No. 607,617. Patented July 19, 1898.

H. P. DAVIS & G. WRIGHT.

REGULATING SWITCH FOR ELECTRIC CIRCUITS.

(Application filed Sept. 18, 1897.)

(No Model.) 5 Sheets—Sheet 1.

Fig. 1.

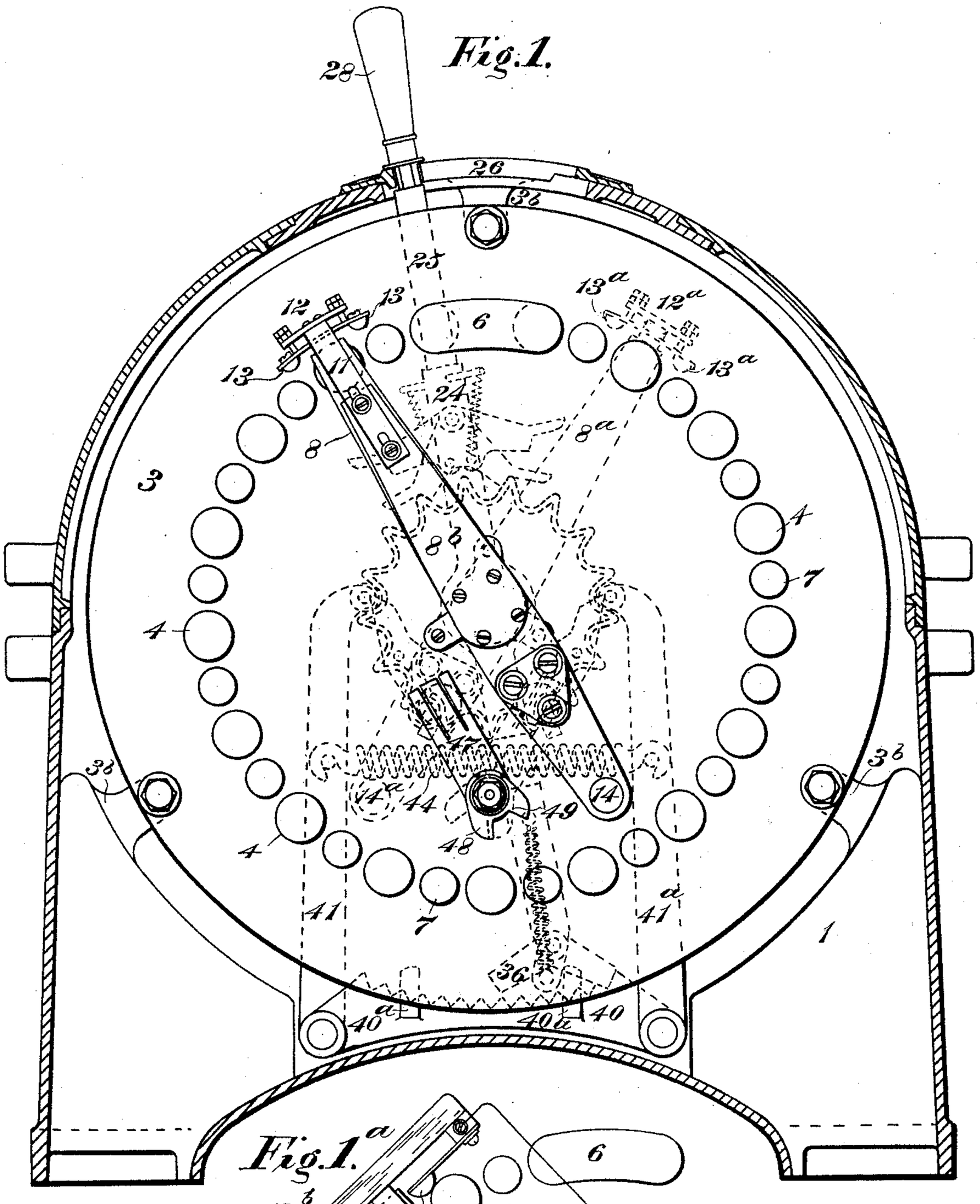
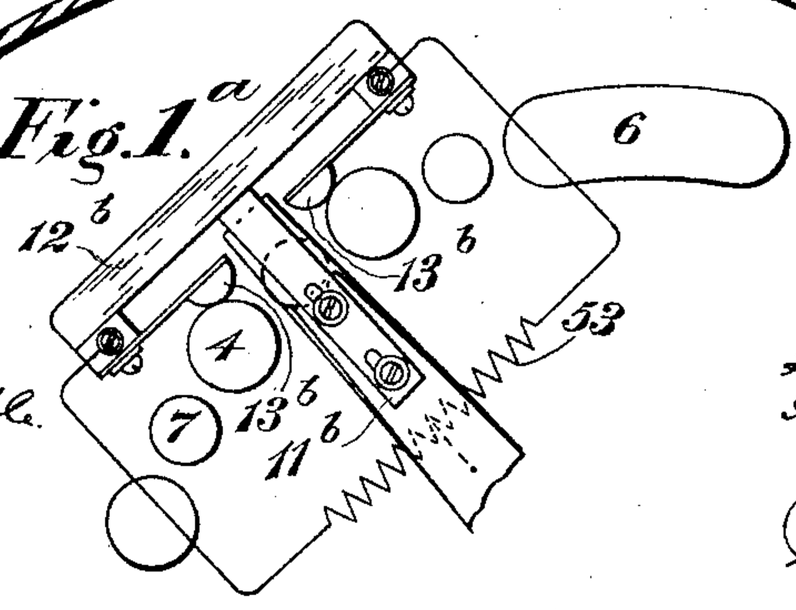


Fig. 1a.



WITNESSES:

W. C. Webb.

H. C. Tener

INVENTORS

Harry P. Davis

Gilbert Wright

BY

Wesley G. Carr

ATTORNEY.

No. 607,617. Patented July 19, 1898.

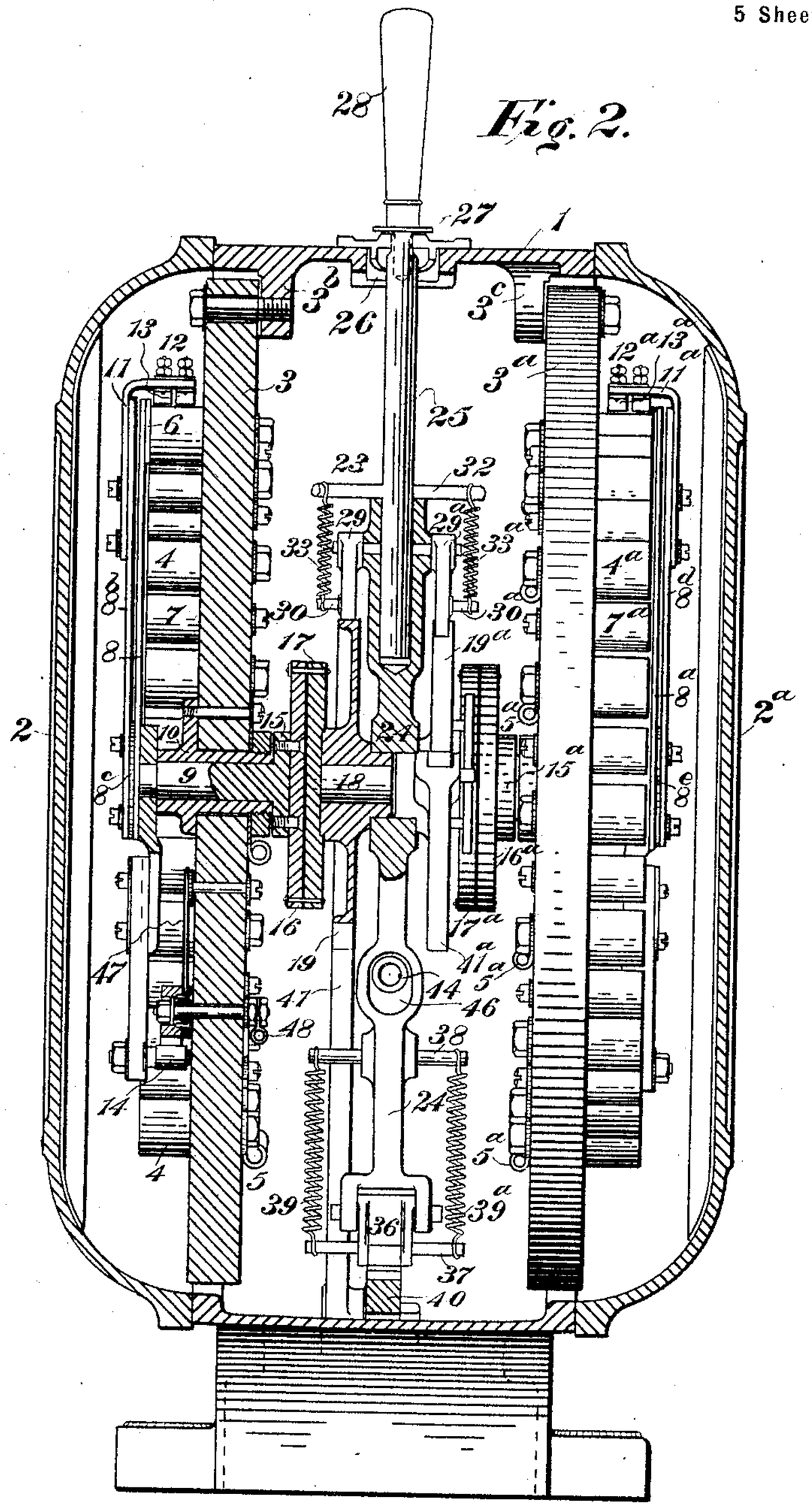
H. P. DAVIS & G. WRIGHT.

REGULATING SWITCH FOR ELECTRIC CIRCUITS.

(Application filed Sept. 18, 1897.)

(No Model.) 5 Sheets—Sheet 2.

Fig. 2.



WITNESSES
W. C. Weible.
H. C. Tener

INVENTORS
Harry P. Davis
Gilbert Wright
BY
Wesley G. Carr
ATTORNEY.

No. 607,617. Patented July 19, 1898.

H. P. DAVIS & G. WRIGHT.

REGULATING SWITCH FOR ELECTRIC CIRCUITS.

(Application filed Sept. 18, 1897.)

(No Model.) 5 Sheets—Sheet 3.

Fig. 4.

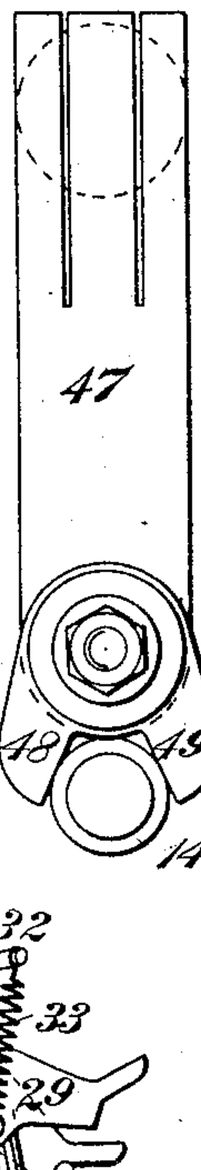


Fig. 5.

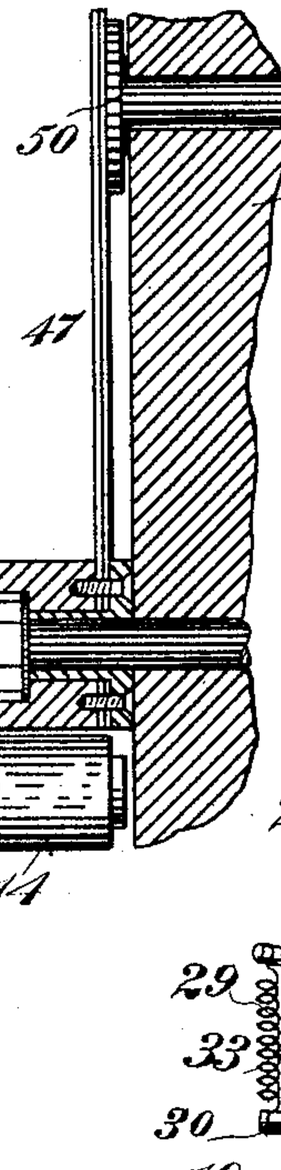


Fig. 3.

Fig. 6.

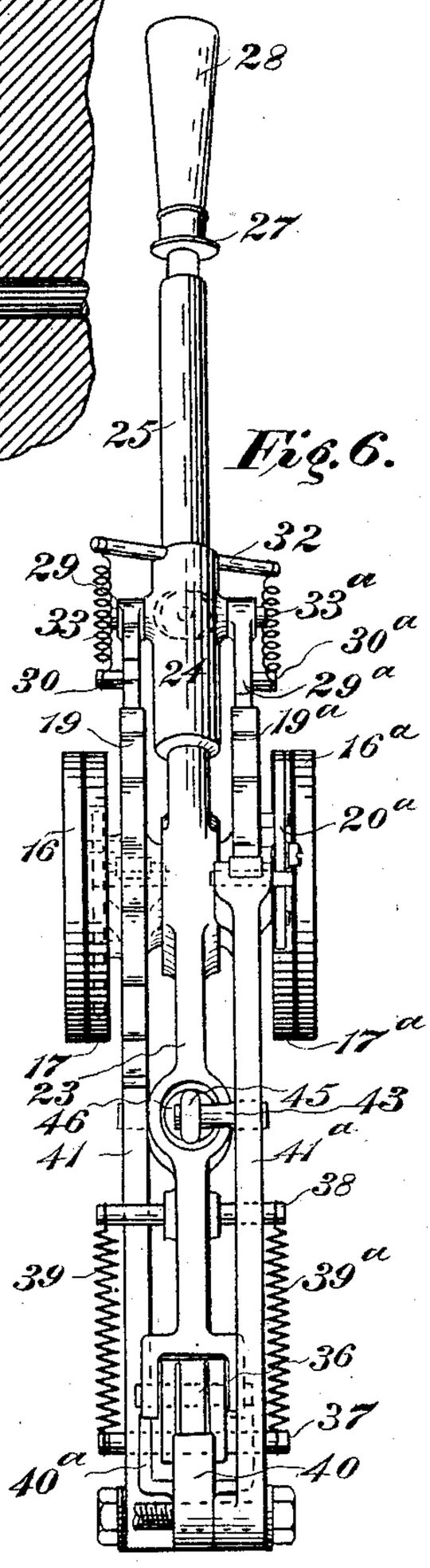
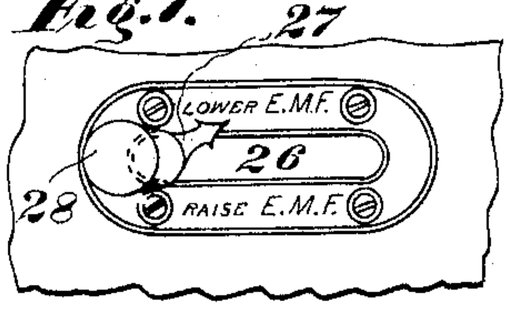


Fig. 7.



WITNESSES:
W. D. Weible.
H. C. Fenner

INVENTORS
Harry P. Davis
Gilbert Wright
BY
Wesley G. Carr
ATTORNEY.

No. 607,617. Patented July 19, 1898.

H. P. DAVIS & G. WRIGHT.

REGULATING SWITCH FOR ELECTRIC CIRCUITS

(Application filed Sept. 18, 1897.)

(No Model.) 5 Sheets—Sheet 4.

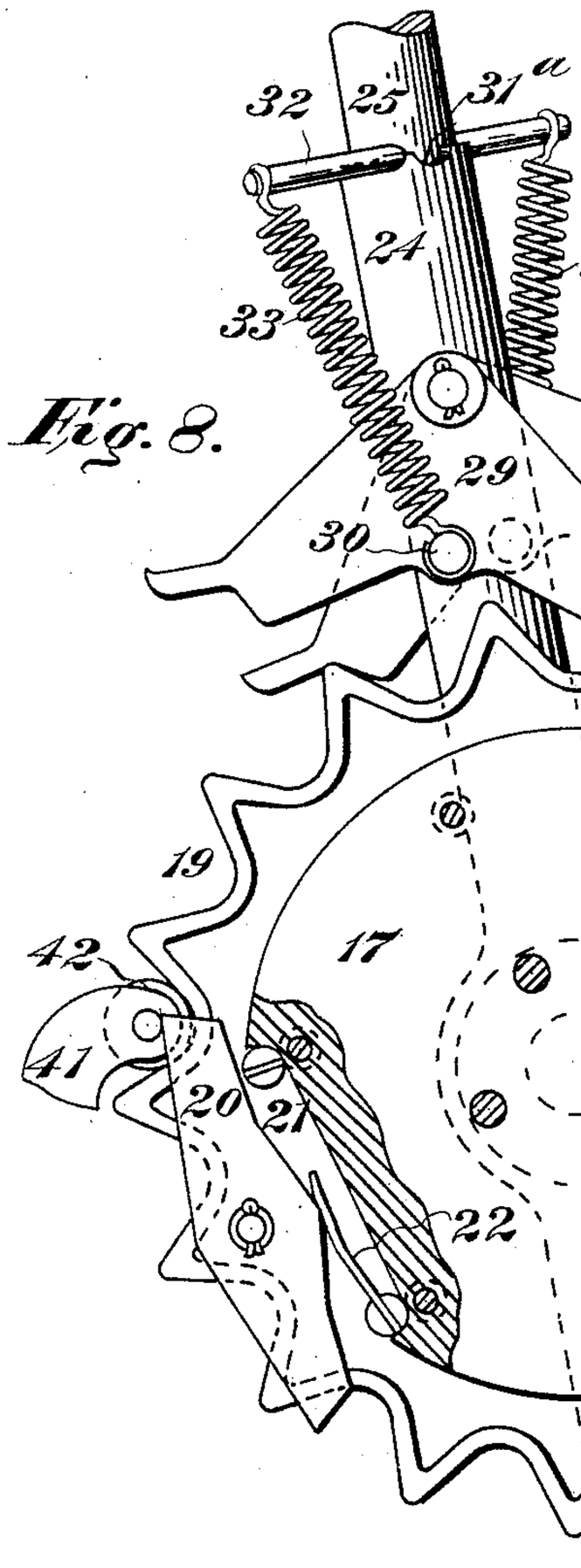


Fig. 8.

Fig. 10.

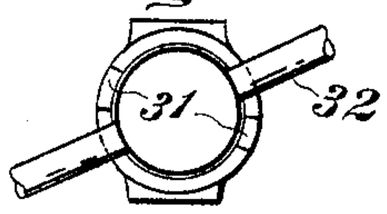
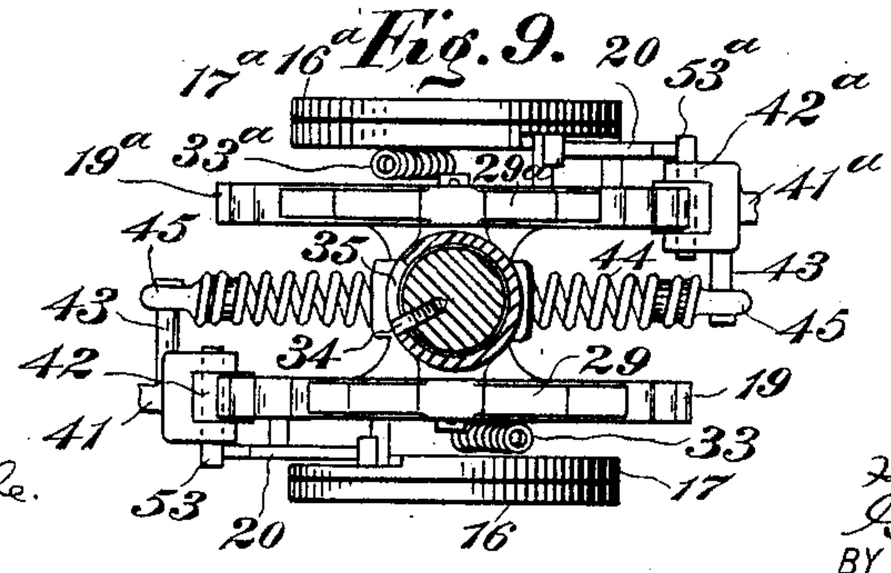


Fig. 9.



WITNESSES:
W. C. Webb.
H. L. Tener

INVENTORS
Harry P. Davis
Gilbert Wright
BY
Hadley & Carr
ATTORNEY.

No. 607,617. Patented July 19, 1898.

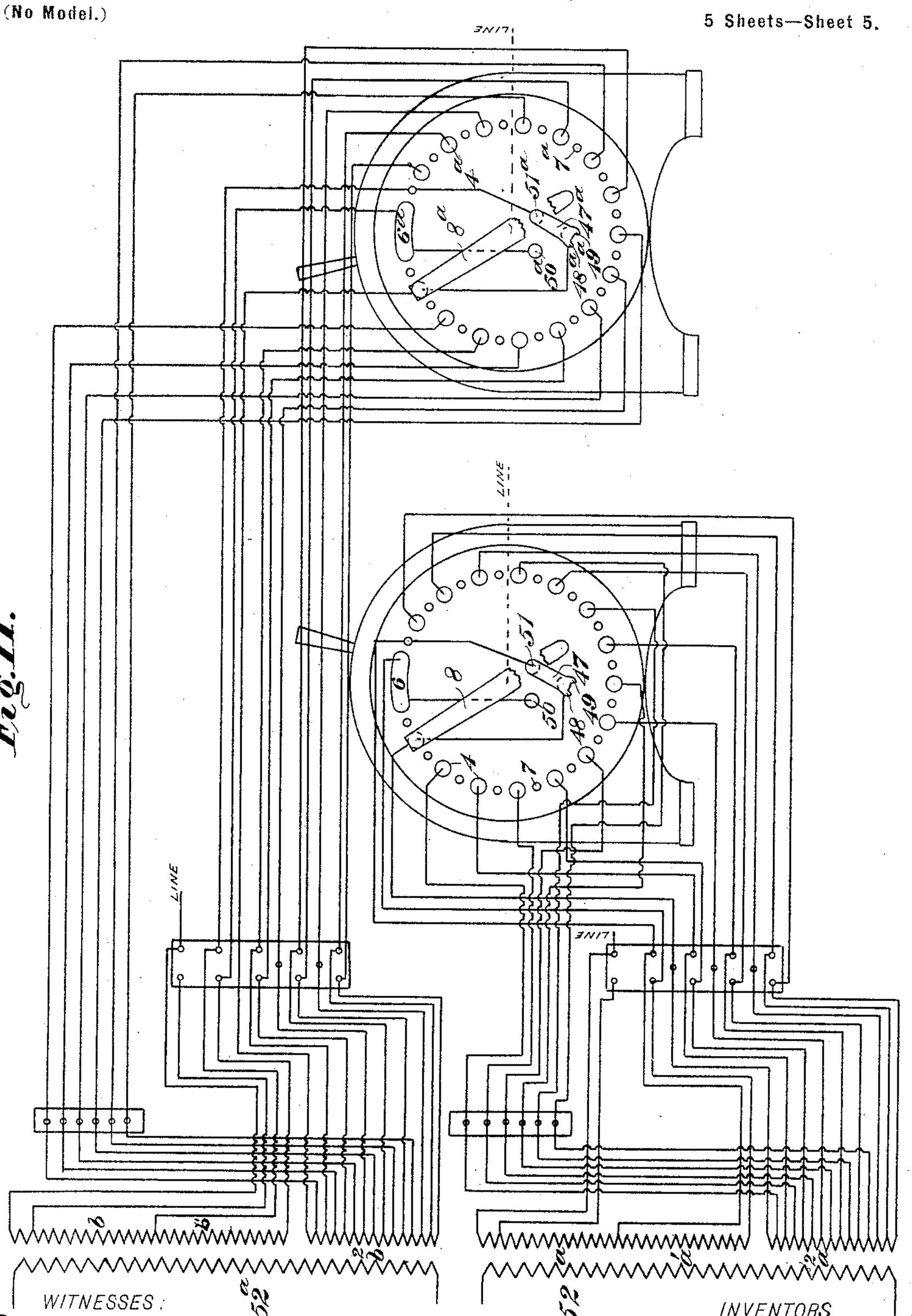
H. P. DAVIS & G. WRIGHT.

REGULATING SWITCH FOR ELECTRIC CIRCUITS.

(Application filed Sept. 18, 1897.)

(No Model.) 5 Sheets—Sheet 5.

Fig. 11.



WITNESSES:
W. C. Noble.
Hale Tener

INVENTORS
Harry P. Davis
Gilbert Wright
BY
Wesley G. Carr
ATTORNEY.

UNITED STATES PATENT OFFICE.

HARRY P. DAVIS, OF PITTSBURG, AND GILBERT WRIGHT, OF WILKINSBURG, PENNSYLVANIA, ASSIGNORS TO THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, OF PENNSYLVANIA.

REGULATING-SWITCH FOR ELECTRIC CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 607,617, dated July 19, 1898.

Application filed September 18, 1897. Serial No. 652,168. (No model.)

To all whom it may concern:

Be it known that we, HARRY P. DAVIS, residing at Pittsburg, and GILBERT WRIGHT, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, citizens of the United States, have invented a new and useful Improvement in Regulating-Switches for Electric Circuits, (Case No. 755,) of which the following is a specification.

Our invention relates to switches for electric circuits, and is particularly designed and intended for raising and lowering the electromotive forces in alternating-current circuits, but is not in all respects limited to such use.

The object of our invention is to provide a switch of the character above referred to which will cover a wide range with a minimum number of compactly-arranged parts and which shall be simple, positive, and effective in operation.

In the accompanying drawings, Figure 1 is a front elevation of the switch, the front plate or cover of the casing being removed; and Fig. 1^a is a detail view of a modified form of contact device. Fig. 2 is a vertical section taken at right angles to the view shown in Fig. 1 and showing some of the operating parts in different positions. Fig. 3 is a front elevation of some of the operating parts shown in Figs. 1 and 2. Fig. 4 is a front elevation of an auxiliary switch. Fig. 5 is a view, partially in side elevation and partially in section, of a portion of a base-plate, one of the auxiliary switches, and the lower portion of the lever for actuating the same. Fig. 6 is a side elevation of the main portions of the switch-operating mechanism. Fig. 7 is a plan view of a portion of the top of the casing. Fig. 8 is a front elevation of a portion of the switch-operating mechanism on an enlarged scale. Fig. 9 is a view, partially in section and partially in plan, of the mechanism shown in Fig. 6. Fig. 10 is a detail view of a portion of the switch-operating lever, and Fig. 11 is a diagram of the main and auxiliary switches and the circuits regulated or controlled by the same.

The details of construction shown in the drawings are as follows:

1 is the main or middle portion of the combined supporting-frame and casing, which is of generally cylindrical contour, but has its bottom portion extended to form supporting-standards, as is clearly shown in the drawings.

2 and 2^a are end plates or caps which are bolted or otherwise fastened to the middle portion 1 and, with such middle portion, constitute an inclosing casing for the entire operating portions of the apparatus.

Circular vertical plates 3 and 3^a, of insulating material, are respectively bolted to lugs 3^b and 3^c, projecting inwardly from the frame 1, near its respective edges. The plate 3 is provided with an annularly-arranged series of contact-pieces 4, which, as shown, are in the form of cylinders, the fastening-bolts for which extend through the supporting-plate and are provided with suitable connectors 5 for the conducting-wires. The two adjacent contact-pieces 4 at the top of the supporting-plate are connected by a conducting-plate 6, so as to form, in effect, a single broad contact. Smaller cylinders 7 are arranged between the contact-pieces 4 and are similarly bolted to the base-plate; but these are not provided with connectors for the reason that they are employed merely to prevent the movable contact-arm, hereinafter described, from dropping between the contact-pieces 4 as it is moved from one to another. The plate 3^a is provided with corresponding parts 4^a, 5^a, 6^a, and 7^a.

The contact-arm 8 is supported by a shaft 9, which extends through an opening in the center of the plate 3 and is journaled in a suitable bearing-box 10, which also extends through the supporting-plate and is bolted or otherwise fastened thereto. An auxiliary arm 8^b is also supported by the shaft 9. The arms are separated by a washer 8^c, but are not independently movable. The auxiliary arm has a strip 11 fastened to its outer end, which is bent at substantially right angles to said arm and is provided with a laterally-extending head 12, such head having at or near its ends contact-pieces 13. These contact-pieces 13 are electrically connected with the contact-arm 8 and with each other and make

initial and final contact with the cylindrical surfaces of the contact-pieces 4 and serve to take any arcs which may be formed as the arm 8 is moved from one to another of the contact-pieces 4.

The contact-arms 8^a and 8^d, the shaft supporting the same and its bearing-box, the washer 8^e, the extension 11^a, head 12^a, and contacts 13^a, mounted upon the plate 3^a, are the same in construction and operation as those just described.

In Fig. 1^a we have shown a modification in which the head 12^b, fastened to the end of extension 11^b, is of non-conducting material, and the supplemental contacts 13^b, mounted thereon, are spaced apart a sufficient distance to simultaneously make contact with adjacent contact-pieces 4. These supplemental contacts 13^b are electrically connected with each other through a resistance-coil 53, and substantially the middle point of the latter is connected to the extension 11^b. By this means the current is reduced sufficiently to prevent destructive arcing between the supplemental contacts 13^b and the contact-pieces 4.

Each of the contact-arms 8 and 8^a projects beyond its shaft in a direction opposite to its contact end a considerable distance, the former being provided with a roller 14 and the latter with a corresponding roller 14^a.

The inner end of the shaft 9 is provided with a head 15, to which is fastened, by means of screws or otherwise, a plate 16, of insulating material. A similar plate 17, having a laterally-projecting stud 18, is riveted or otherwise securely fastened to the plate 16. A ratchet-wheel 19 is mounted rigidly upon the stud 18 and has pivoted to its outer face, near the edge, a stop-piece 20. (See Figs. 3 and 8.) The adjacent plate 17 is cut away at 21 to provide space for the movement of the stop-piece 20, and in this space is mounted a flat spring 22, the free end of which bears against the inner edge of the stop-piece 20, so as to retain such stop-piece in any position to which it may be moved. A head 15^a, plates 16^a and 17^a, a stud projecting from the latter, but not shown, a ratchet-wheel 19^a, a stop-piece 20^a, and a spring therefor, of like construction to the parts above described, are correspondingly located with reference to the plate 3^a and its contact-pieces.

Located centrally with reference to the plates 3 and 3^a is an operating-lever 23, which is journaled upon the hubs of the two ratchet-wheels 19 and 19^a. This lever comprises two principal parts 24 and 25, the main part 24, which is journaled upon the hub of the ratchet-wheels 19 and 19^a, being provided with a socket extending some distance downward from its upper end, and in this socket is located the lower end of the part 25. This part 25 projects through an oblong opening 26 in the top of the frame or casing and just above such opening is provided with a pointer 27. Above the pointer extends a handle 28, which is of such form and dimensions as to be readily manipulated to move the lever. Pivoted to the main portion 24 of the lever, a short distance above the ratchet-wheels, are two double-ended pawls 29 and 29^a, each of which is in the same plane with the corresponding ratchet-wheel. The pawls 29 and 29^a are respectively provided with laterally-projecting pins 30 and 30^a near their lower edges and midway of their ends. The upper end of the socket portion 24 of the lever 23 is provided with pairs of notches 31 and 31^a, and extending through the upper portion 25 of the lever, in position to rest in one or the other pair of notches, is a long pin 32. The ends of this pin 32 are connected by coiled springs 33 and 33^a with the corresponding laterally-projecting pins 30 and 30^a on the lower edges of the pawls 29 and 29^a.

In order to permit the upper portion 25 of the lever to be given a partial rotation, so as to move the pin 32 from one pair of notches to the other, it is provided with a pin 34, which projects laterally through an opening 35 in the side of the socket. (See Fig. 9.) This opening 35 is of such size that, while it will permit of the necessary degree of rotation of the upper portion of the lever, it will also prevent the withdrawal of such lever portion from its socket. The lever 23 projects downward from its middle or bearing portion to a point near the bottom of the frame and has pivoted to its lower end a double-ended dog 36, the lower end being bifurcated in order to receive this dog. The dog is provided midway of its ends and at its lower edge with a pin 37, which projects laterally from both sides, and the lever at some distance above the dog is provided with a similar pin 38. Coiled springs 39 and 39^a connect the corresponding ends of these pins, as shown. A plate or bar 40, having a toothed or notched upper edge, is located in the bottom of the frame or casing, the teeth being arranged in the arc of a circle and in the plane of the path of movement of the dog 36 as the lever is moved back and forth on its bearings. This toothed plate is also provided on one side with two lugs or projections 40^a, extending upward a sufficient distance to be in the path of movement of one end of the pin 37.

A holding-pawl 41 for the ratchet-wheel 19 is pivoted to one end of the toothed plate 40, extends upward, and is provided with a roller 42 in position to engage between the teeth on one side of the ratchet-wheel. A holding-pawl 41^a of similar construction is pivoted to the other end of the toothed plate, extends up, and is provided at its upper end with a roller 42^a for engaging between the teeth at the side of the other ratchet-wheel 19^a. A pin 43 projects laterally from each of these holding-pawls, and the two pawls are drawn toward each other and held in contact with the corresponding ratchet-wheels by means of a coiled spring 44, having at each end a hook 45, which engages with the corresponding pin 43 on the

holding-pawl. The lever is provided with an opening 46, through which this coiled spring extends, the opening being of sufficient size to permit the lever to move through its entire range without interfering with or being interfered with by the action of the coiled spring.

An auxiliary-switch arm 47 is pivoted to the outer face of the plate 3, and its pivot pin or bolt is provided at the inside of the plate with a coupling device 48 for the conducting-wire, similar to those described in connection with the contact-pieces 4. (See Figs. 1, 2, and 11.) This auxiliary-switch arm has two lugs 48 and 49 projecting below its pivot, one of which is always in position to be engaged by the roller 14 on the lower end of the contact-arm 8. The plate 3 is provided with two stationary contact-pieces 50 and 51, with one of which this auxiliary-switch arm is always in contact, except, of course, when it is being moved from one to the other. It will be understood that the plate 3^a is also provided with a switch-arm 47^a, having projections 48^a and 49^a, and with contact-pieces 50^a and 51^a, corresponding to the parts above described, and that in general the construction and operation of the several parts of the apparatus are exactly the same on the two sides of the operating-lever.

In Fig. 11 is shown a diagram of the two parts of the switch and two transformers 52 and 52^a, the primary windings of which are respectively connected to the stationary contacts of these switches in such manner that the active length of each winding may be either increased or decreased step by step, according to the direction of rotation of the contact-arms of the switch, so as to vary the electromotive force supplied by the secondary winding.

The operation of the apparatus is as follows: Assuming that the parts are in the positions indicated in Figs. 3, 6, 7, and 11, the lever 23 being at the extreme left position and the part 25 turned, as indicated in Fig. 7, so as to lower the electromotive force, if the handle be moved from left to right as far as the opening in the top of the casing will permit the pawl 29^a will move the ratchet-wheel 19^a one notch and with it the corresponding contact-arm 8^a. With the parts in the position just indicated it will be observed by referring to Fig. 11 that the circuit through the switch-arm 8^a at the right, the contact-piece on which it rests, and the auxiliary switch 47^a 51^a includes the portion b of the primary winding of transformer 52^a. When the arm 8^a is moved, by means of the lever 23, the pawl 29^a, and ratchet 19^a, on to the next stationary contact, this same portion b of the primary winding of the transformer 52^a will be in circuit and also one division of the portion b^2. It will be observed that in moving the handle and its lever from left to right a complete stroke is necessary before returning it to the original position for the reason that the dog 36 drags over the toothed edge of the plate or bar 40 and is held in such position by the springs 39 and 39^a, and that if any attempt is made to reverse the movement of the lever before the complete stroke is made the dog will catch upon a tooth and stop the motion of the lever. When, however, the lever is moved completely over to the end of the slot in the top of the casing, the pin 37 will strike against the lug 40^a at the left and trip the dog, thus carrying the springs 39 and 39^a to the other side of the center, where they will hold the dog in the tripped position. The same function will be effected when the movement of the lever is made in the other direction until the end of the stroke, when the lug 40^a at the right-hand side will again trip the dog into the position shown in Figs. 1 and 3.

The movement of the lever from right to left will carry with it the corresponding ratchet-wheel 19 and the contact-arm 8 by reason of the pawl 29, which engages with the adjacent tooth of the ratchet-wheel, and thus cut into circuit a division of the portion a^2 of the primary of the transformer 52 in the same manner as has been described in connection with the transformer 52^a. This back-and-forth movement is repeated, and the contact-arms are moved step by step in opposite directions to cut into circuit one after another the divisions of the portions a^2 and b^2 of the transformer primaries until the contact-arms have reached the last stationary contact-pieces before coming upon the long contacts 6 and 6^a at the top of the switch. When these points are reached, the entire divisions a^2 and b^2 of the primary windings are in circuit. When the contact-arms are moved the next step or notch, the rollers on their lower ends engage with the outermost lugs projecting from the auxiliary-switch arms and move the arms from their stationary contacts. The circuits will then include the portions $a\,a'$ and $b\,b'$ of the primary windings and the portions a^2 and b^2 will be cut out. The next movement of one notch or step throws the auxiliary switches over onto their other stationary contacts, as is shown in Fig. 1.

The operation may be continued the same as has already been described, the portions a^2 and b^2 of the transformer primary windings being cut step by step into circuit as the contact-arms are moved from contact to contact in opposite directions around the two disks or plates. When these arms have been moved until they come to the last contacts before reaching the long contacts at the top, the entire winding of each transformer will be included in circuit and it will be impossible to continue the operation of the parts from that point for the reason that the stop-pieces 20 and 20^a will respectively engage with the pins 53 and 53^a projecting from the sides of the holding-pawls. If it is now desired to raise the electromotive force, the handle 25 is given a partial rotation, which carries with it the pin 32 and the springs 33 and

33ª, connecting the ends of the same with the pins 30 and 30ª on the lower side of the pawls 29 and 29ª until the pin 32 drops into the other pair of notches 31 and 31ª in the top of the socket. This position of the pin brings the pulling action of the springs to bear at such an angle that the two pawls will be tripped or reversed, as is shown in Fig. 8. When in this position, the movement of the operating-handle will move the ratchet-wheels and contact-arms step by step from contact to contact in the same manner as has already been described and gradually cut out of circuit the portions a^2 and b^2 of the primary windings until one revolution of the arms has been made, when the rollers on the lower ends of the arms will engage with the projections on the auxiliary-switch arms and throw them into contact with the other stationary contact pins or pieces, thus cutting into circuit the portions a^2 and b^2 and simultaneously cutting out of circuit the portions a' and b'. The operation may then be continued until the portions a^2 and b^2 are entirely cut out, leaving only the portions a and b in circuit. It will be readily understood that this entire operation need not be carried out, since any degree of variation of the electromotive force either up or down may be effected by a proper manipulation of the operating-lever.

It should be stated that when the main and auxiliary switch contact-arms are in the positions indicated in Fig. 11 and the operating parts are as indicated in Fig. 3 the stop-pieces are so located with reference to the stop-pins projecting from the holding-pawls that the forward end of the stop-pieces will clear such pins during the first rotation, but that in passing the pins and making the second rotation these stop-pieces will be turned on their pivots by such pins, as will be understood, so that when the second rotation is completed the ends which project beyond the line of the pins will come into contact therewith and stop the ratchet-wheels and contact-arms.

It will be understood that the portion of each transformer-winding that is always in circuit may have any length desired, it being desirable, however, that the two portions which replace each other should be approximately of the same length. It will be further understood that the winding, the active length of which is varied, may be either the primary or the secondary, and that the switch may be otherwise employed in different relations.

While we have described specific apparatus for practicing our invention, we desire it to be understood that the details both as regards the form of the parts and also their location and arrangement may be considerably varied without departing from the spirit and scope of our invention.

We claim as our invention—

1. In a switch for electric circuits, the combination with two sets of annularly-arranged stationary contacts, a pivoted coöperating contact-arm for each set of stationary contacts, a single pivoted operating-lever having a limited reciprocatory movement and means intermediate the lever and each contact-arm whereby said arms may be oppositely moved from one stationary contact to the next through the entire set in either direction.

2. In a switch for electric circuits, the combination with two annularly-arranged sets of stationary contacts, a coöperating contact-arm for each set of stationary contacts provided with a ratchet-wheel, a single pivoted operating-lever having a limited reciprocatory movement, two reversible pawls pivoted to said lever, and means for retaining them in either operative position, whereby the contact-arms may be oppositely moved step by step in either direction.

3. An electromotive-force-regulating switch for two-phase circuits comprising two non-conducting base-plates, two sets of stationary contact-pieces mounted respectively on said base-plates, corresponding movable contact-arms, a reciprocating actuating-lever, and pawl-and-ratchet mechanism between said lever and each of said movable contact-arms whereby these latter are moved one step in opposite directions by each double stroke of the operating-lever.

4. An electromotive-force-regulating switch for two-phase electric circuits comprising two sets of stationary contact-terminals—one for each phase—two corresponding movable contact-arms, a reciprocating lever, and pawl-and-ratchet mechanism between said lever and each of said movable contact-arms whereby a complete double stroke of the lever serves to move said contact-arms one step in opposite directions.

5. An electromotive-force regulator for two-phase circuits comprising two base-plates, a supporting-frame therefor, two sets of stationary contact-terminals, two corresponding movable contacts, a ratchet rigidly connected to each of said movable contacts, a pivoted operating-handle, a double-acting pawl for each ratchet pivoted to said handle and means for adjusting each pawl so as to actuate its ratchet in either direction.

6. In a switch for electric circuits, the combination with two sets of annularly-arranged stationary contacts, a contact-arm and ratchet-wheel for each set, a two-part operating-lever having a reversible pawl for each ratchet-wheel pivoted to the inner part of the lever and elastic means connecting each pawl with the outer part of the lever whereby a partial rotation of the latter will reverse the pawls.

7. In a switch for electric circuits, the combination with an annularly-arranged series of stationary contacts, a pivoted coöperating contact-arm provided with a ratchet-wheel, a pivoted operating-lever provided with a reversible pawl and having a limited reciprocatory movement and means for preventing

a reversal of movement of the lever before the completion of a stroke in either direction.

8. In a switch for electric circuits, the combination with an annularly-arranged set of stationary contacts, a coöperating contact-arm having a ratchet-wheel, an operating-lever provided with a reversible pawl, a reversible dog pivoted to the operating-lever and a notched plate or bar provided with stops for tripping or reversing the dog at the end of a stroke in either direction, the notches in said bar or plate preventing a reverse movement of the lever before it has made a complete stroke.

9. In a switch for electric circuits, the combination with a series of annularly-arranged stationary contacts, a pivoted contact-arm having a ratchet-wheel, a holding-pawl for said ratchet-wheel, a pivoted reciprocatory operating-lever provided with a reversible actuating-pawl, a holding-pawl, and a reversible stop-piece carried by the ratchet-wheel.

10. In a switch for two electric circuits, the combination with two sets of annularly-arranged stationary contacts, two coöperating contact-arms provided with ratchet-wheels, a pivoted operating-lever provided with reversible pawls for actuating said ratchet-wheels alternately, two holding-pawls—one for each ratchet-wheel—connected by a spring and an automatically-reversible stop-piece pivoted to each ratchet-wheel.

11. The combination with two sets of annularly-arranged stationary contacts, a coöperating contact-arm for each set, means for moving said arms from one contact to the next alternately and in opposite directions and means for stopping said arms when they have moved a predetermined distance.

12. The combination with a transformer, of an annularly-arranged series of stationary contacts connected to leads from a subdivided portion of the transformer-winding, a contact-arm movable step by step to cut said portion of the winding progressively either into or out of circuit, and an auxiliary switch actuated by the contact-arm when the subdivided portion is all cut either in or out to simultaneously cut out or reinsert said subdivided portion and insert or cut out another substantially equal portion.

13. The combination with two transformers the winding of each of which has a portion subdivided by leads, two sets of annularly-arranged stationary contacts to which said leads are connected, contact-arms for said sets of stationary contacts, means for moving the same oppositely step by step in either direction, and an auxiliary switch for each transformer and set of contacts which is actuated by the corresponding arm when the subdivided portion is all cut either in or out to simultaneously cut out or reinsert the subdivided portion and insert or cut out another portion of the winding of substantially the same length.

14. An electromotive-force regulator for two-phase circuits comprising a transformer for each circuit, a set of stationary contacts for each transformer respectively connected to different points in one of its windings, a movable contact-arm for each set of stationary contacts and means for moving said contact-arms oppositely and alternately in either direction from contact to contact whereby the relation between the respective windings of the two transformers is varied to the same degree.

In testimony whereof we have hereunto subscribed our names this 17th day of September, 1897.

HARRY P. DAVIS.
GILBERT WRIGHT.

Witnesses:
WESLEY G. CARR,
H. C. TENER.