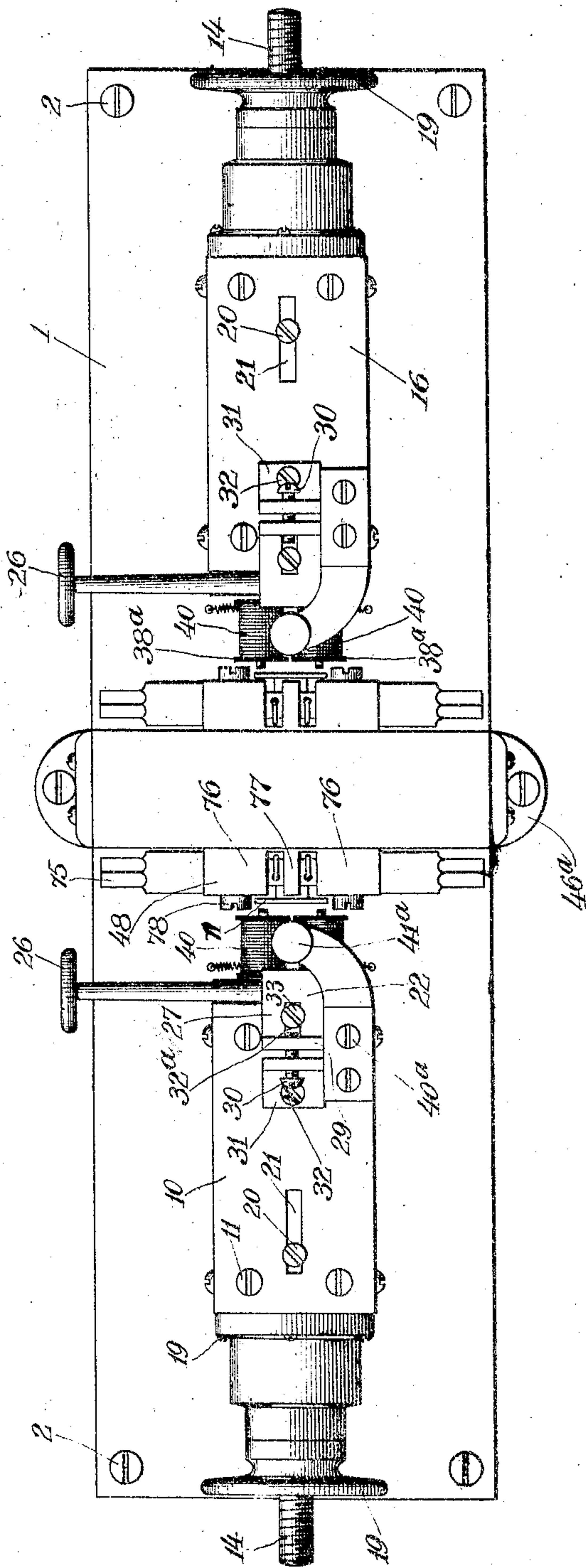


1,203,325.

E. GRISSINGER.
TELEPHONE RELAY OR REPEATER.
APPLICATION FILED APR. 27, 1910.

Patented Oct. 31, 1916.
8 SHEETS—SHEET 1.

Fig. 1



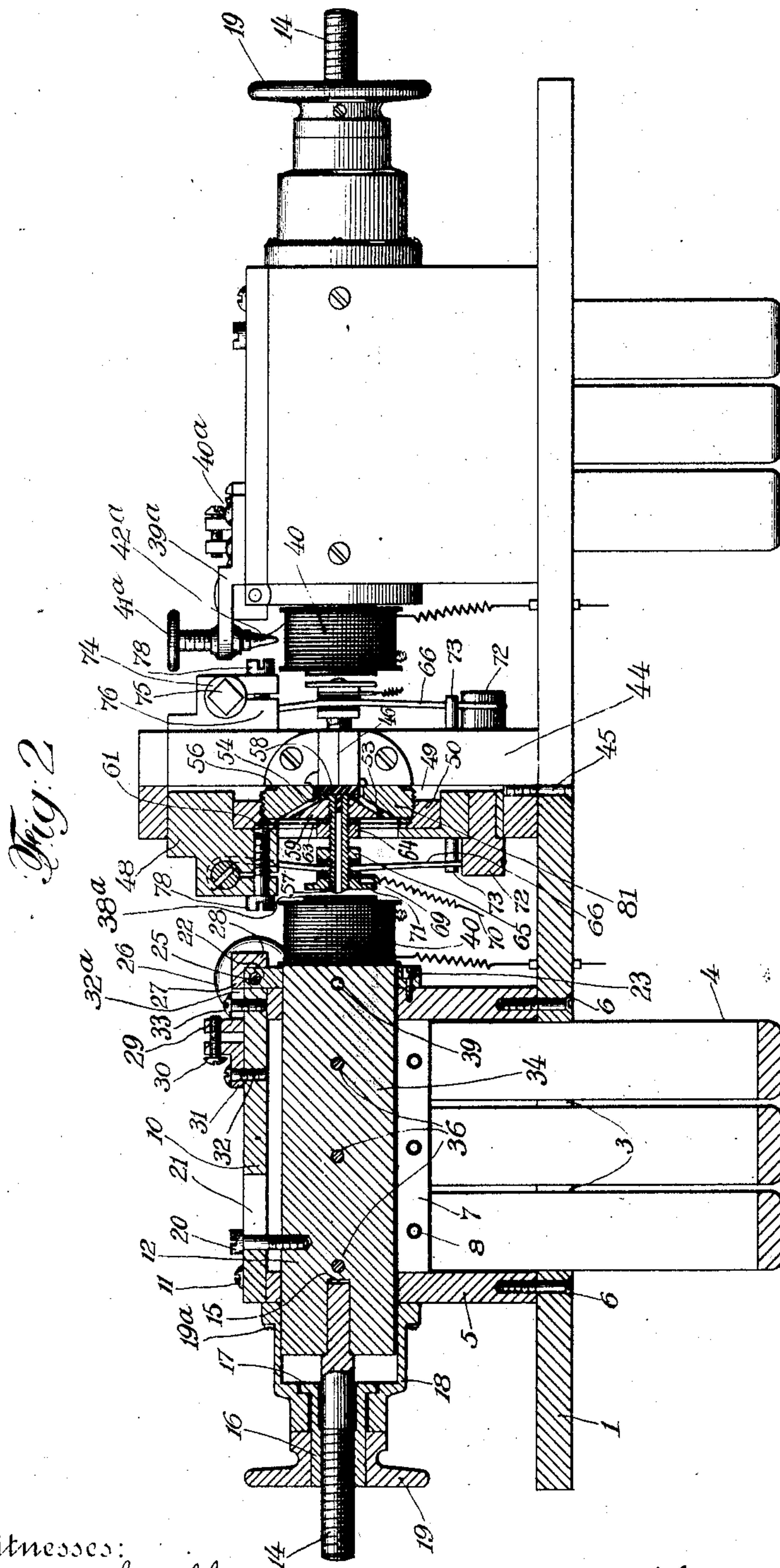
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8 SHEETS—SHEET 2.



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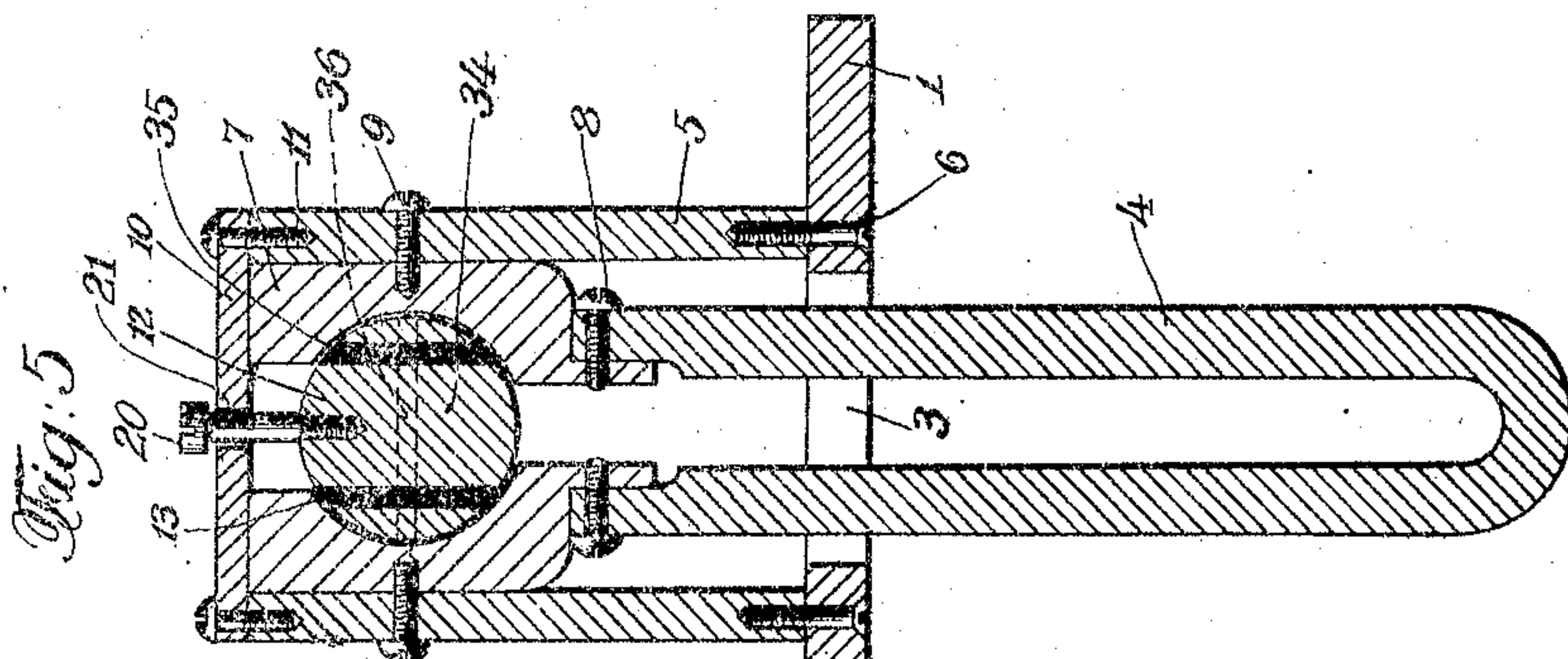
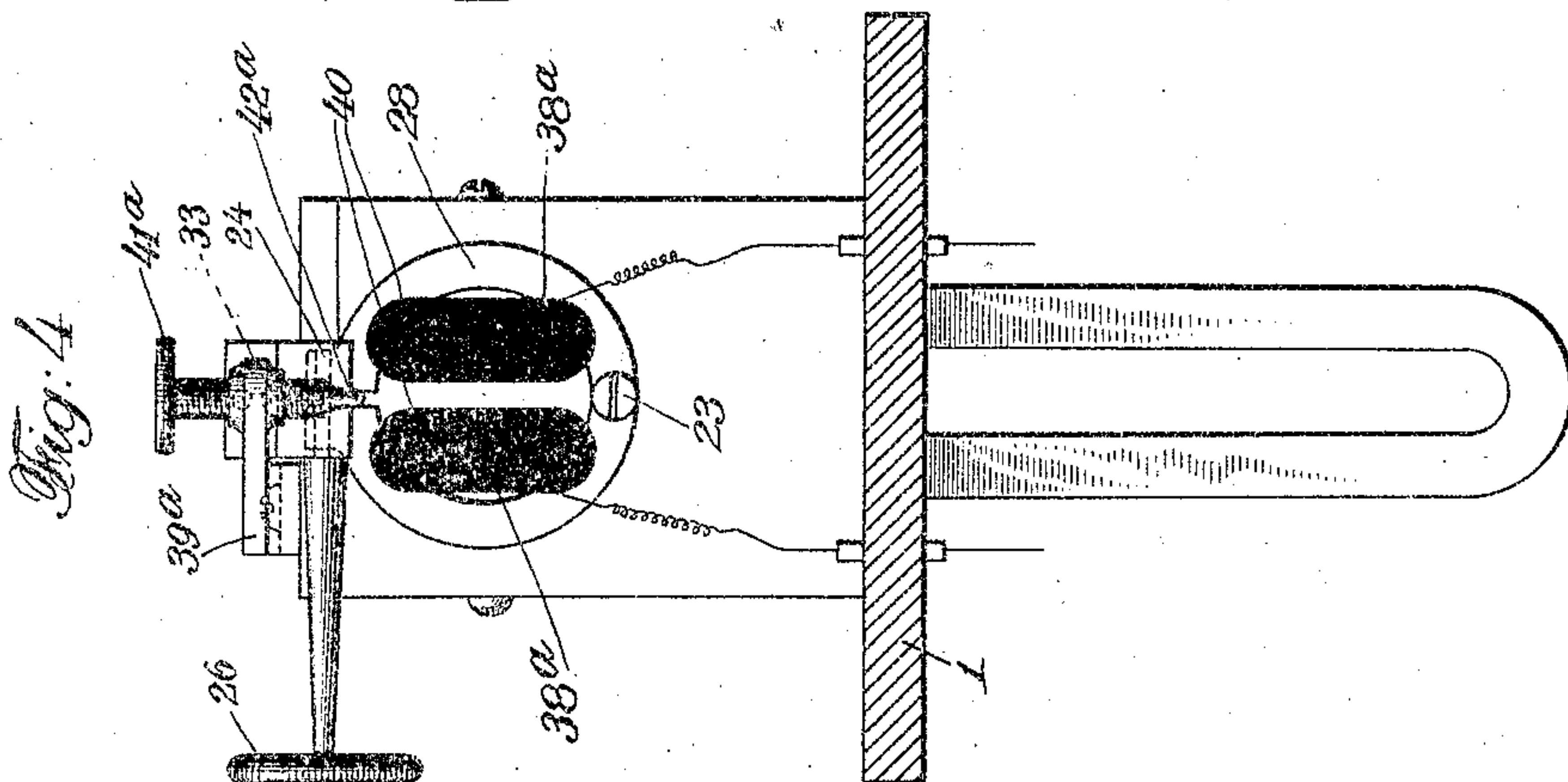
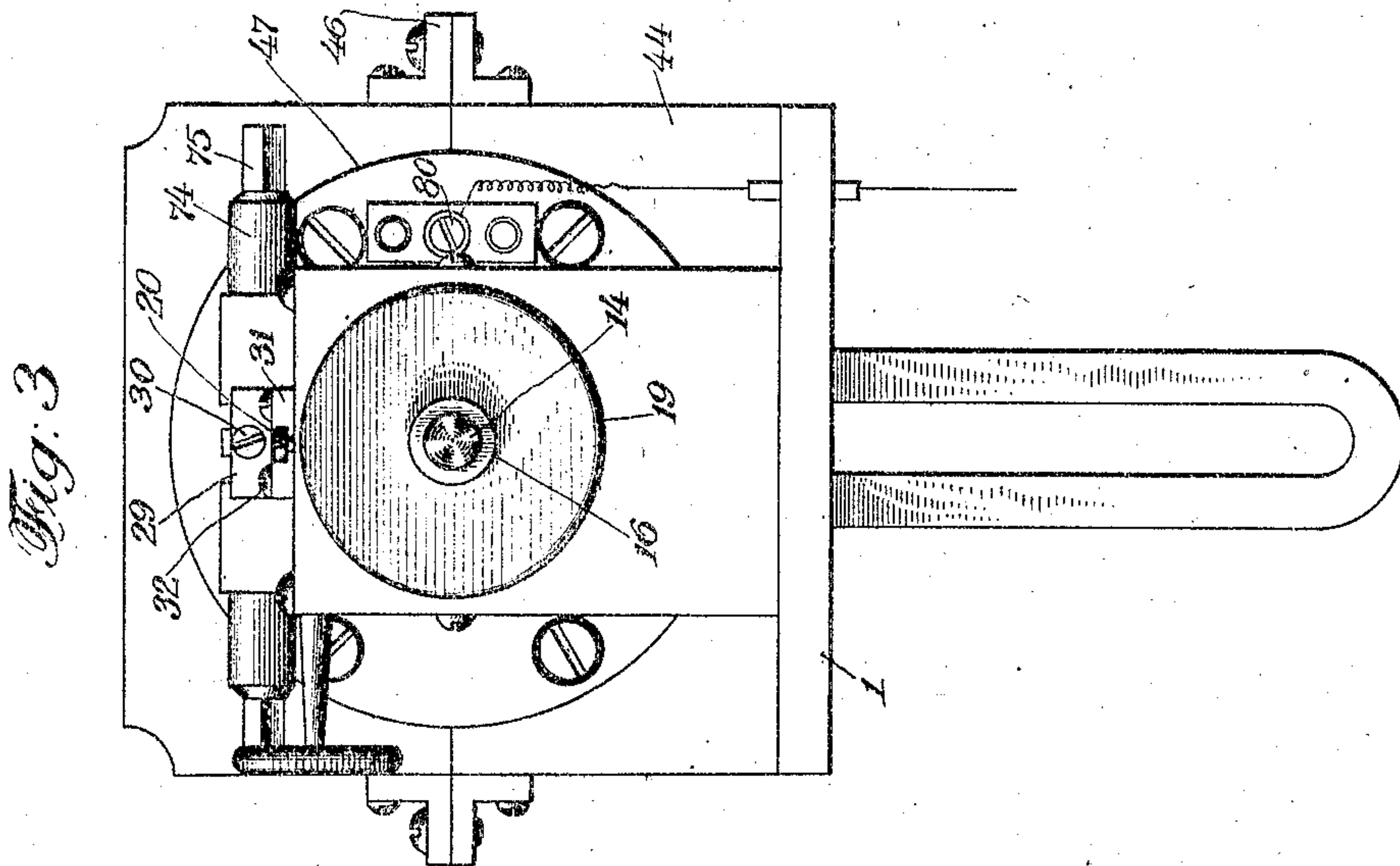
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8 SHEETS—SHEET 3.

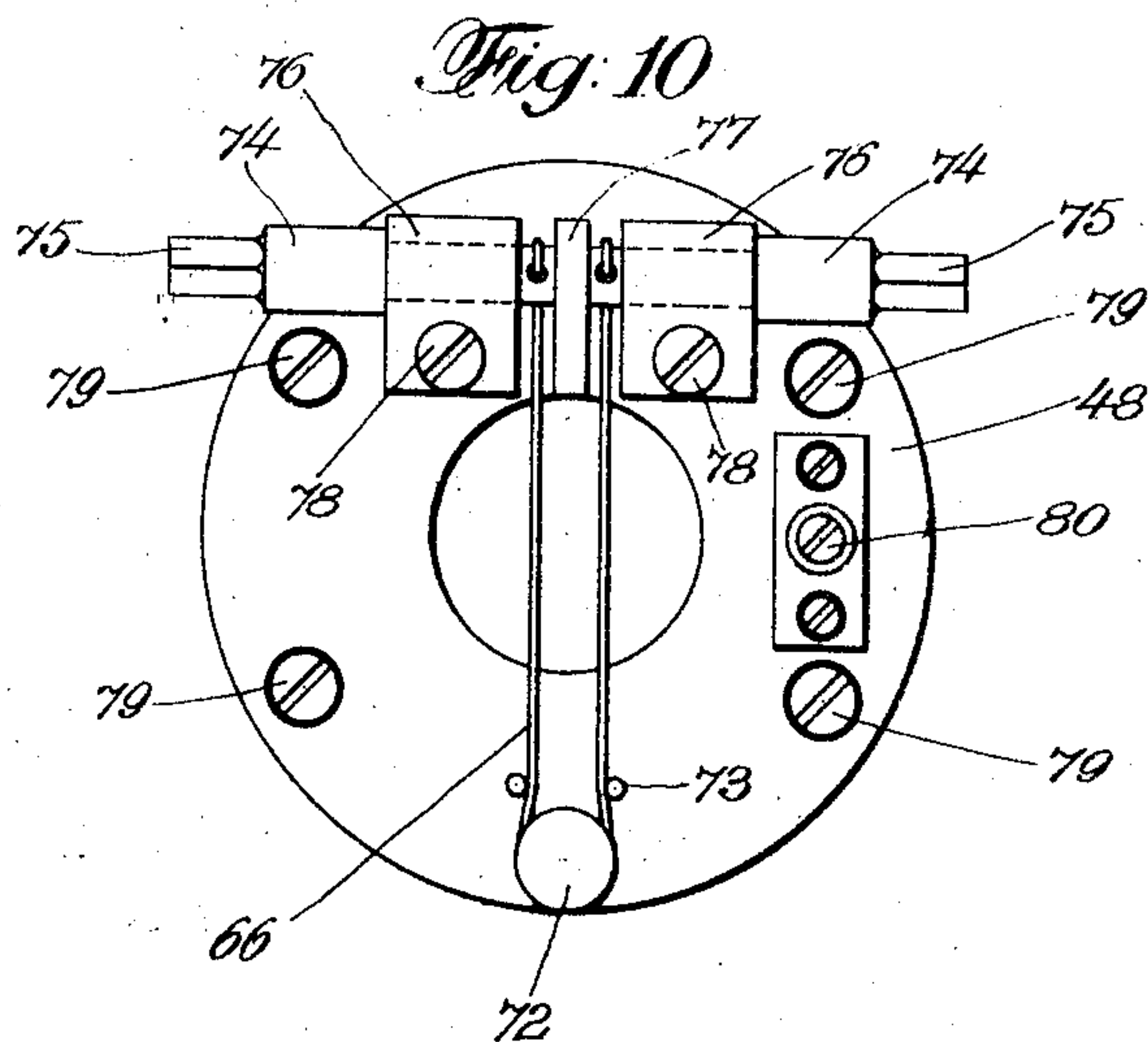
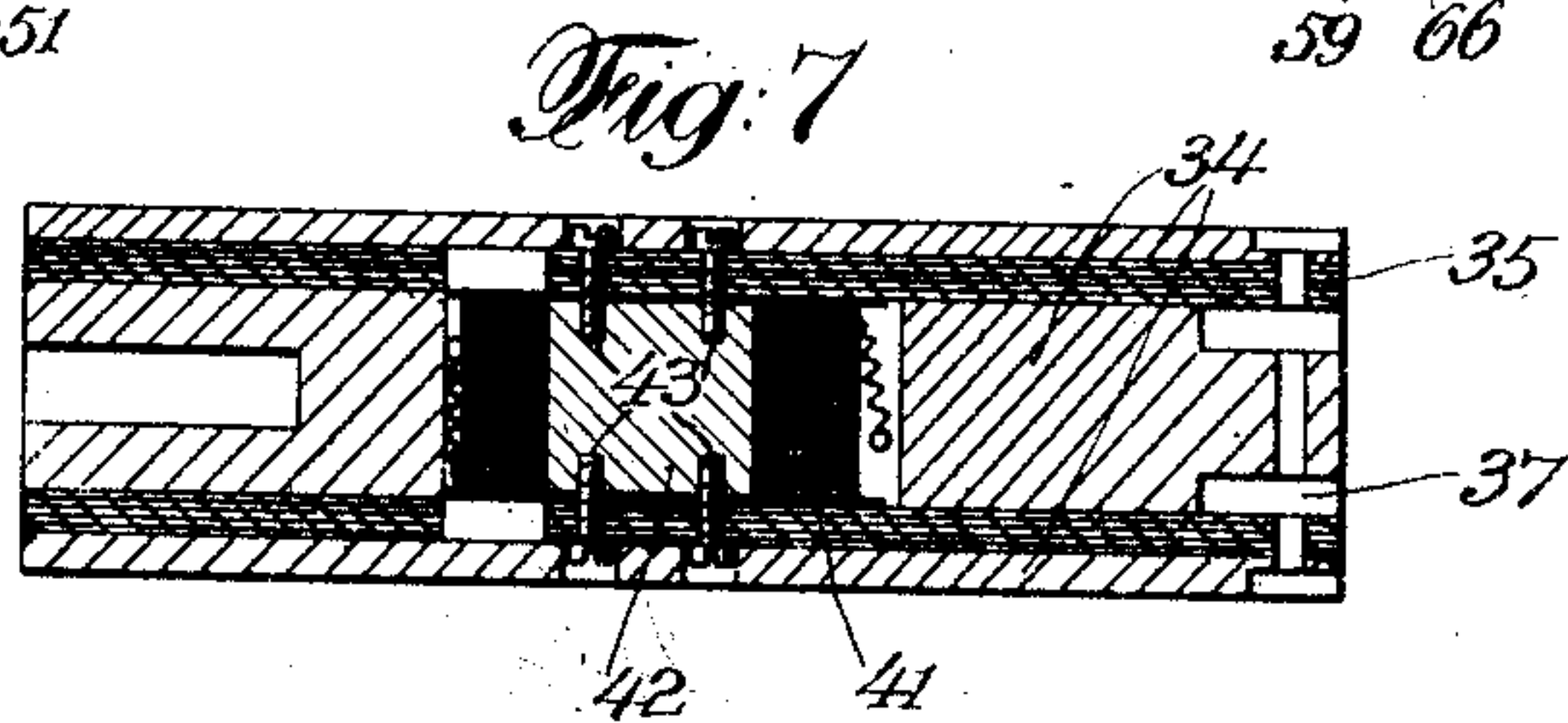
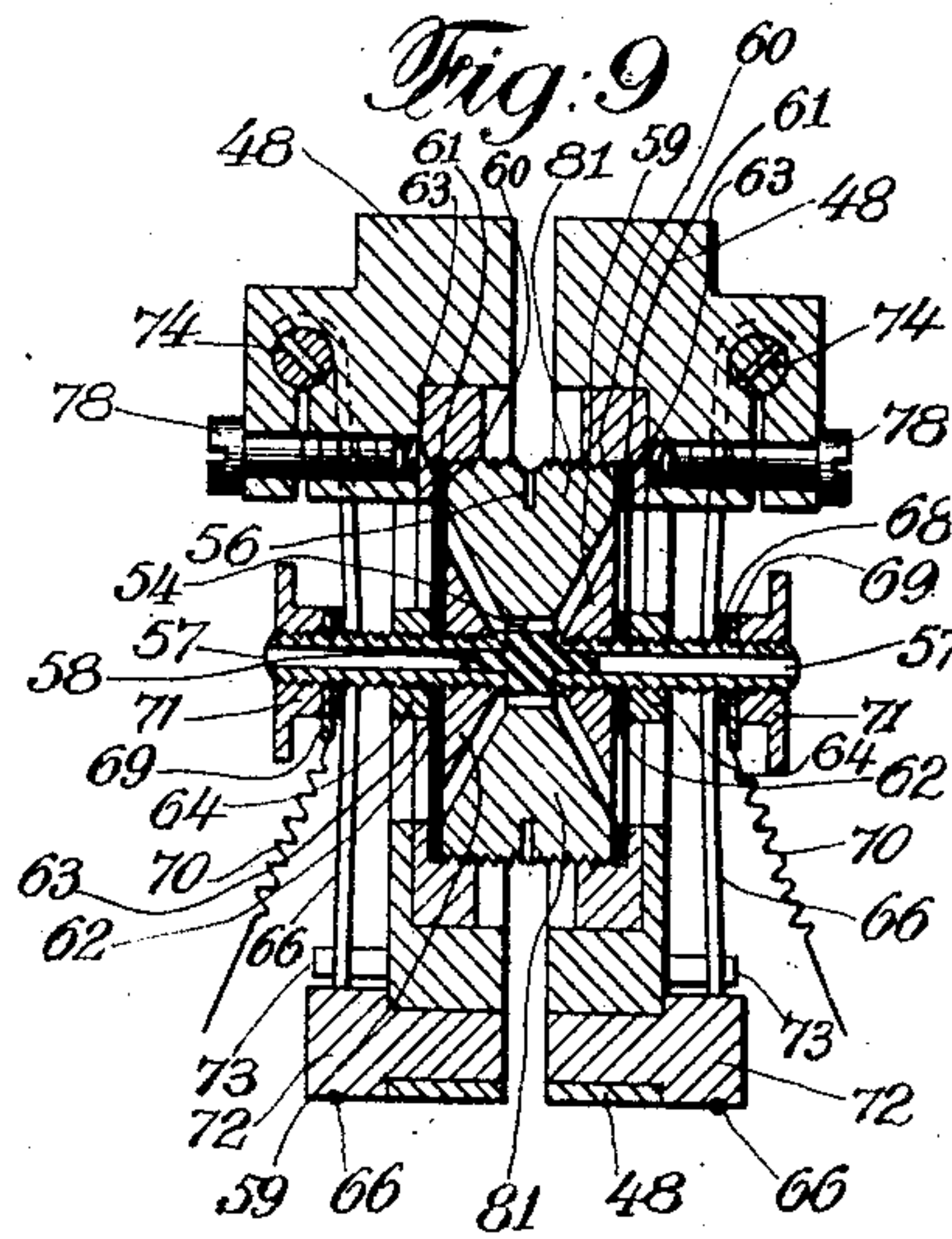
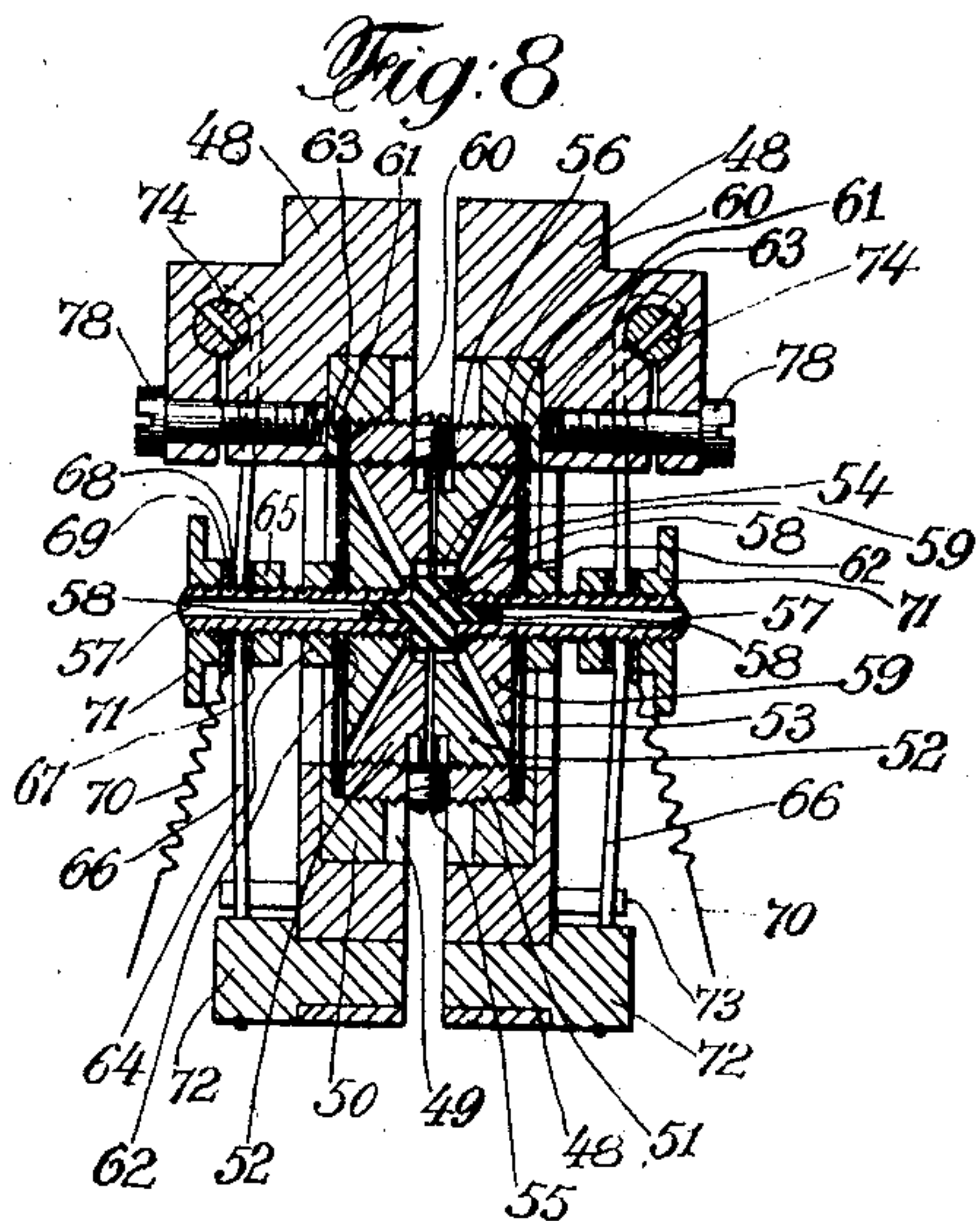


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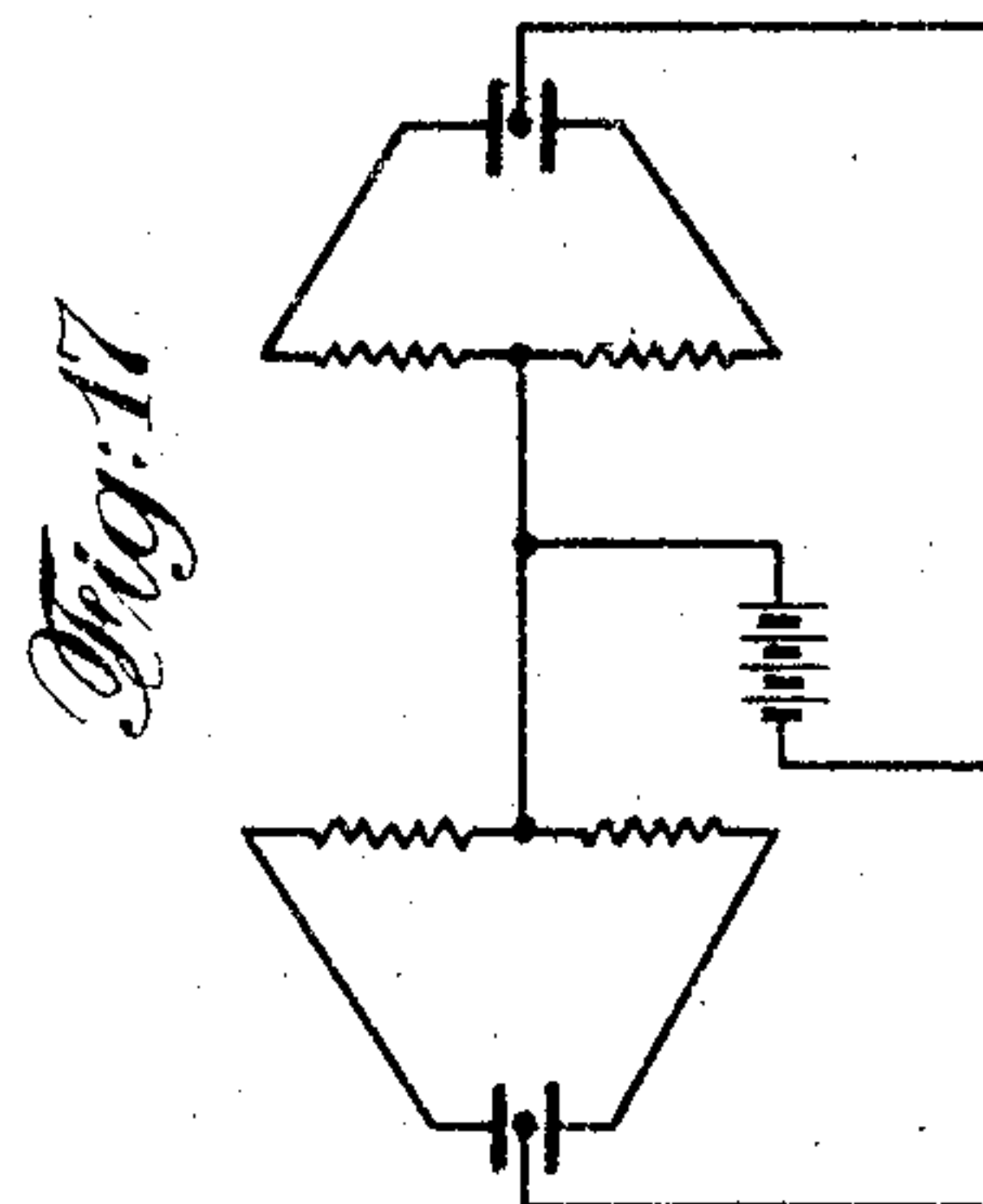
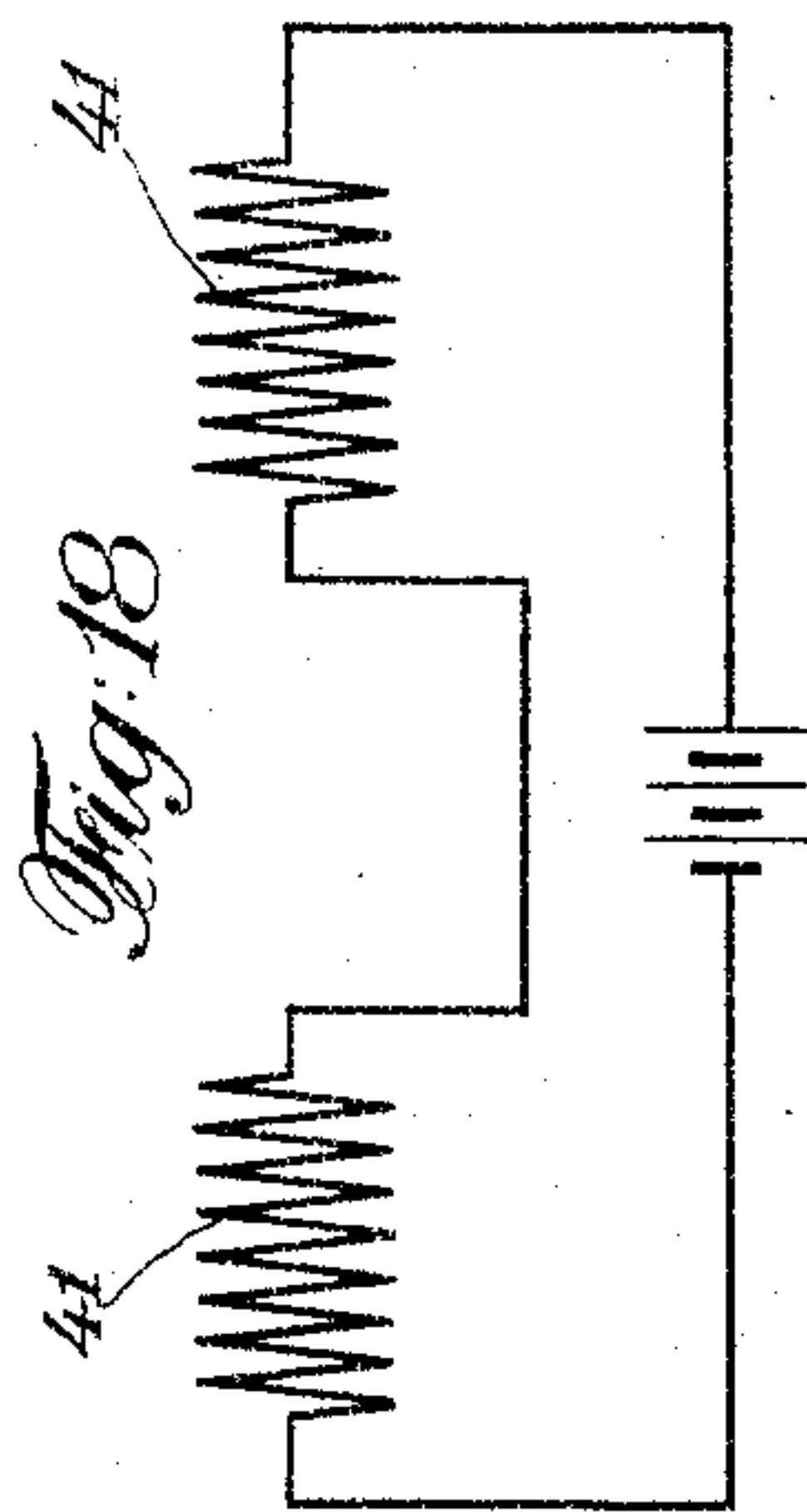
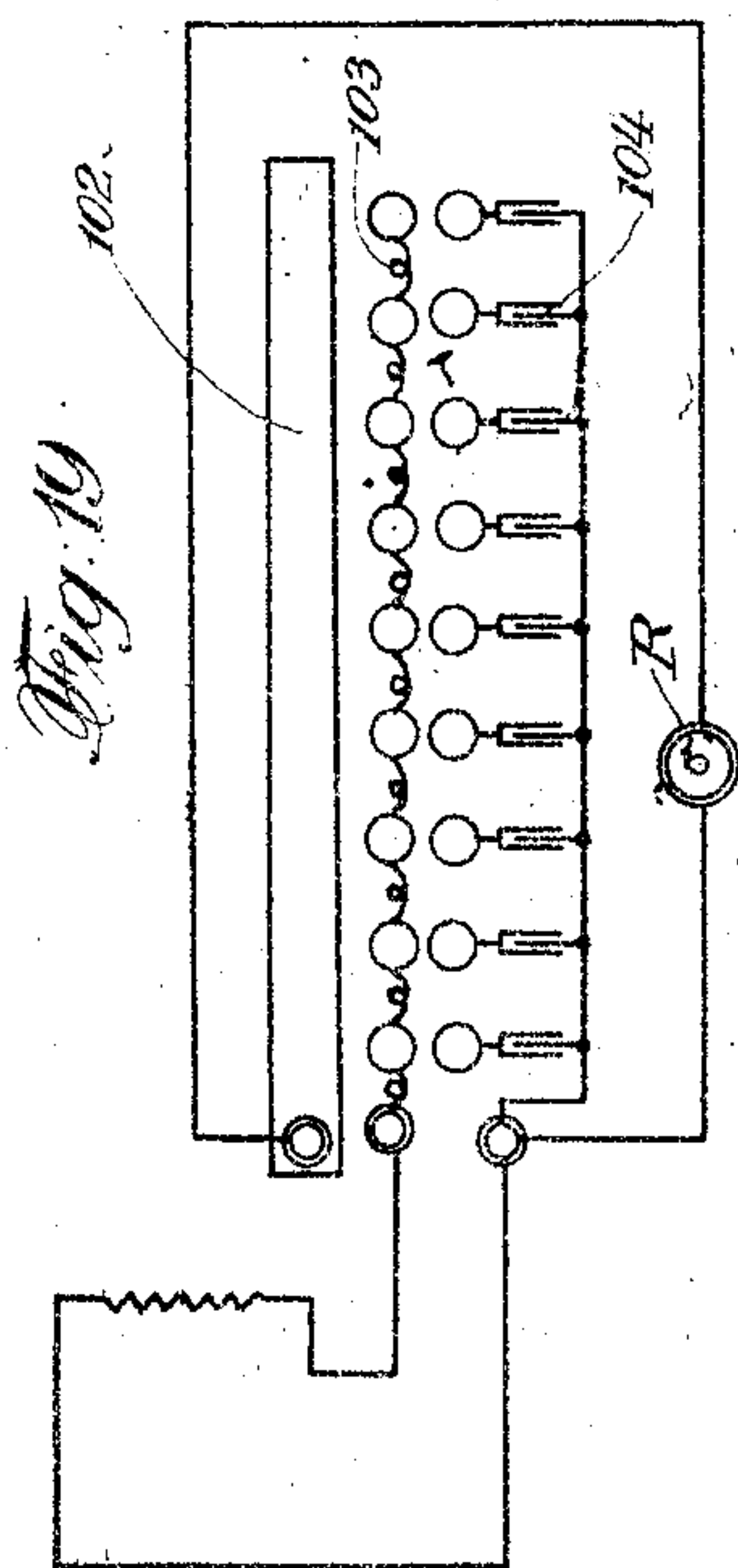
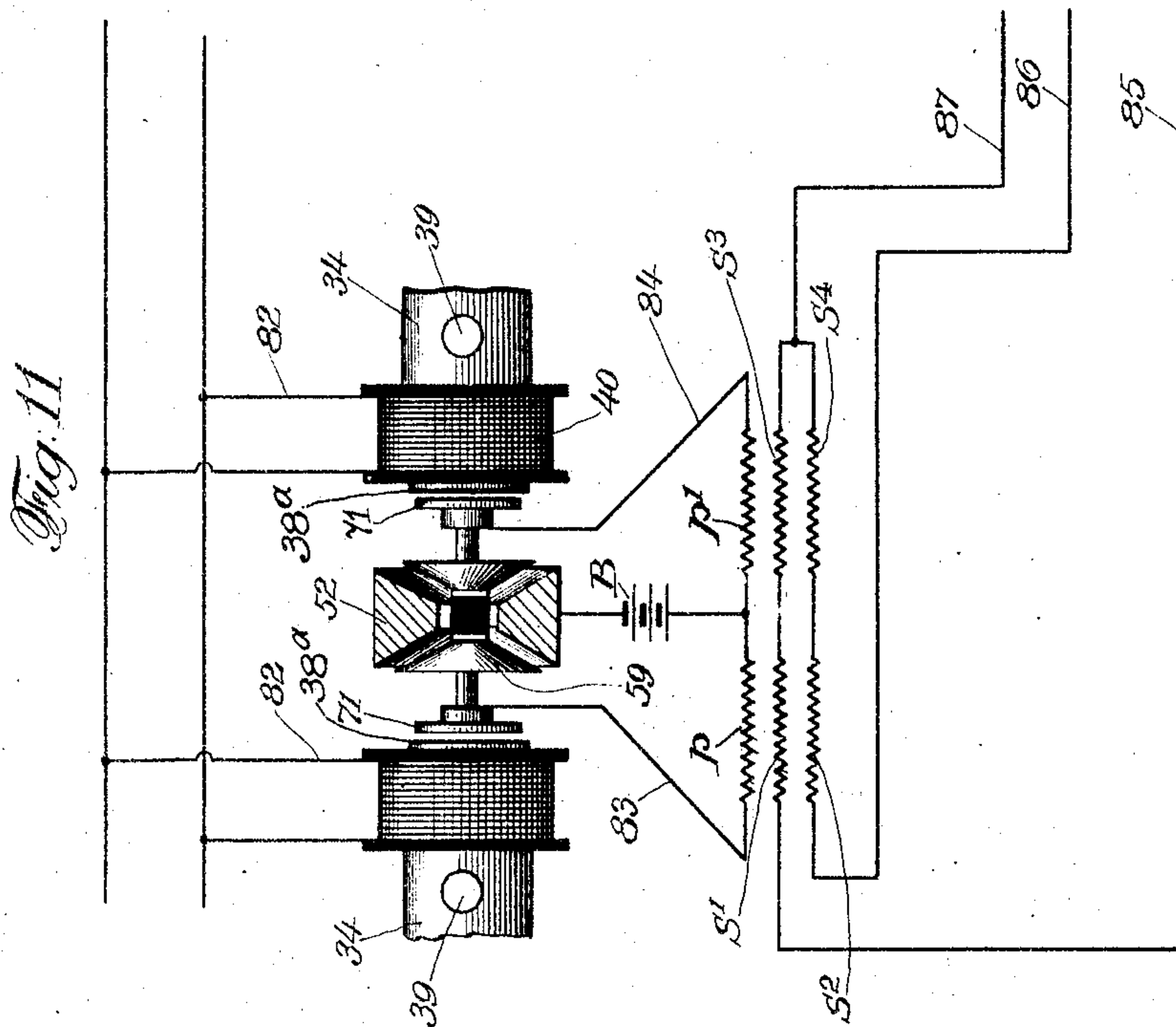
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APPLICATION FILED APR. 27, 1910.

1,203,325.

Patented Oct. 31, 1916.

8 SHEETS—SHEET 6.



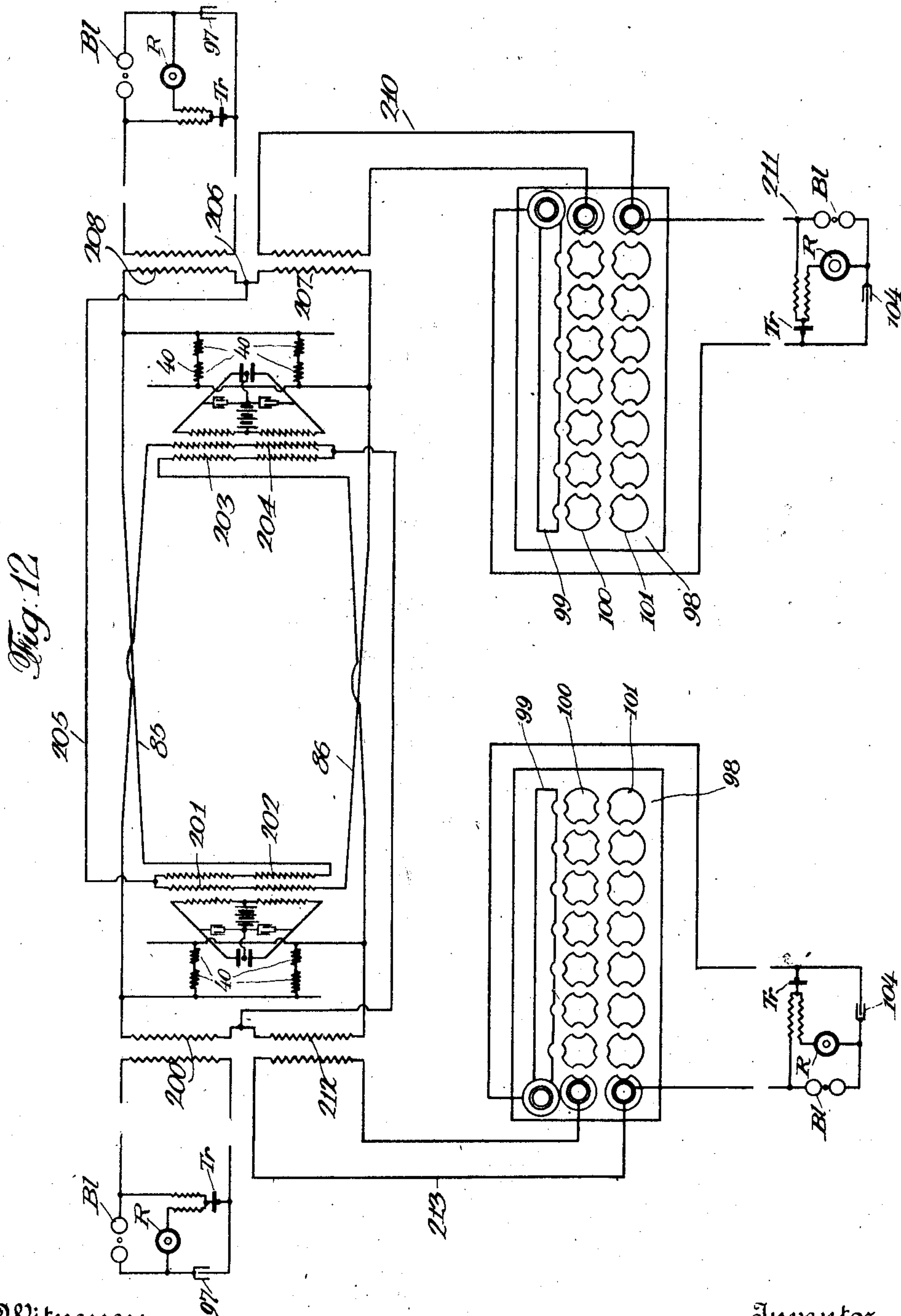
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APPLICATION FILED APR. 27, 1910.

1,203,325.

Patented Oct. 31, 1916.
8 SHEETS—SHEET 7.

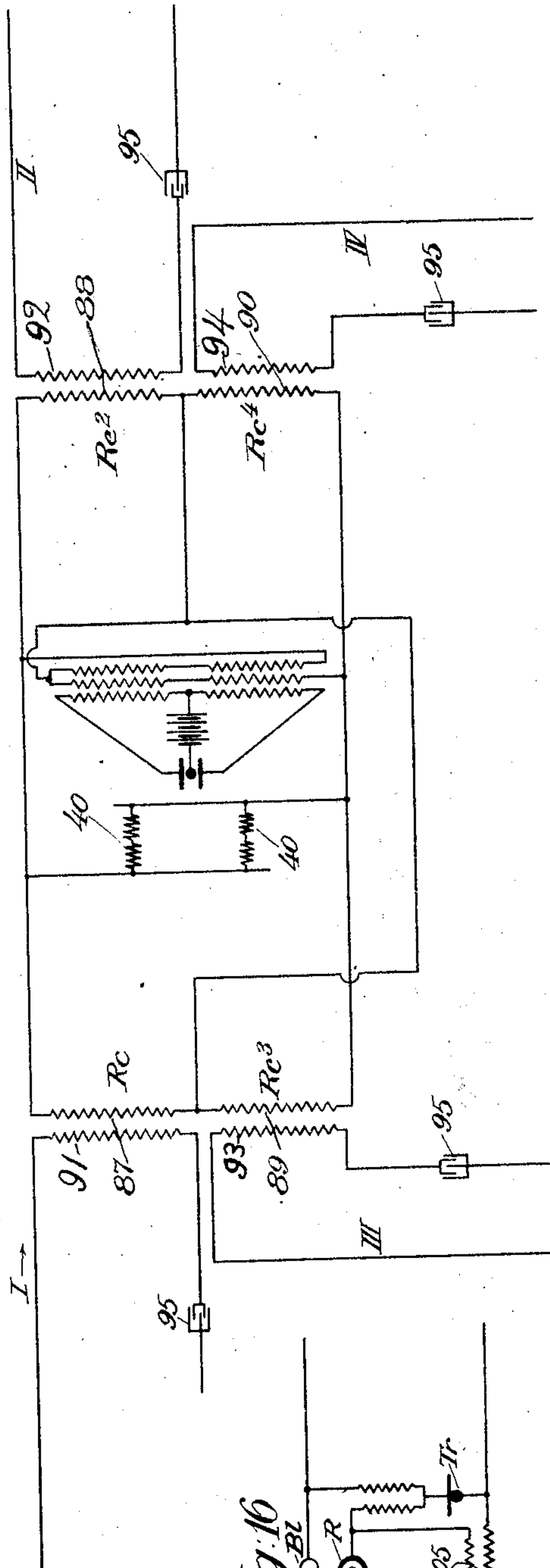


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Fig. 14



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Fig. 16

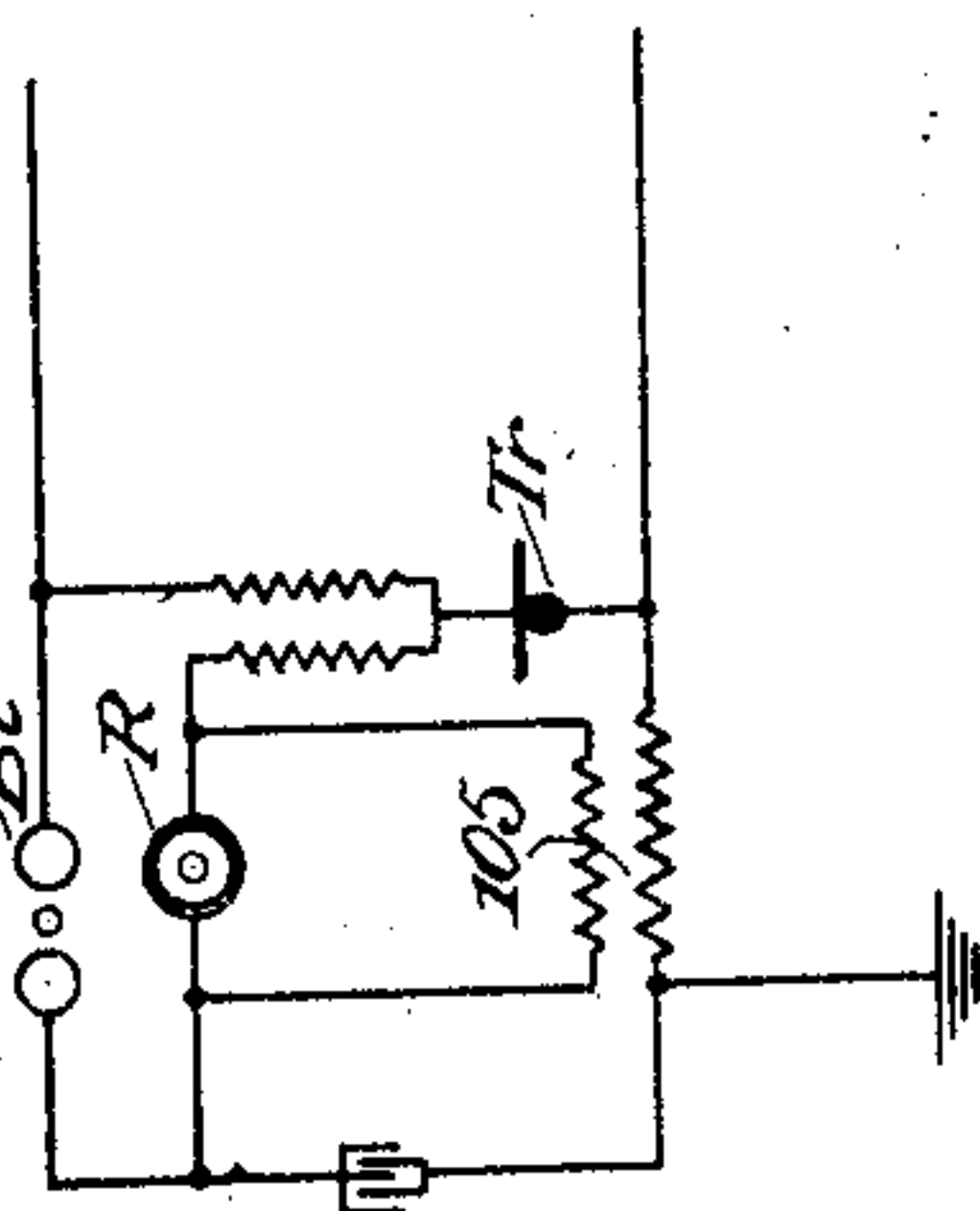
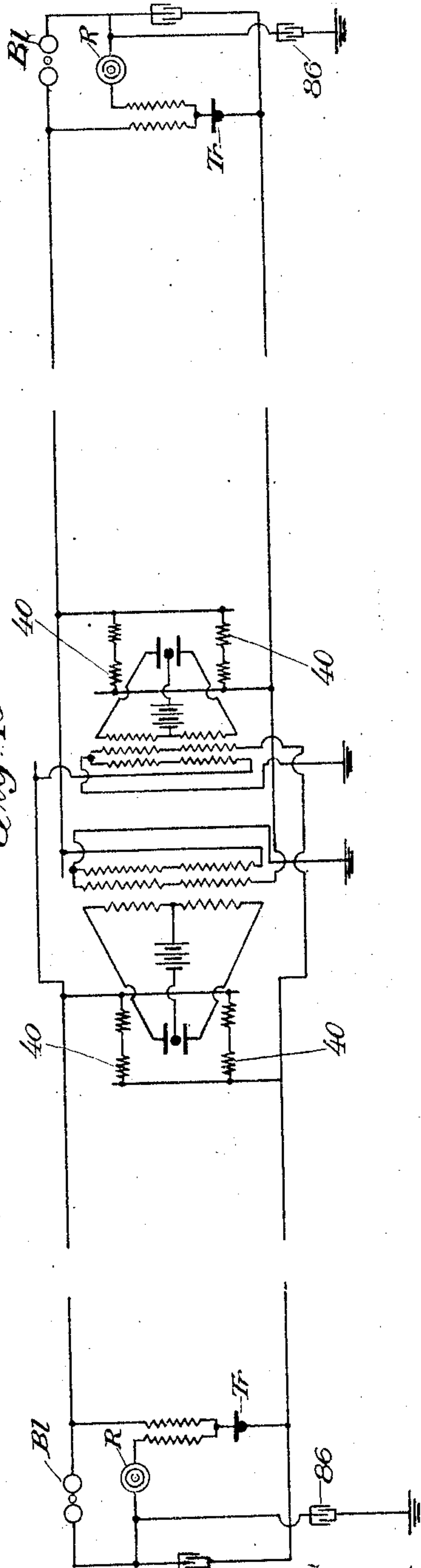


Fig. 15



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UNITED STATES PATENT OFFICE.

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TELEPHONE RELAY OR REPEATER.

1,203,325.

Specification of Letters Patent.

Patented Oct. 31, 1916.

Application filed April 27, 1910. Serial No. 558,045.

To all whom it may concern:

Be it known that I, ELWOOD GRISSINGER, of Buffalo, in the county of Erie, and in the State of New York, have invented a certain new and useful Improvement in Telephone Relays or Repeaters, and do hereby declare that the following is a full, clear, and exact description thereof.

My invention relates to an improvement in telephone relays or repeaters, and the object of my invention is to provide a relay of exceptional sensitiveness which will magnify the electric waves to an unusual degree, which is capable of the very finest adjustment, which avoids the effects of self-induction and cross-circuiting arising in the telephone relays now in use, and to provide a relay with numerous other advantages and improvements, which will be set forth in detail in connection with the description hereinafter.

I have shown certain embodiments of my invention in the accompanying drawings, in which—

Figure 1 is a plan view of the relay; Fig. 2 is an elevational view of the same partly in section; Fig. 3 is an end elevation of the same; Fig. 4 is a vertical elevation of the part used for producing one of the magnetic fields; Fig. 5 is a vertical cross-section of the same; Fig. 6 is a horizontal cross-section of the core of one of the magnets used for producing the magnetic fields; Fig. 7 is a similar cross-section of another modification of the core; Fig. 8 is a vertical cross-section of the parts for supporting the variable resistance medium and armatures; Fig. 9 is a similar view of another modification thereof; Fig. 10 is an elevation of one of the parts used for adjusting the armatures; Fig. 11 is a diagrammatic view of the circuit arrangement, including the relay; Fig. 12 is a diagrammatic view of the preferred form of circuit using two relays; Fig. 13 is a diagrammatic view of one form of grounded circuit using a single relay; Fig. 14 is a diagrammatic view of a closed non-grounded circuit using a single relay; Fig. 15 is a diagrammatic view of a grounded circuit using two relays adapted to be operated as repeaters; Fig. 16 is a diagrammatic view of a subscriber's set using an extra induction coil; Fig. 17 is a diagrammatic view of a circuit arrangement used for supplying two relays with the current from a single battery; Fig. 18 is a dia-

grammatic view of the circuit arrangement used in connection with the core modification shown in Fig. 17; Fig. 19 is a diagrammatic view of one of the subscribers' circuits, showing the details of the arrangement for throwing in resistance and capacity; and Fig. 20 is a diagrammatic view of one of the subscribers' sets, supplied with its own source of current.

In the drawings, 1 is a metal plate adapted to be attached to any suitable non-conducting support by means of screws 2. The plate 1 is provided with a pair of rectangular apertures 3, one at either end thereof, for receiving the lower ends of permanent magnets 4. A metal casing 5 is provided for covering the upper end of each of the permanent magnets 4, said casing 5 being attached to the plate 1 by means of screws 6. Each permanent magnet 4 is of the horse-shoe type, and each of the poles thereof is connected to a pole-shoe 7 by means of a screw 8. The pole-shoes 7 are in turn secured to the side walls of the casing 5 by means of screws 9, the casing 5 being provided with a cover 10 to protect the upper ends of the pole-shoes 7. The cover 10 is secured to the casing 5 by means of screws 11. In order to receive a core 12 of large diameter, the pole-shoes 7 are hollowed out to produce a longitudinal cylindrical cavity 13. The core 12 fits loosely within the cavity 13, so as to permit longitudinal adjustment thereof. In order to effect said longitudinal adjustment, a screw-threaded rod 14 is secured in an aperture 15 in the end of each of said cores, the screw-threaded end of the rod 14 being designed to engage with a screw-threaded sleeve 16, having a cylindrical shoulder 17 for retaining the same within a yoke 18. A knurled hand-wheel 19 is made tight upon the outer end of the sleeve 16 to prevent said sleeve from moving in any except a rotary direction within the yoke 18. The yoke 18 is secured by means of screws 19^a to the end of the casing 5. In order to prevent the core 12 from turning while it is being adjusted in a longitudinal direction, the former is supplied with a screw 20 which extends upwardly through a slot 21 in the cover 10. A knurled hand-wheel 19 is used for readily adjusting the core 12. For retaining the core 12 in its adjusted position, a ring 22 is provided, the lower part of which is attached to one side of the casing 5 by means

of a screw 23. The opposite or upper portion of the ring 22 is split and provided with two extensions 24, which are designed to be engaged by a screw-threaded rod 25 carrying upon its end a hand-operated wheel 26. When the wheel 26 is turned so as to bring the two extensions 24 together, the core 12 is clamped in its adjusted position. Means is also provided for preventing any longitudinal movement of the upper side of the ring 22. This comprises a plate 27 having a right-angle extension 28 extending over said upper portion of the ring 22, and an upwardly directed right-angle extension 29, which is adapted to receive the end of a screw 30 carried by a bracket 31 attached by means of a screw 32 to the cover 10. The plate 27 has a slot 32^a to receive a screw 33 projecting upwardly from the cover 10. By this construction it will be seen that the upper end or side of the ring 22 may be retained against the face of the casing 5 by causing the screw 30 to pull the right-angle extension 28 in the direction of the casing. The screw 33 can also be used for retaining the plate 27 in its adjusted position.

As shown in Figs. 5 and 6, each of the cores is constructed of three plates of brass 34, having interposed between the same two layers of soft-iron plates 35 constructed preferably of ferro-type iron. The brass plates 34 and the soft-iron plates 35 are secured together by transverse rivets 36. Two recesses 37 are provided at one end of the core 12, adjacent to the ends of the iron plates 35, to receive the inner ends of the pole pieces 38, a screw 39 being provided for clamping the pole pieces 38 in position. The other ends of the pole pieces 38 pass through coils 40, one coil 40 being provided for each of the pole pieces 38. The coils are of similar construction to the usual telephone coils. The ends of the pole pieces 38 may be protected by a mica diaphragm 38^a, to prevent the adherence of magnetic particles.

The parts described permit a mechanical adjustment of the core 12. I also provide a mechanism for adjusting the magnetic field of the parts described. For this purpose I provide the cover 10 of the casing 5 with a bracket 39^a, which is attached to said cover by means of screws 40^a. The outer end of the bracket 39^a carries a screw 41^a, the lower end of which carries a magnetic projection 42^a. The parts for producing the magnetic field shown at the other end of the plate 1 are constructed in a similar manner, except that the coils carried upon the pole pieces therein are wound so as to produce a magnetism of the opposite polarity.

Another modification of the core is shown in Fig. 7, in which the permanent magnet 4 is entirely dispensed with, and in lieu thereof an electro-magnet 41 is provided in

the interior of the core for producing the magnetic field. In order to accommodate the coil 41, a portion of the central brass plate of the core 12 is slotted out for this purpose. In the interior of the coil 41 a soft-iron core 42 is inserted, which core is clamped to the soft-iron plates 35 by screws 43 passing through the sides of the core. For receiving the variable resistance medium, a box 44 is attached by means of screws 45 to the center of the plate 1. The box 44 is separable vertically at the center thereof, and is provided with brackets 46 for securing the parts together. In the center of the box 44 there is a cylindrical opening 47 for receiving a pair of rings 48 of like construction. The rings 48 support in recesses 49 upon their inner faces a pair of interiorly screw-threaded rings 50.

Referring particularly to Fig. 8, the rings 50 are designed to support upon their interiors an interiorly and exteriorly screw-threaded ring 51. The interior of the ring 51 engages with the screw-threaded exteriors of a pair of electrodes 52, having cavities 53 in their faces, and apertures 54 in their centers. Screws 55 passing through the rings 51 are provided for holding the electrodes 52 in position. The electrodes 52 may be rotated for longitudinal adjustment by removing the screws 55, and inserting through the screw-holes a rod to engage with one of the recesses 56 provided upon the exterior of the electrodes 52. A pair of exteriorly screw-threaded sleeves 57, attached to each other by an insulating block 58, passes through the apertures 54 in the electrodes 52. Each of the sleeves 57 carries, adjacent to the insulating block 58, a conical electrode 59, screw-threaded upon the exterior of said sleeve. Adjacent to the conical electrode 59, the sleeve 57 carries a fabric diaphragm 60, supported upon a washer 61. Adjacent to the fabric diaphragm 60, the sleeve 57 carries a small washer 62, and adjacent to this a mica diaphragm 63. The fabric diaphragm 60, the washer 61, and the mica diaphragm 63 are secured in position between the edge of the sleeve 51 and the ring 50. A nut 64 is passed over the sleeve 57 to retain the washer 62 against the faces of the diaphragms. Another nut 65 is screw-threaded upon the sleeve 57 for the purpose of bowing outwardly a steel wire 66 to tighten the same. An insulating washer 67 separates the nut 65 from the wire 66. An insulating washer 68 is passed over the exterior of the sleeve 57 to separate an annular terminal 69 carried upon said sleeve and connected with one of the leads 70 from said wire. Finally, an armature 71 is screw-threaded upon the end of the sleeve 57 and retains the terminal 69 in position. The electrodes 52 and 59 may be made of polished carbon, but they

are preferably made of metal electroplated with platinum, gold or some other metal not readily oxidizable.

The steel wire 66 is supported upon the lower side of each of the rings 48 upon a post 72. Thence the wire passes upwardly between a pair of smaller posts 73, projecting from the face of the ring 48, and each end of the wire passes over a winding-key 74, having a squared end 75, the winding-key 74 being supported in projections 76 and 77 upon the face of the ring 48. Each end of the wire 66, therefore, passes upwardly between the projections 76 and 77. Each of the projections 76 is split at one side and provided with a screw 78, so that the winding-key 74 may be retained in any adjusted position. The rings 48 are tightly secured together by screws 79, thereby clamping all of the parts of the variable resistance chamber together. When the variable resistance chamber is set up, it is provided with a quantity of granular carbon or other variable resistance medium in the chamber between the electrodes 52 and the electrodes 59.

One terminal of the local relay circuit is connected to the wire 70, while the other terminal is preferably connected to one of the rings 48 by means of a binding post 80, or it is connected to any other convenient portion of the conducting parts connected to the exterior of the variable resistance chamber.

The modification shown in Fig. 9 is constructed in a similar manner to the variable resistance chamber shown in Fig. 8, but varies therefrom in the following particulars: Instead of providing the variable resistance chamber with the two external electrodes 52, a single external electrode 81 is provided. This being the case, the ring 51 and the screws 55 are entirely dispensed with. The wires 66 in this instance are bowed inwardly instead of outwardly, and as a consequence, the nut 65 and insulating washer 67 are dispensed with.

The modification shown in Fig. 8 is preferable, inasmuch as the sleeves 57 and interposed insulating block 58 are adapted better to withstand a compressing strain than a tensile strain.

The operation of the parts described is as follows: The cores 12 containing the iron plates or laminations 35, which plates or laminations approach very closely but do not touch the pole-shoes 7, are adjusted longitudinally by means of the hand-wheel 19 until the pole-pieces 38 approach very closely to but do not touch the armatures 71. During this adjustment of the cores 12, the rings 22 are loosened by turning the screws 26. When the cores 12 have been moved into their proper positions, the rings 22 are tightened upon the same by turning the wheels 26 in the opposite direction. This

arrangement constitutes what might be termed an open magnetic circuit, which is the ideal circuit where an iron core is to be excited by currents of a high and variable frequency. This magnetic circuit is termed an open magnetic circuit, inasmuch as the iron plates 34 are maintained out of contact with the pole-shoes 7, and as the pole-pieces 38 are not permitted to touch the armatures 71. In contrast with this, a closed magnetic circuit arrangement is shown in the construction appearing in Fig. 7. By means of this construction, the iron plates 34 are continually magnetized, but not so strongly as in the case of the other modification already described.

In the case of the variable resistance means shown in Fig. 8, the electrodes 52 may be adjusted to and from the electrodes 59 by removing the screws 55, inserting a rod in one of the apertures 56, and rotating said electrodes 52. The fabric diaphragm 60 is designed to retain the variable resistance medium in position, while permitting the greatest amount of resiliency, and the mica diaphragm 63 is designed for excluding moisture from the chamber of the variable resistance medium. It is necessary that the electrodes 59, when moved backwardly and forwardly through the influence of the armatures 71, should be returned quickly and with great exactitude to their original or normal positions. It is for this purpose that I have provided the steel wire mechanism. In the modification shown in Fig. 8, in order to adjust the parts for use, the steel wire 66 is wound as tightly as possible upon the winding-keys 74, the projections 76 being loosened and then tightened for this purpose. When this has been done the nuts 65 are rotated, so as to move the wire 66 outwardly, thereby tightening them more than would be possible merely by the rotation of the winding-keys 74.

The parts of the modification shown in Fig. 9 are adjusted in a similar manner, except that the electrodes 81 therein are not designed to be adjusted, and except that the wires 66 are bowed inwardly by the rotation of the armatures 71. In practice, the pole-pieces 38 at one side of the instrument can be caused to approach one of the armatures more closely than the pole-pieces 38 upon the other side of the instrument, inasmuch as the armatures 71 are caused to vibrate only in one direction. It is to be understood, in this connection, that the windings of the coils 40 are such that a wave which will cause the armature 71 at the right of the instrument to be attracted to a greater degree toward its adjacent pole-pieces 38, will cause the armature 71 on the other side of the instrument to be attracted to a smaller degree by its adjacent pole-pieces 38, the receiving circuit being caused

to pass through the coils 40 in multiple. The magnetic field itself at each side of the instrument may also be adjusted by moving the screw 41^a upwardly and downwardly, so as to cause the magnetic projection 42^a to approach or recede from the magnetic field. By this means I make use of a double variable resistance medium, both portions of which assist each other. The various adjusting means enable me to obtain a very nearly perfect adjustment of the armatures 71 in relation to the cores 12. At the same time the provision of the wires 66 absolutely insures that the armatures 71 and attached parts, as well as the electrodes, will be retained in the exact positions which they have been caused to assume by the adjustment. A further benefit that is derived from the use of the wires 66 is the very great degree of resiliency which is obtained, making the parts extremely sensitive to very slight changes in the magnetic fields. Still a further advantage that flows from this construction is the equalization of heat effects. The passage of a current through a variable resistance chamber results in raising the temperature of the variable resistance medium. This causes the medium to expand and thereby force the electrodes and attached armature apart. In the construction which I have provided, on the contrary, any movement of one of the armatures 71 in one direction, because of the expansion of the variable resistance medium adjacent thereto, will be counter-acted by a similar expansion in the other chamber containing the variable resistance medium, inasmuch as the current is conducted from all portions of the middle electrode or electrodes to the conical electrodes at all times.

The circuit connections in their simplest form are shown in detail in Fig. 11. In this figure the receiving circuit is shown as being connected to the coils 40 in multiple by means of wires 82. A single battery B is provided for supplying current to the two local relay circuits 83 and 84, the circuits 83 and 84 having a common lead, containing the battery B, which is connected to the outer electrode 52, and with separate leads which connect with the two armatures 71. Each of the circuits 83 and 84 includes the primary windings p and p' of an induction coil. The secondary or repeating circuit, as shown in Fig. 11, comprises two outside leads 85 and 86, conveying the current in one direction, and a third lead 87 conveying the current in the other direction. The outside leads 85 and 86 include secondary windings s' and s^3 and s^2 and s^4 respectively, located upon the primary coils p and p' referred to. That is to say, each of the leads 85 and 86 includes secondary coils located upon both of the induction coils connected to the local relay circuits 83 and 84, the said

secondary coils of the induction coils being wound in duplex, the coil s' of the lead 85 being of the same dimensions and located at the side of the coil s^2 located in the lead 86, and the same being true of the coils s^3 and s^4 of the other induction coil. By this means exactly the same waves of the same length are imposed upon the two outside leads 85 and 86, and as a consequence, there is a zero potential difference across said leads at all times. The induction coils are completely inclosed in a closed magnetic circuit, such as a tube, or in the familiar "hedge-hog" fashion.

In Fig. 13 I have shown a simple grounded circuit in which a single relay may be used. In this figure, SS and Ss' indicate two subscribers' stations, R the receiver, Tr the transmitter, BZ the bell, and C the condensers of one station, and R' the receiver, Tr' the transmitter, BZ' the bell, and C' the condensers of the other circuit, being arranged as in the case of the usual Bell telephone common battery system. In the arrangement shown in this figure, the two outside leads are connected in multiple with the coils 40, and are also connected in the manner shown in Fig. 11, with the secondaries of the induction coils of the relay system. The third lead of each of the subscribers' stations is connected to the ground, and the third lead connected to the secondaries of the induction coils is also grounded. This system operates as a booster. When a message is sent from one of the subscribers' stations, the current passes through the coils 40 and avoids passing through the secondaries of the induction coils, for the reason that the resistance of these secondaries is made so great that the large impedance factor prevents the passage of the current. The current passing through the coils 40 causes the armatures 71 and attached electrodes to vibrate, thereby changing the resistances of the variable resistance mediums. As a consequence, the strengths of the currents which pass through the two local relay circuits are varied, thereby setting up induced currents in the secondaries of the induction coils. The induced and strengthened currents or waves produced in the secondaries are then added to and imposed upon the currents or waves passing over the main leads of the circuit. The current thus strengthened passes on to the subscriber at the other station. The arrangement described presumes that there is no direct current upon the line at the point where the relay is connected. If there should be a direct current on the line at this point, a condenser 88 is interposed in each of the main leads, as shown in Fig. 13. These condensers will prevent the passage of direct currents, but will permit the passage of high frequency electrical waves.

In Fig. 14 I have shown another circuit arrangement in which a single relay is used, but in which the various circuits are inductively instead of directly connected to the relay circuits. In the arrangement shown in this figure I have provided four subscribers' lines, I, II, III and IV. Assuming that an electrical wave is coming in over line I, in the direction of the arrow, a wave is induced upon a secondary 87 of a repeating coil R_c , the lines I, II, III and IV being provided respectively with repeating coils R_c , R_c^2 , R_c^3 and R_c^4 , said repeating coils in turn being constructed with secondaries 87, 88, 89 and 90, and primaries 91, 92, 93 and 94. This wave induced in the secondary 87 has two possible paths, one through the coils 40, and the other through the secondaries of the relay induction coils. As the secondaries of the relay induction coils have such a high impedance factor, the current will pass through the coils 40 in preference. The resulting change in the magnetic fields is transformed into a current in the secondaries of the relay induction coils, and as a consequence, a current or wave of greater strength is imposed upon the current or wave induced in the secondary 87. The strengthened current or wave then in turn induces a similar current or wave in one of the other subscribers' lines. This system operates as a booster, inasmuch as the additional current or wave is imposed upon the current or wave sent from the subscriber's sending station. It is advisable that the cores of the repeating coils shown in this figure be always in a neutral magnetic condition. I, therefore, find it desirable to insert a condenser 95 in each of the circuits I, II, III and IV, to prevent the passage of all direct currents so as to maintain the cores of the repeating coils in a neutrally magnetic state and thereby the better to serve as a highly efficient telephone transformer.

In Fig. 15 I have shown still another circuit arrangement, involving the use of a grounded return and two independent relays. This system involves the use of two subscribers' stations arranged in the same manner as shown in Fig. 13, except that the grounded leads have been provided with the condensers 86 to prevent disturbance from stray electrical currents in the earth. It is to be understood, however, that instead of the grounded return, a third wire may be used for this purpose in the arrangement shown in this figure, it being understood that this third wire may, if desired, be one side of a second telephone circuit. In this arrangement, shown in Fig. 15, each of the main leads of each of the subscribers' stations is connected in multiple with the coils 40 of one of the relays, and is connected

with the secondaries of the other relay. A current or wave coming from one of the subscribers' stations would pass through the coils 40, to which it is connected, in preference to passing through the secondaries, because of the high impedance factor of the latter, and as a consequence, a new current or wave will be set up in the circuit of the other subscriber's system. This system shown in this figure, therefore, constitutes a true repeater system, inasmuch as the current or wave which is sent out from one of the subscribers' stations is caused to induce an entirely separate current or wave in the circuit of the other subscriber's system.

The two-way repeating system shown in Fig. 12 comprises two relays, such as already described, which are interconnected with each other and with the two subscribers' circuits or line sections in such a manner that neither relay can affect the other. It will be seen that the incoming telephonic current wave from, say, the left-hand subscriber's circuit, will induce a corresponding wave in the coil 200, which wave will traverse the receiving coils 40 of the left-hand relay and will actuate that relay without producing any effect upon the other relay, the coils 203 and 204 of the latter being secondary coils associated with the primary circuit of the other relay. The energization of the coils 40 of the left-hand relay causes a new and corresponding telephonic current wave to be produced in the two windings 201 and 202 of the secondary circuit of that relay, and such reinforced current wave may be described as passing through the wire 205 to the point of connection 206 where it divides, a part going through the repeating induction coil 208 back to the other end of the originating secondary coil 202 and a part going back through repeating induction coil 207 to the other end of the other originating induction coil 201. None of this reinforced wave should traverse the receiving coils 40 of the right hand relay, inasmuch as the operation of the latter would obviously produce counterrepetition and resultant confusion or howling. This is avoided first by the adjustment of the coils 208—202 and 207—201 in each branch, so that the resistances thereof are approximately equal. The coils 40 (of the right hand relay) will then be bridged between points of substantially equal potential. By associating with the repeating induction coil 207 an artificial line or circuit 210 having the same electrical characteristics as the subscriber's circuit associated with the repeating induction coil 208 in the other branch, the phase value of the current in each branch is balanced or equalized. By this means the relayed current wave emanating from the secondary coils 201 and 202 becomes transformed or re-

peated into the artificial line 210 from one branch, and into the right hand subscriber's line from the other branch, and the current in both branches is in phase, as stated, and of substantially equal value, so that the receiving coils 40 of the right hand relay remain inactive. An operator's listening-in set 211 is connected at the end of the artificial line 210, and when such line has been adjusted so as to equal the electrical characteristics of the subscriber's circuit, the operator will get through her listening-in set the same character of transmission as is being experienced by the subscriber. Thus various subscribers' circuits may be connected with the repeating induction coil of one branch and readily balanced by the adjustment of the artificial line, and the operator can in each case ascertain whether the transmission to such circuits is as it should be.

The circuit is symmetrical. A telephonic current wave emanating from the right hand subscriber's station actuates the right hand relay, and the relayed current emanating from the secondary coils 203 and 204 thereof is transformed and repeated by the coils 200 and 212 to the other subscriber's circuit and to the artificial balancing line 213 thereof, which latter, when adjusted to equal the characteristics of the former, will result in preventing reaction by the left-hand relay. It will thus be seen that the relay in each case is bridged across or between equal branches of the circuit through which the relayed current passes, and the phase of the current in each branch is balanced or equalized by means of the artificial line.

The details of the means for adjusting the artificial lines comprise an insulating plate 98 having a contact-plate 99 adjacent to a series of contact-studs 100 with apertures between to receive a plug to complete the electrical circuit at any desired point for introducing inductance, and another series of studs 101 adapted to serve in like manner for introducing capacity. In Fig. 19 there is shown a diagram of the wiring of this device, 102 being a contact-plate, 103 the series of resistance coils, and 104 being a series of condensers. The diagram R represents the operator's listening-in set, which it will be noted is connected to the artificial line through such inductance and capacity as may be introduced therein by the manipulation of the plugs.

In Fig. 16 there is shown another modification of the subscriber's set, which varies from the arrangement in general use in the Bell system, and which has already been described, in the inclusion of an induction coil 105, the primary of which is attached to the ground circuit, and the secondary of which is connected across the terminals of the subscriber's receiver.

In Fig. 17 I have shown an arrangement of circuits whereby two relays may be provided with current from the same battery.

In Fig. 18 an arrangement of circuit is shown by means of which the coils 41, of Fig. 7 are energized.

Fig. 20 shows an arrangement of the subscriber's set, in which each set is supplied with electrical energy within or near the set, as distinguished from the arrangement in the common battery telephone system, such as the usual Bell telephone arrangement already referred to. The arrangement shown in Fig. 20 comprises the grounded return. In this figure Tr is a transmitter, B a local battery, p the primary of the local induction coil, B l the bell, C a condenser, R the receiver, s the secondary of the induction coil, of which p is the primary. Currents coming to such a station pass into primaries pp' of a triple wound repeating coil, the third winding s' of which is connected with a receiver R'. The condenser C' is inserted between each side of the main line and the terminals of the coil pp' , the other terminals of these coils being connected together and to a ground return or third wire return, as desired.

While I have described my invention above in detail, I wish it to be understood that many changes may be made therein without departing from the spirit of my invention.

I claim:—

1. A telephone circuit comprising a pair of subscribers' stations, a relay apparatus having an input circuit and an output circuit, said output circuit including the primary of an induction coil, said induction coil having two secondary windings one in each branch of a duplex circuit, said input circuit being connected to points of equal potential in said branches, an artificial line, and a repeating coil in each branch, one of said coils serving to repeat the relayed current to a subscriber's circuit, and the other to the artificial line.

2. A telephone circuit comprising a pair of subscribers' stations, a relay apparatus having a receiving coil and transmitting means, an induction coil the primary of which is in circuit with the transmitting means, said induction coil having a secondary winding in each branch of a duplex circuit, said receiving coil being connected across points of equal potential in said branches, an artificial line, and a repeating coil in each branch, one of said coils serving to repeat the relayed current to a subscriber's circuit, and the other to the artificial line.

3. A telephone circuit comprising in combination with the subscribers' stations, a relay having its receiving coil bridged across equal branches of the circuit through which

the relayed current passes, a repeating induction coil in each such branch, one of such coils serving to repeat the relayed message to a subscriber's circuit, and the other to an artificial line, said artificial line having capacity and inductance therein corresponding to the said subscriber's circuit and also having an operator's listening-in set connected therein.

4. A two-way repeating circuit comprising in combination two subscribers' circuits each having a relay adapted to be actuated thereby, each relay having an input element and an output element, the output element including an induction coil having a winding in each branch of a duplex circuit, the input element of each relay being connected between points of equal potential in the branches of the duplex circuit of the other relay, and means for equalizing or balancing the phase displacement at such points comprising an artificial line inductively associated with the duplex circuit and having the same electrical characteristics as the subscriber's circuit.

5. A two-way repeating circuit comprising in combination two subscribers' circuits each having a relay adapted to be actuated thereby, each relay having an input receiving coil and an output element, the output element including an induction coil having a winding in each branch of a duplex circuit, the receiving coil of said relay being connected between points of equal potential in the branches of the duplex circuit of the other relay, and means for equalizing or balancing the phase displacement at such points comprising an artificial line inductively associated with the duplex circuit and having the same electrical characteristics as the subscriber's circuit.

6. A two-way repeating circuit comprising in combination two subscribers' circuits each having a relay adapted to be actuated thereby, each relay having an input element and an output element, the output element including an induction coil having a winding in each branch of a duplex circuit, the input element of each relay being connected between points of equal potential in the branches of the duplex circuit of the other relay, a repeating coil in one branch adapted

to repeat the relayed current to the receiving subscribers, and means including a coil in the other branch and a line inductively associated with such coil for neutralizing the effect of phase displacement in said branches.

7. A two-way repeating circuit comprising in combination two subscribers' circuits each having a relay adapted to be actuated thereby, each relay having an input receiving coil and an output element, the output element including an induction coil having a winding in each branch of a duplex circuit, the receiving coil of each relay being connected between points of equal potential in the branches of the duplex circuit of the other relay, a repeating coil in one branch adapted to repeat the relayed current to the receiving subscribers, and means including a coil in the other branch and a line inductively associated with such coil for neutralizing the effect of phase displacement in said branches.

8. A telephone repeating circuit comprising two relay instruments and means for preventing reaction of the relays upon themselves, comprising an artificial line adapted for adjustment to have the same electrical characteristics as one of the subscribers' circuits, and an operator's listening-in set connected in such artificial line whereby the transmission to the listening-in operator is the same as to the subscriber receiving the relayed message.

9. A telephone repeating circuit comprising two subscribers' circuits, a relay actuated by each, and each relay having its receiving coil connected in balanced relation with the secondary circuit of the other relay, and means for adjusting the balance comprising an artificial line having the same electrical characteristics as a subscriber's line and including an operator's listening-in set adapted for connection at the end of such artificial balancing line.

In testimony that I claim the foregoing I have hereunto set my hand.

ELWOOD GRISSINGER.

Witnesses:

CHARLES J. KELLY,
MAY E. CORMICK.