No. 854,829. PATENTED MAY 28, 1907.

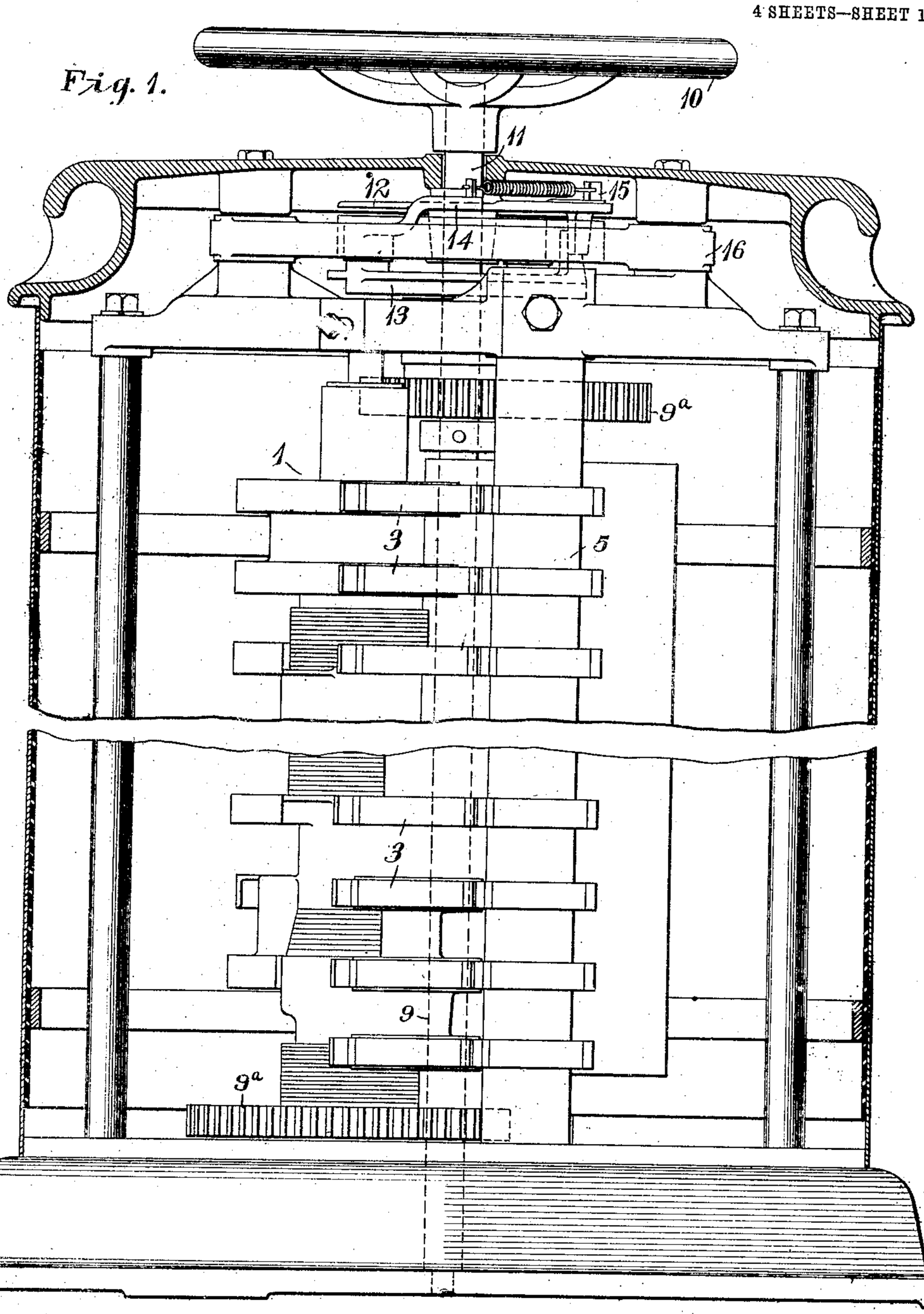
E. LEHR.

POTENTIAL REGULATOR.

APPLICATION FILED SEPT. 20, 1906.

4 SHEETS—SHEET 1.

Fig. 1.



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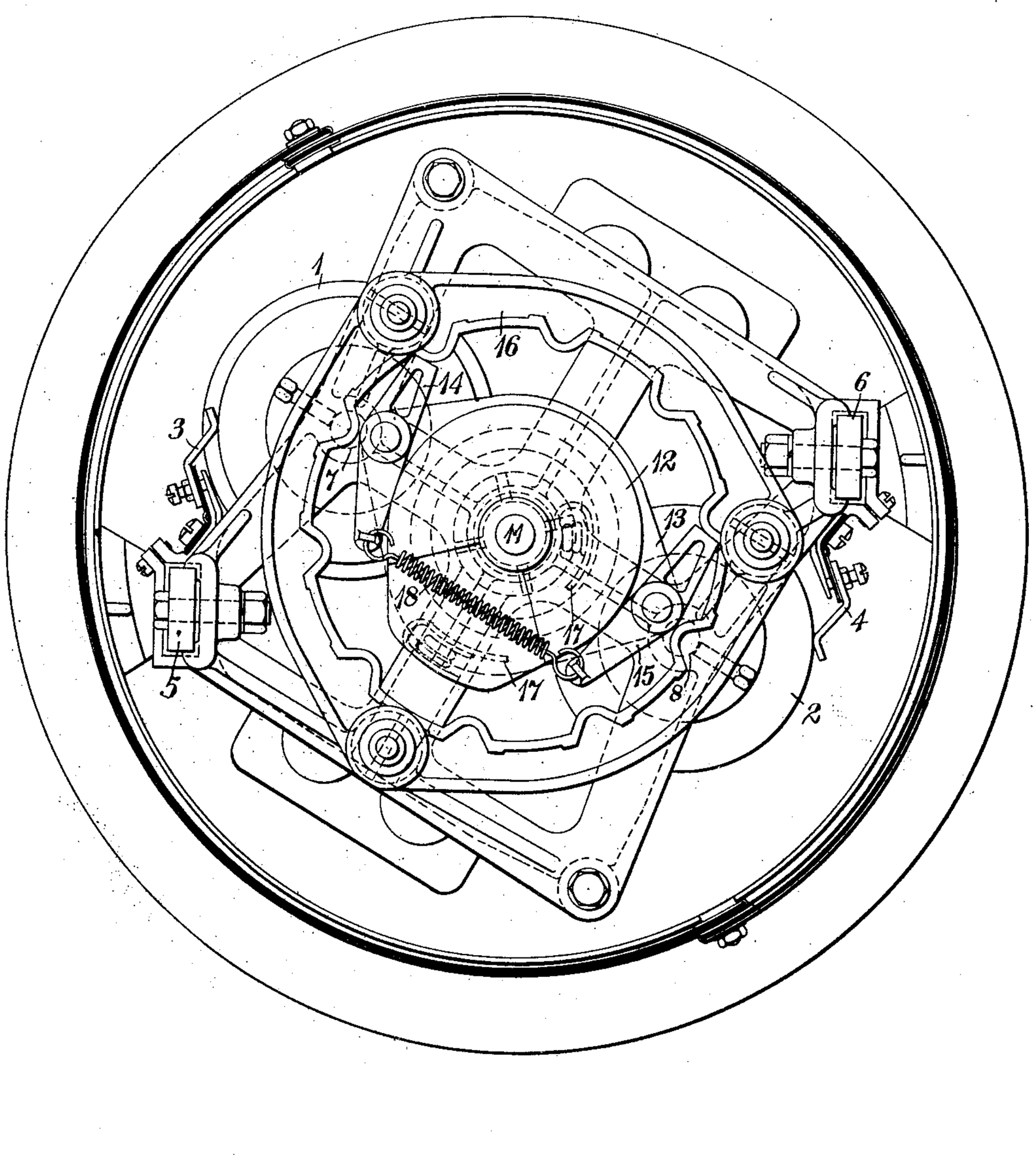
4 SHEETS—SHEET 2.

Fig. 2.



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4 SHEETS—SHEET 3.

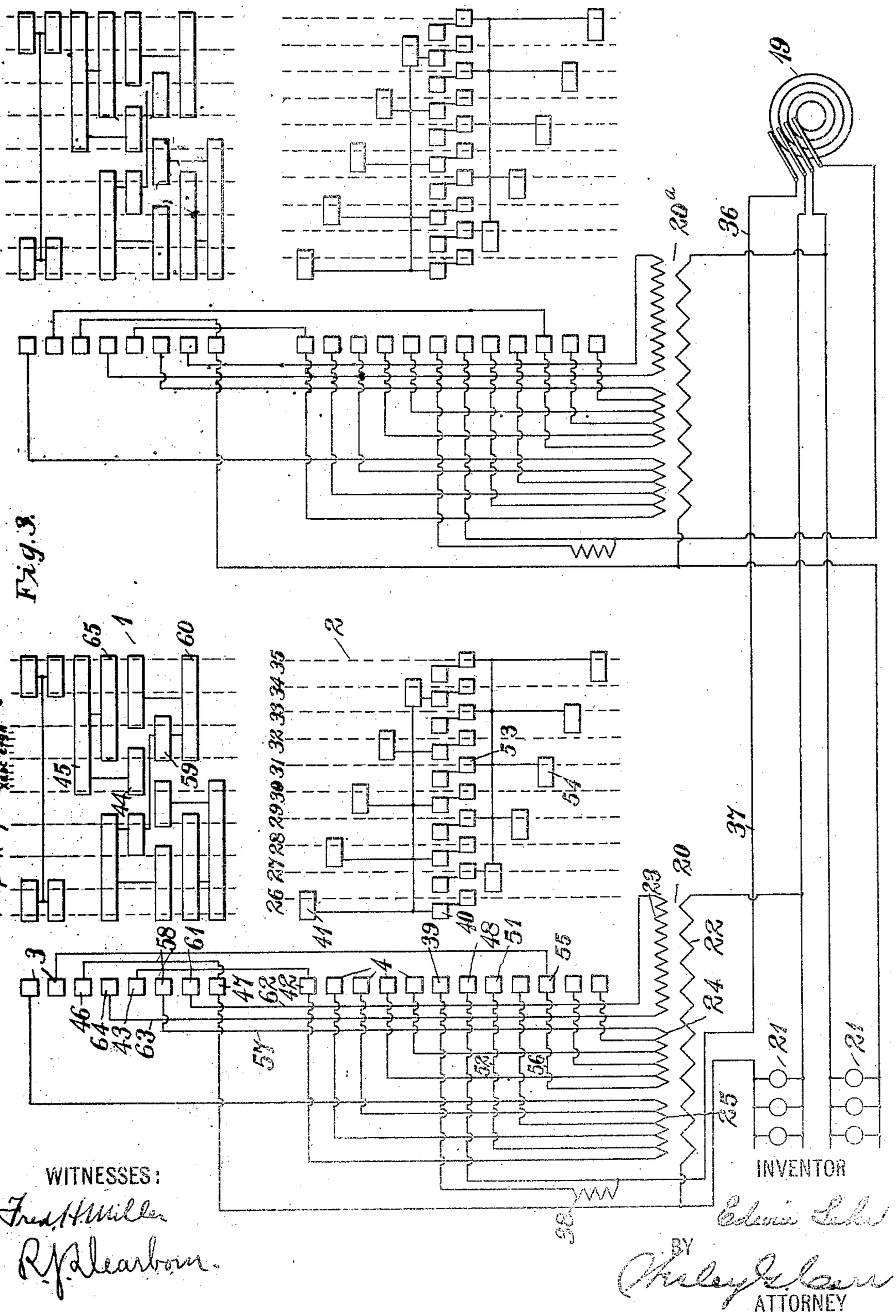

Fig. 3.

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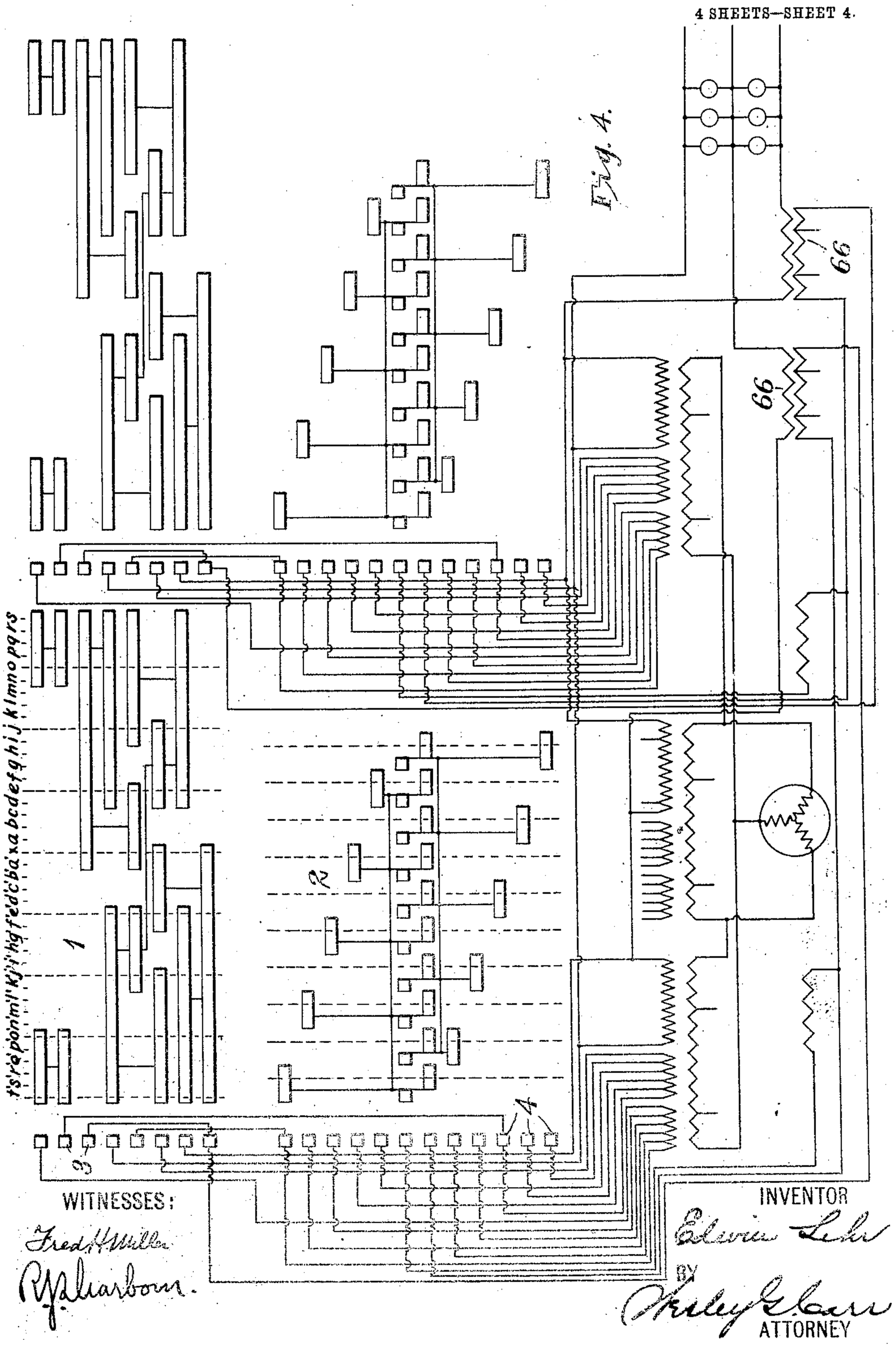
4 SHEETS—SHEET 4.



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POTENTIAL-REGULATOR.

No. 854,829. Specification of Letters Patent. Patented May 28, 1907.

Application filed September 20, 1906. Serial No. 335,506.

To all whom it may concern:

Be it known that I, EDWIN LEHR, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Potential-Regulators, of which the following is a specification.

My invention relates to alternating current systems of electrical distribution, and has special reference to the potential regulation of the distributing circuits for such systems.

The object of my invention is to provide, in a system of the aforesaid class, means for effecting a considerable variation in the potential of distributing circuits, that shall be simple and durable in construction; that shall effect such regulation in relatively small steps and that shall insure a quick transition from one step to the next which is independent of the action of the attendant.

Transformer regulators, as heretofore constructed, have usually comprised either single regulating windings having a plurality of intermediate taps and switching means whereby the desired number of turns actively included in the circuit may be varied, or a main transformer winding having relatively few intermediate taps in connection with a single auxiliary winding which is provided with a relatively large number of intermediate taps and which comprises a number of convolutions substantially equal to one section between taps of the main winding. With the latter arrangement, a considerable movement of the switching device is required for effecting the suitable changes between the main transformer winding and the auxiliary winding.

According to my present invention, I provide a main transformer winding which may comprise a single section of any desired number of convolutions or may be divided into two or more sections by intermediate taps, and two similar auxiliary windings having a relatively large number of intermediate taps which are successively connected in such a manner as to oppose or assist the main winding by means of a suitable switching device, the action of which will be better understood by reference to the accompanying drawings and to the detailed description of the invention hereinafter contained.

Figure 1 of the drawings is a front elevation, the case being partially removed to disclose the working-parts, of a switching device constructed in accordance with my invention. Fig. 2 is a plan view, with the cover removed, of the device illustrated in Fig. 1, and Figs. 3 and 4 are diagrammatic views of systems of distribution embodying the regulator of my invention.

Referring to Figs. 1 and 2, the switching device comprises two rotatably-mounted contact-carrying drums 1 and 2, two sets of stationary engaging fingers 3 and 4 therefor which are respectively mounted on stationary rods 5 and 6 from which they are insulated in a well known manner. The drums 1 and 2 are mounted on substantially parallel shafts 7 and 8 and are actuated from an intermediate shaft 9 by means of two pairs of engaging spur gears 9^a. A speed ratio of four to one being effected between the operating shaft 8 and the drum 1, while the speed ratio of one to one is effected between the operating shaft and the drum 2. The shaft 9 is driven indirectly by an operating handle 10, which is rigidly attached to a short shaft 11 that is in alinement with the operating shaft 9 and to which a release cam 12 is attached. A pair of similar pawls 14 and 15 are pivotally mounted on opposite extremities of a frame 13, which is fixed to the shaft 9, the pawls being adapted to engage a stationary ratchet ring 16. The pawls 14 and 15 are so arranged as to respectively prevent the rotation of the operating shaft 9 in either direction until they are released by the cam 12 which is moved by the handle 10. The shaft 11 is so connected with the main shaft 9, by a spiral spring 17, that a motion of the operating handle 10 in either direction tends to produce rotation of the main shaft, but rotation of this shaft is not effected until the cam 12 is moved into engagement with the inner extremity of that pawl which normally prevents rotation of the shaft in the direction of movement of the handle. In this way, although the motion of the operating handle is relatively slow, the motion of the operating shaft is never permitted, until the spiral spring is subjected to sufficient tension or compression, to cause a quick motion of the shaft. As soon as the pawl is disengaged from the cam, it is brought into engagement with the next notch on the ratchet ring

16, by means of a spring 18, which connects the inner ends of the pawls. The several notches on the ratchet ring 16 are arranged to correspond to the various positions which the drums 1 and 2 are adapted to occupy.

The quick passage of the switching drums from one position to the next is a feature of special advantage, since the possibility of electric arcs being maintained between the contact members of the drums and the stationary engaging fingers is reduced to a minimum.

Referring to Fig. 3, in which the switching drums 1 and 2 are shown as developed into a single plane, alternating current energy may be supplied from any convenient source, such as a two-phase generator 19, through regulating transformers 20 and 20[a], to translating devices 21, to which it is desirable to supply energy at voltages which vary relative to those at the generator terminals. Since the regulation of both phases of the two-phase system are identical, only one will be considered. The regulating transformer 20 comprises a primary winding 22 and a secondary winding which is made up of a main section 23 and two similar auxiliary sections 24 and 25. The secondary sections of this transformer may be connected in series with one phase of the generator 19 and in this way the electromotive force applied to the outgoing circuits may be varied.

When the operating handle 10 is in its "off" position, which may be indicated on the top cover of the switching device in the usual manner, the drum 1 occupies a position indicated on the diagram by X, and the drum 2 occupies a position indicated by 26, and as the operating handle is moved in one direction the drum 1 may traverse positions *a* to *s*, inclusive, and the drum 2 at the same time completes two revolutions and traverses the positions 26 to 35, inclusive, twice. As the operating handle is moved in the opposite direction, the drum 1 traverses positions *a'* to *t'*, inclusive, and the control drum 2 passes through the positions 35 to 26, inclusive, twice.

When the control drum 1 occupies position *x* and the drum 2 approaches position 26, circuit connections are first completed from one terminal 36 of the generator through conductor 37, preventive resistance 38, contact finger 39, contact segments 40 and 41 of the drum 2, contact finger 42, contact finger 43 of the drum 1, contact segments 44 and 45 and contact fingers 46 and 47, from which point circuit is continued to the translating devices 21. When the aforesaid position 26 is fully reached by the drum 2, the circuit connections just enumerated will be maintained except that the contact finger 48 will be in engagement with the contact segment 40 and the preventive resistance 38 be thereby short-circuited. It will be observed that when the above specified circuit conditions obtain the electromotive force applied to the translating devices is the same as that delivered from the generator. As the control drums 1 and 2 are respectively moved into the positions *a* and 27, the preventive resistance 38 is included in the circuit, as before, and then short-circuited. Circuit is then continued from contact finger 51, which is connected by a conductor 52 to an intermediate tap in a transformer section 25, through a portion of this transformer section and conductor 52 to contact finger 42, and from this point the circuit is completed as before. In this way, a few turns of the transformer section 25 are connected in series with the outgoing circuit and are so magnetically interlinked with the primary transformer winding 22 as to cause a small increase in the electromotive force applied to the translating devices 21, over that which is delivered from the generator 19.

As the drums 1 and 2 respectively occupy positions *c*, *d* and *e* and positions 28, 29 and 30, transformer section 25 is gradually included, portion by portion, in series with the line in a manner already explained, and when the drums occupy positions *f* and 31, respectively, the circuit is completed from contact finger 48, through contact segments 53 and 54, contact finger 55 and conductor 56 to one extremity of the transformer section 24, circuit being continued from this point through the transformer section, conductor 57, contact finger 58, contact segments 59 and 60, contact finger 61, conductor 62, transformer section 23, conductor 63, contact finger 64, contact segments 65 and 45 to contact finger 46, circuit being completed from this point, as hereinbefore indicated. It will be observed that after transformer section 25 is entirely included in the circuit, the main section 23 is connected in circuit in a similar manner with the section 24 opposed to it. The number of convolutions included in the transformer section 23 so compares with the convolutions of the sections 24 and 25, which are similar, as to effect only a normal increase in voltage, equal to an increase effected by including one of the small portions of the transformer section 25, when the aforesaid change takes place.

As the control drums respectively occupy positions *g*, *h*, *i* and *j* and 32, 33, 34 and 35, the transformer section 24, which opposes section 23, is gradually decreased and when the drum 1 occupies position *k*, the drum 2 occupies position 26 and the entire transformer section 23 is connected in series with the circuit and raises the voltage applied to the translating device without opposition from the other sections. When the drums respectively occupy positions *l*, *m*, *n*, *o* and *p* and 27, 28, 29, 30 and 31, the transformer

section 25 is again gradually included in series with the line so as to assist the winding 23. And as drum 1 traverses the remainder of its positions in this direction, the drum 2 completes its second revolution and the transformer section 24 is gradually included in the circuit so as to assist the sections 23 and 25. When this point is reached, the maximum voltage attainable with the regulator illustrated is effected.

As the drum 1 traverses positions a' to t', inclusive, and the drum 2 is rotated through two revolutions in the opposite direction, the transformer section 24 is first gradually included in the circuit in such a manner as to reduce the voltage applied from the generator, the section 23 is next similarly connected in the circuit and the entire transformer section 25 is connected in opposition to it, then the section 25 is gradually decreased and removed from the circuit, the section 24 is gradually connected in series with section 23, and finally the section 25 is gradually connected in series with both transformer sections 23 and 24, so that the minimum voltage is applied to the translating devices. Since the circuit connections involved for the various steps are similar to those already described, I deem it unnecessary to include a detailed description thereof.

When a single auxiliary winding has been employed in connection with a main winding for potential regulation, a control drum similar to the drum 2 has often been used, but it is necessary to effect a radical change in the circuit connections at the end of each revolution of the drum when the auxiliary winding is transferred from one main winding tap to the next. Consequently the mechanical switch mechanism was complicated and a relatively large arc of drum rotation was taken up at these critical points in traversing a single position.

The mechanism of my present invention is relatively simple, since one auxiliary winding may be transferred while the active convolutions of the other set are being varied, and since the entire regulation may be effected by two control drums which are permanently geared together and to the operating mechanism. Furthermore, the arcs of rotation corresponding to a change from any one position to the next adjacent may all be of equal length.

Although the regulating system shown in Fig. 3 comprises a transformer having a primary winding and a divided secondary winding, the principle may obviously be applied to an auto-transformer or to the primary of a two-winding transformer.

Referring to Fig. 4, a slightly modified arrangement is here illustrated which is adapted for three phase circuits and in which the increase and decrease of the electromotive forces in the circuit is effected by series transformers 66, the secondaries of which are varied by a switching device in a manner similar to that described for Fig. 3.

It will of course be understood that when the regulator is adapted for use with polyphase circuits, a single switching device will be employed in which each group of similar drums may be mounted on a single vertical shaft.

I desire that variations in size and arrangement of details which do not depart from the spirit of my invention shall be included in its scope.

I claim as my invention:

1. An alternating current regulator that comprises a main transformer winding, two similar auxiliary windings and a plurality of intermediate taps in said auxiliary windings.

2. In a transformer regulator, the combination with a main winding, two similar auxiliary windings and a plurality of intermediate taps in said windings, of means for gradually connecting, in circuit, one auxiliary winding, the main winding and the two auxiliary sections in opposition thereto, the main winding and one auxiliary winding and the main winding and both auxiliary windings.

3. In a regulating transformer, the combination with a main winding, two similar auxiliary windings and a plurality of intermediate taps therein, of switching means for gradually increasing the effective turns in steps, which are substantially equal to one of the divisions in the auxiliary winding between two adjacent taps, from zero to the total number of convolutions in the three windings.

4. The combination with a main transformer winding, of two similar auxiliary windings the combined convolutions of which are slightly fewer in number than those of the main winding, as and for the purpose set forth.

5. The combination with a main transformer winding, of two similar auxiliary windings and a plurality of intermediate taps therefor which divide the auxiliary windings into substantially equal parts, said main winding containing a number of convolutions equal to the two auxiliary windings plus a single division between the intermediate taps in the latter.

6. The combination with a main transformer winding, and two similar auxiliary windings, of means for varying the effective turns that comprise a regulator having rotatable contact-carrying drums and means for rotating the drums through a plurality of predetermined positions.

7. The combination with a main transformer winding, and two similar auxiliary windings, of means for varying the effective turns of the windings that comprise a pair of

regulating contact-carrying drums adapted to occupy a plurality of predetermined positions, an operating handle therefor, and resilient means interposed between the handle and the drums.

8. The combination with a main transformer winding, two similar auxiliary windings and a plurality of intermediate taps in the auxiliary windings, of means for varying the effective turns that comprise a pair of switching drums adapted to occupy a plurality of positions, means for accentuating said positions and means for effecting a quick motion from one position to the next.

9. In a transformer regulator, the combination with a main winding, two similar auxiliary windings having a plurality of intermediate taps, of switching means for gradually varying, between zero and the total number of convolutions of the three windings, the effective turns in steps which are substantially equal to a division of the auxiliary winding between adjacent taps, that comprises a pair of switching drums adapted to occupy a plurality of positions, means for accentuating said positions and means for effecting a quick motion from one position to the next.

10. In a transformer regulator, the combination with a main winding, two similar auxiliary windings having a plurality of intermediate taps, of switching means for gradually varying the effective turns in steps which are substantially equal to a division of the auxiliary winding between adjacent taps, between zero and the total number of convolutions of the three windings that comprise a pair of contact-carrying drums adapted to occupy a plurality of predetermined positions, means for accentuating said positions, an operating handle for said drums, a yielding connection between the handle and the drum, and means dependent upon the operating handle for permitting the rapid transition of the drums from one position to the next.

11. In a transformer regulator, the combination with a main winding, a pair of similar auxiliary windings having a relatively large number of intermediate taps, of means for connecting the auxiliary windings with the main winding and for varying such connection to gradually increase or decrease the effective turns of the regulator.

In testimony whereof, I have hereunto subscribed my name this 18th day of September, 1906.

EDWIN LEHR.

Witnesses:
W. E. REED,
BIRNEY HINES.