.

19. In an electric-current controller the combination of a carriage or movable support, a number of resistance units mounted upon and movable with said carriage, a yielding equalizer and an operating-lever arranged to move said carriage and resistance units with more or less force against said equalizer and to subject said resistance units to an equally-distributed variable pressure, substantially as described.

20. In an electric-current controller the combination of a yielding equalizer, a carriage movable toward and from said equalizer, a number of resistance units whose electrical conductivity is increased by pressure, mounted upon said carriage, a lever adapted to move said resistance units with said carriage against said equalizer, and provided with a roller movably mounted thereon, a runway for said roller gradually approaching the fulcrum of said lever as it recedes from its neutral position, and means tending to force said roller against said runway, substantially as described.

21. In an electric-current controller the combination with a suitable frame, of a resistance medium whose electrical conductivity is varied by pressure, removably mounted in said frame and having detachable electrical connections and means for subjecting said medium to pressure, substantially as described.

22. In an electric controller the combination with a suitable frame, of a compressible resistance removably mounted in said frame, means insuring its being placed and held in the proper position in said frame, and means for subjecting said resistance to pressure, substantially as described.

23. In an electric-current controller the combination with a suitable frame, of a number of tubes loosely held at one end in said frame and containing a resistance medium whose electrical conductivity is increased by pressure, a rack on said frame provided with one or more removable rods for holding said tubes in place therein, and means for subjecting the resistance medium to a variable pressure, substantially as described.

24. In an electric-current controller the combination of a variable resistance, means for closing and opening the circuit through said resistance, a blow-out magnet arranged to extinguish arcs formed by breaking the circuit through said resistance, and means for cutting out said magnet before all the resistance has been cut out of the circuit and for bringing said magnet into the circuit before it is broken and while it includes such resistance, substantially as described.

25. In an electric-current controller the combination of a variable resistance, means for closing and opening the circuit through said resistance comprising movable and insulated contact-pieces, and a blow-out magnet connected across the space between the insulated contact-pieces over which the movable contact-piece passes only when high resistance is included in the circuit, substantially as described.

26. In an electric-current controller, the combination of a resistance medium whose electrical conductivity is varied by pressure, a stationary switch-base provided with insulated contact-plates connected and arranged to reverse the current and to open and close the circuit through said resistance medium, and an operating-lever provided with brushes or contact-pieces and adapted to be moved in opposite directions from a normal or neutral position and when moved from such position in either direction to first close the circuit through said resistance medium and then subject the same to a gradually-increasing pressure, substantially as described.

27. In an electric-current controller the combination of a number of resistance units whose electrical conductivity is varied by pressure, means for subjecting said resistance units to a variable pressure, and switching devices arranged to cut out or short-circuit said resistance units in groups or sections one after another when they are subjected to high compression and offer little or no resistance to the current, substantially as described.

28. In an electric-current controller the combination of a carriage, resistance mounted thereon and composed of material whose

electrical conductivity is increased by pressure, an abutment against which said resistance is pressed by the movement of said carriage, and an operating-lever provided with a roller which is adapted to engage with said carriage and to approach a perpendicular to the carriage passing through the fulcrum of the lever as said lever is moved away from its neutral position, substantially as described.

29. In an electric-current controller the combination of a carriage, resistance mounted thereon and variable by compression, an abutment against which said resistance is pressed by the movement of said carriage, and an operating-lever provided in a line transverse to its axis with two rollers each of which is arranged to approach a perpendicular passing through the fulcrum of the lever to the carriage when said lever is moved in one direction away from its neutral position and to move said carriage toward said abutment with gradually-increasing power, substantially as described.

30. In an electric-current controller, a resistance unit composed of a column of current-conducting disks, having a cover of non-combustible insulating material loosely wrapped around it and inclosed in a protecting and supporting tube, substantially as described.

31. In an electric-current controller the combination of a compressible resistance medium, and a yielding equalizer against which said resistance is compressed, comprising a bar, screw-threaded guide-rods on which said bar is adjustably secured and adjustable springs tending to press said bar toward said resistance medium, substantially as described.

32. In an electric-current controller the combination of a compressible resistance medium and a carbon-tipped metallic electrode, adapted to bear against and form an electrical contact with said resistance medium, substantially as described.

33. In an electric-current controller the combination of a compressible resistance medium whose electrical conductivity is increased by compression and a lever adapted to compress said medium and to act thereon with greater power as the compression and reaction of said medium are increased, substantially as described.

In witness whereof I hereto affix my signature in presence of two witnesses.

LYNDE BRADLEY

Witnesses:
Chas. L. Goss,
Bernard C. Roloff.