May 9, 1933. L. SHAPIRO 1,907,594

RADIO RECEIVING APPARATUS

Filed May 5, 1923 10 Sheets-Sheet 1

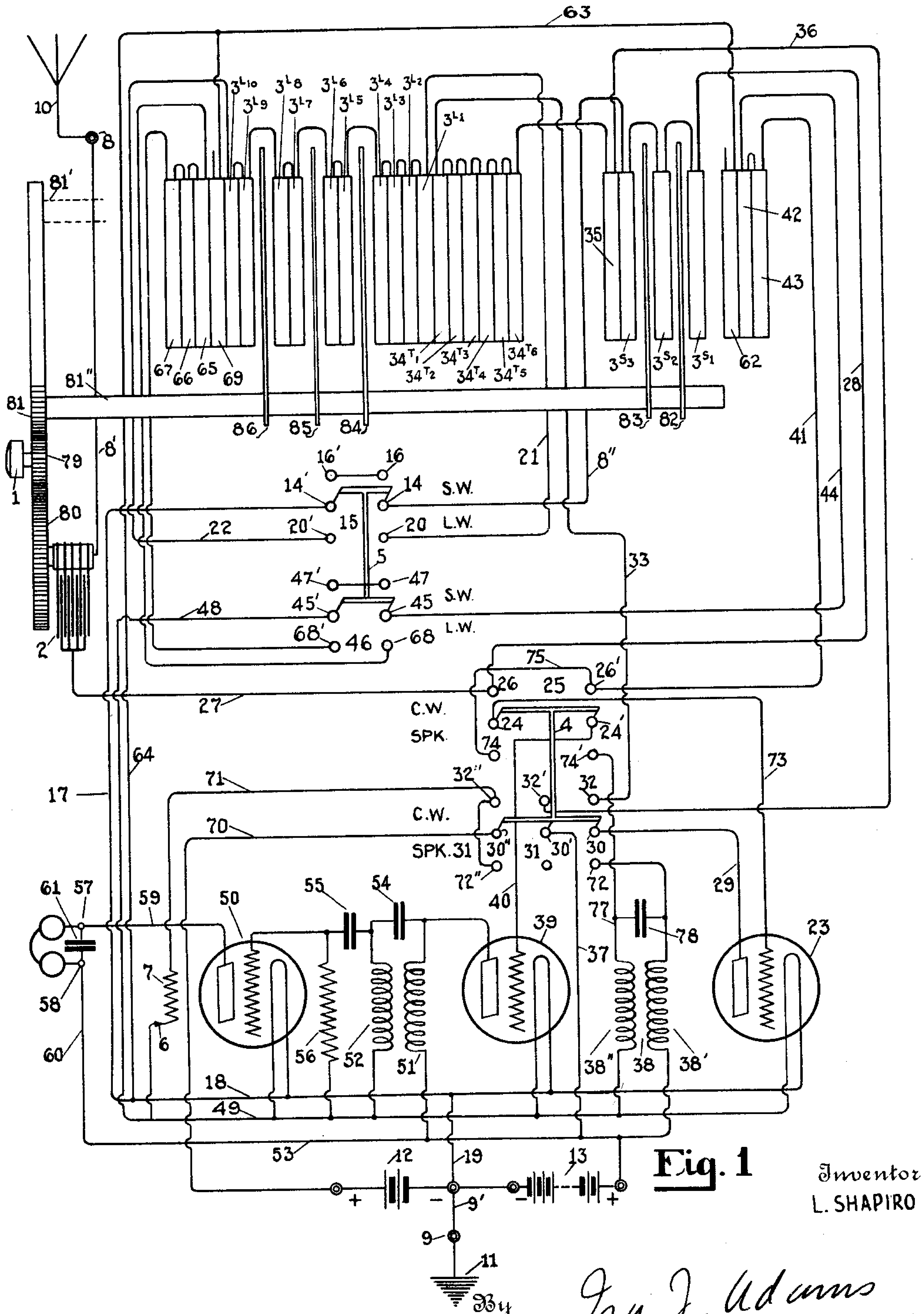

Fig. 1

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Fig. 2

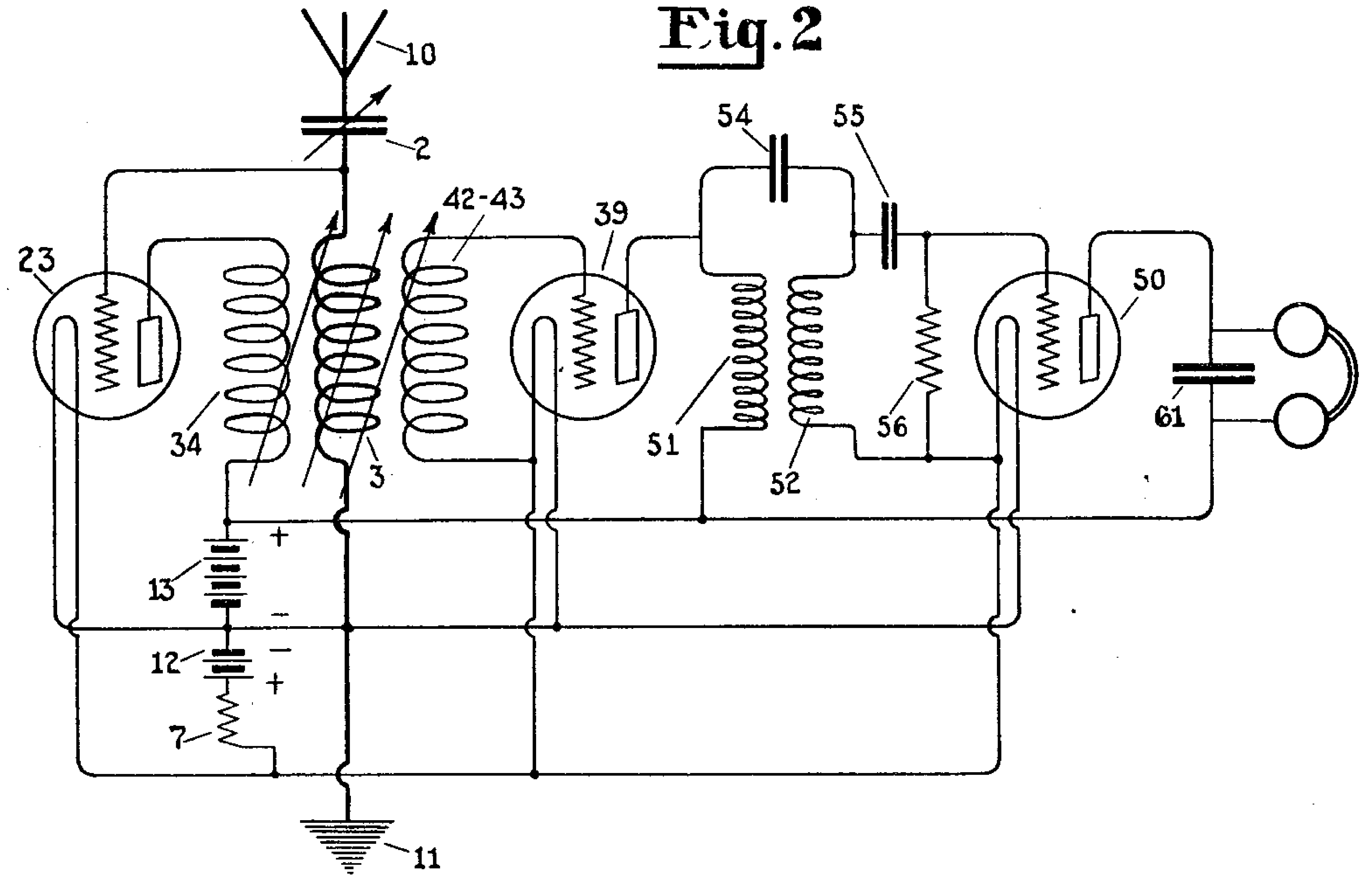

Fig. 3

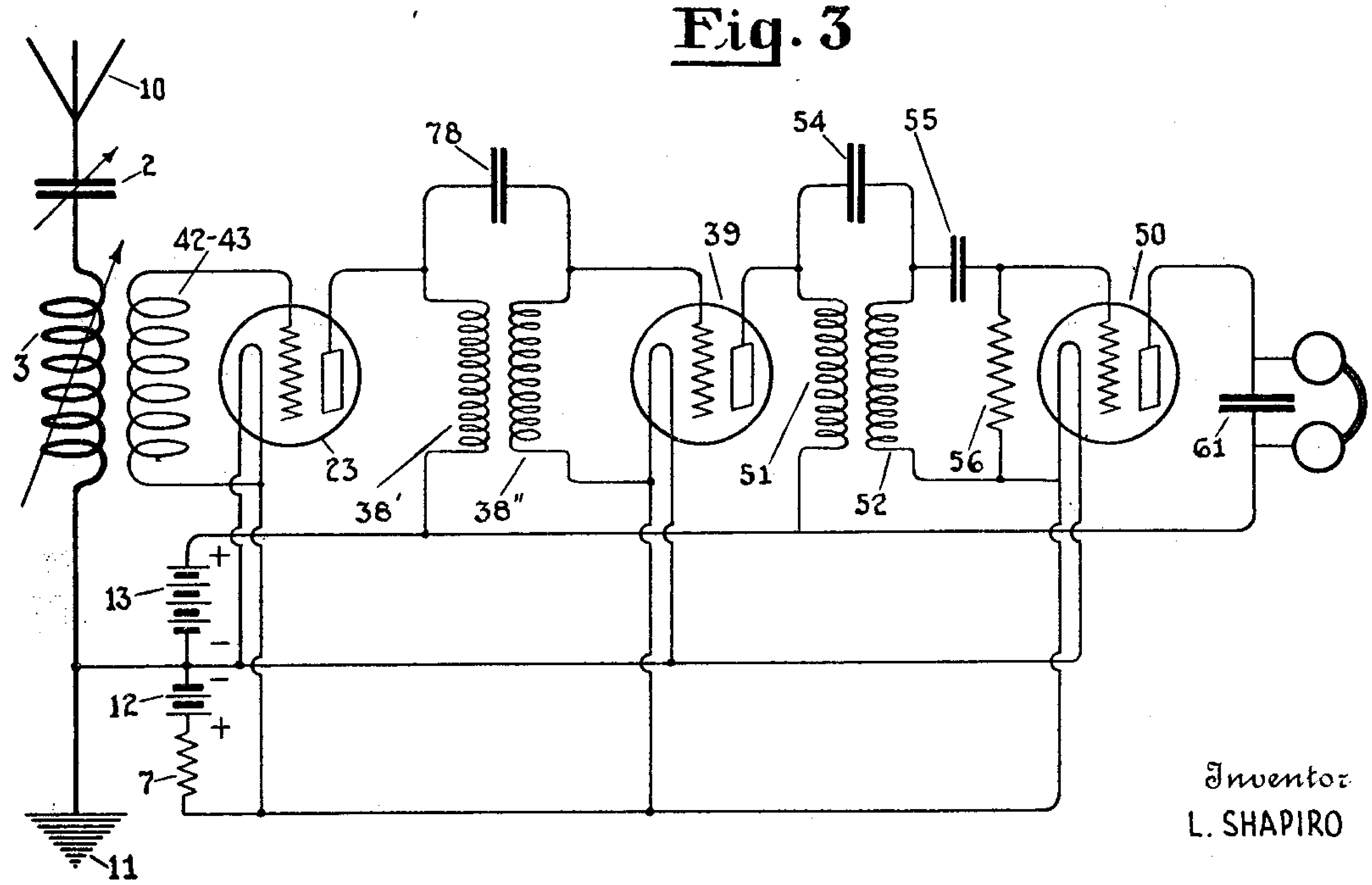

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Fig. 4

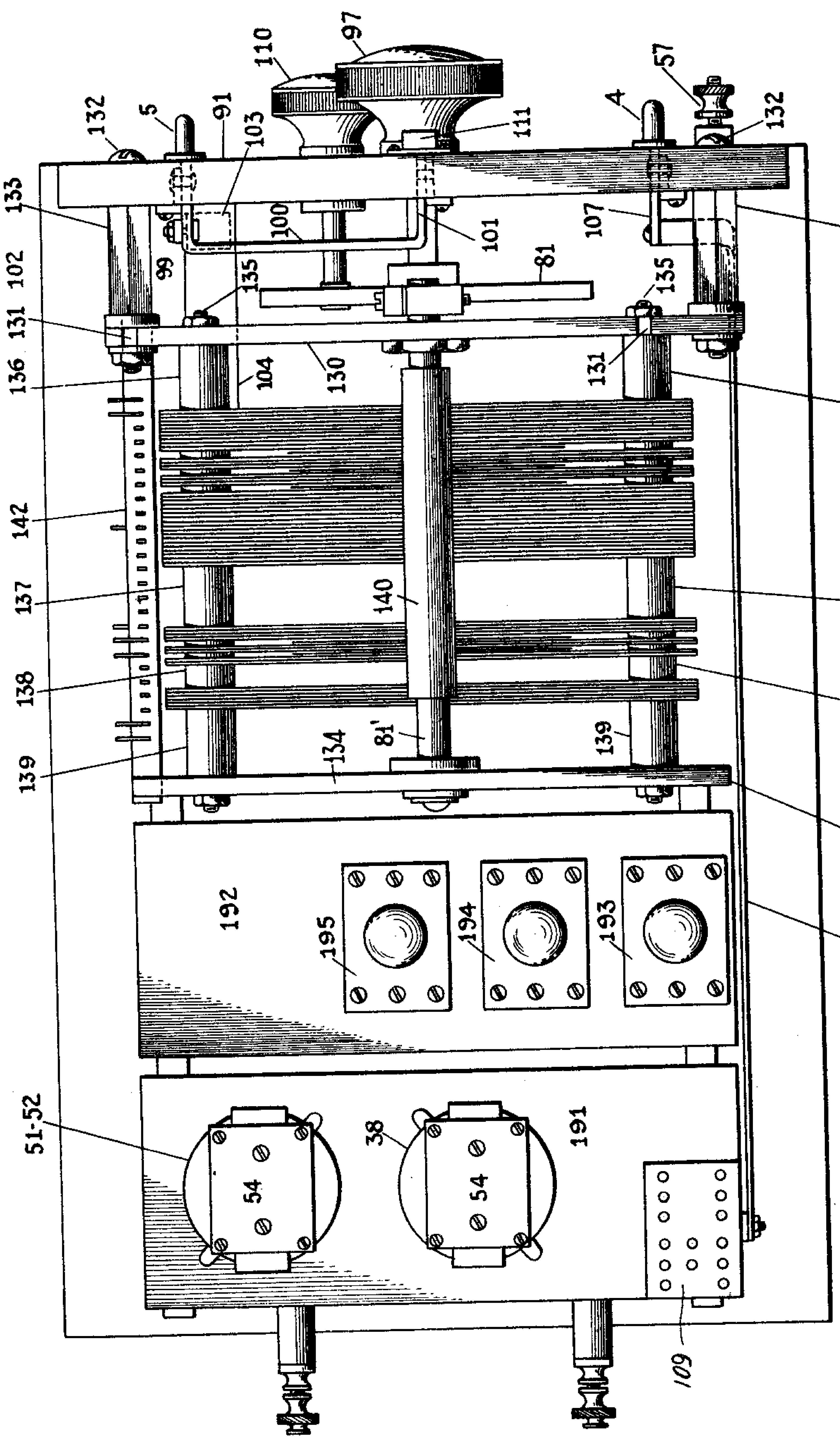

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Fig. 5

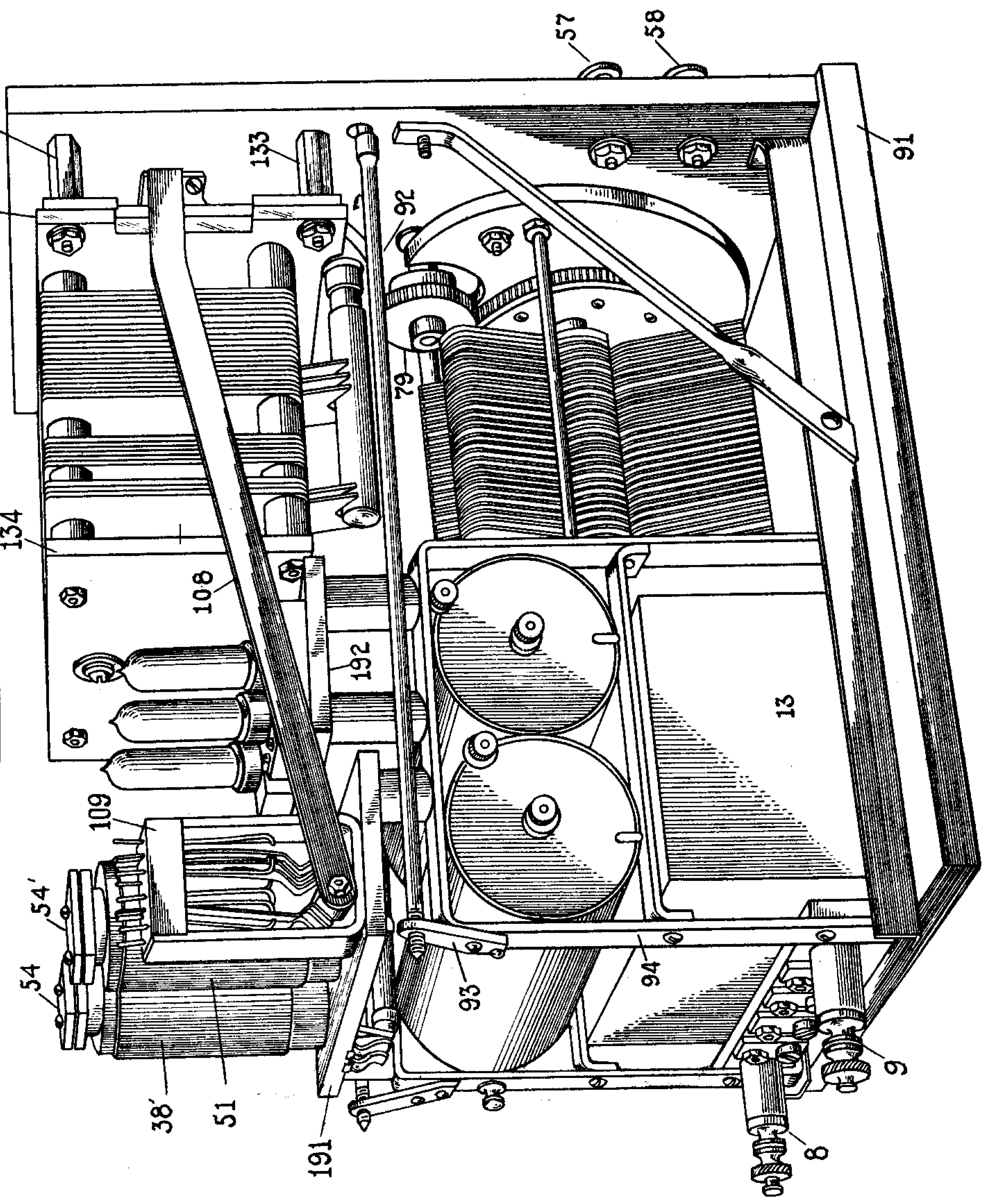

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Fig. 6

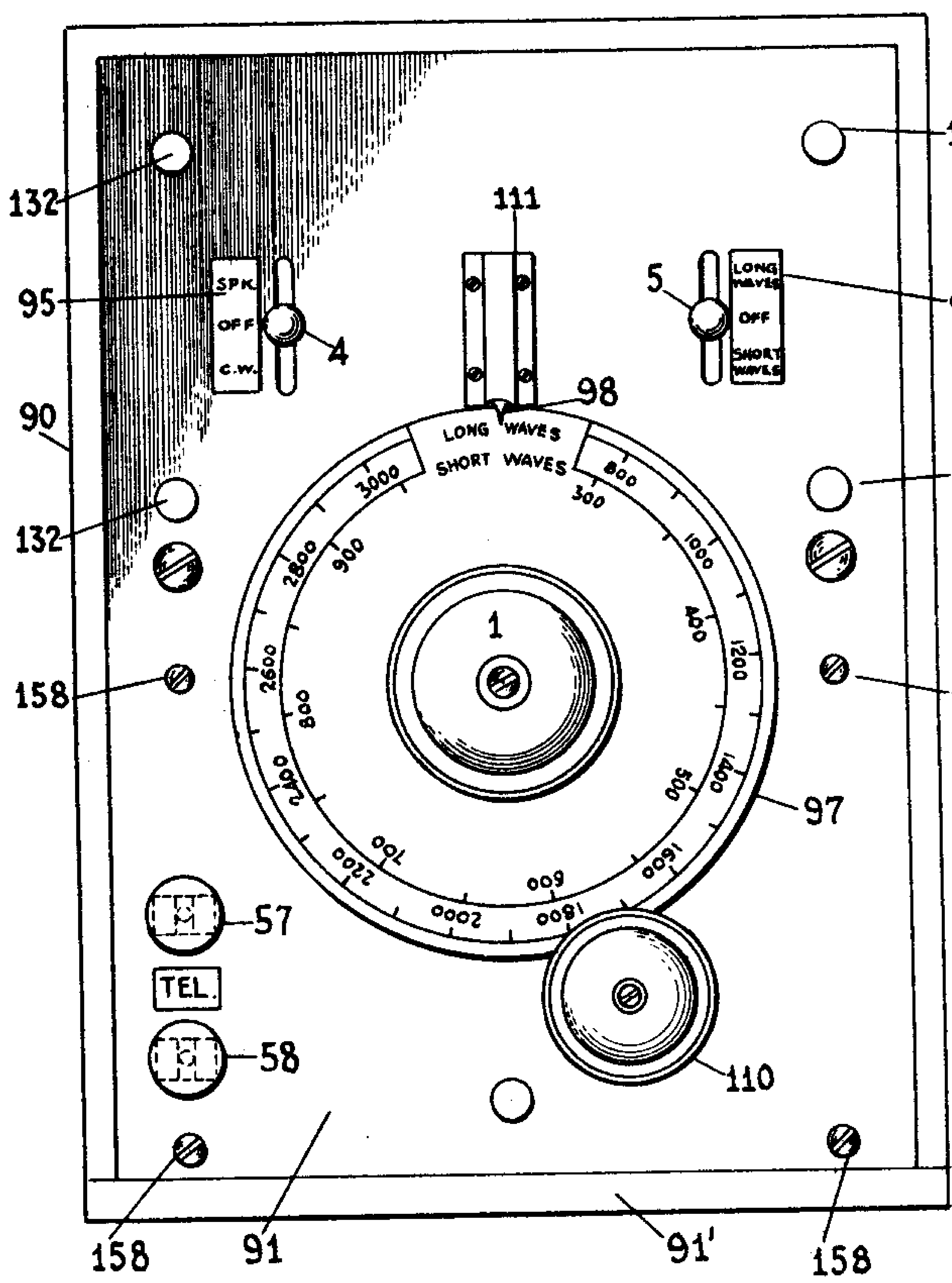

Fig. 7

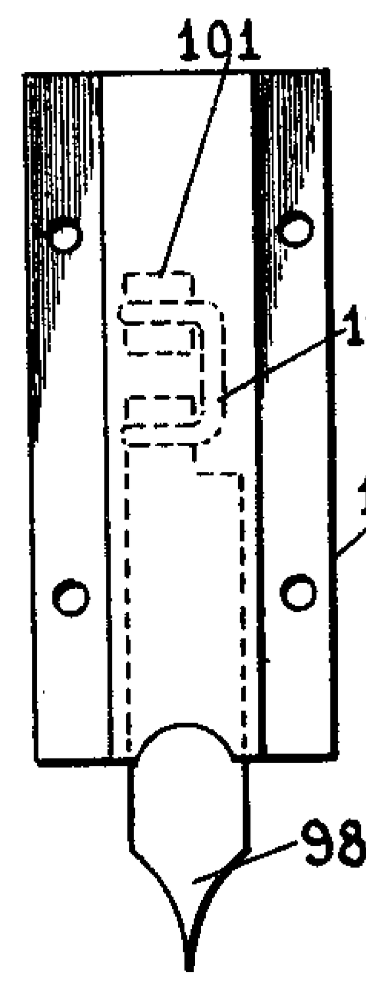

Fig. 10

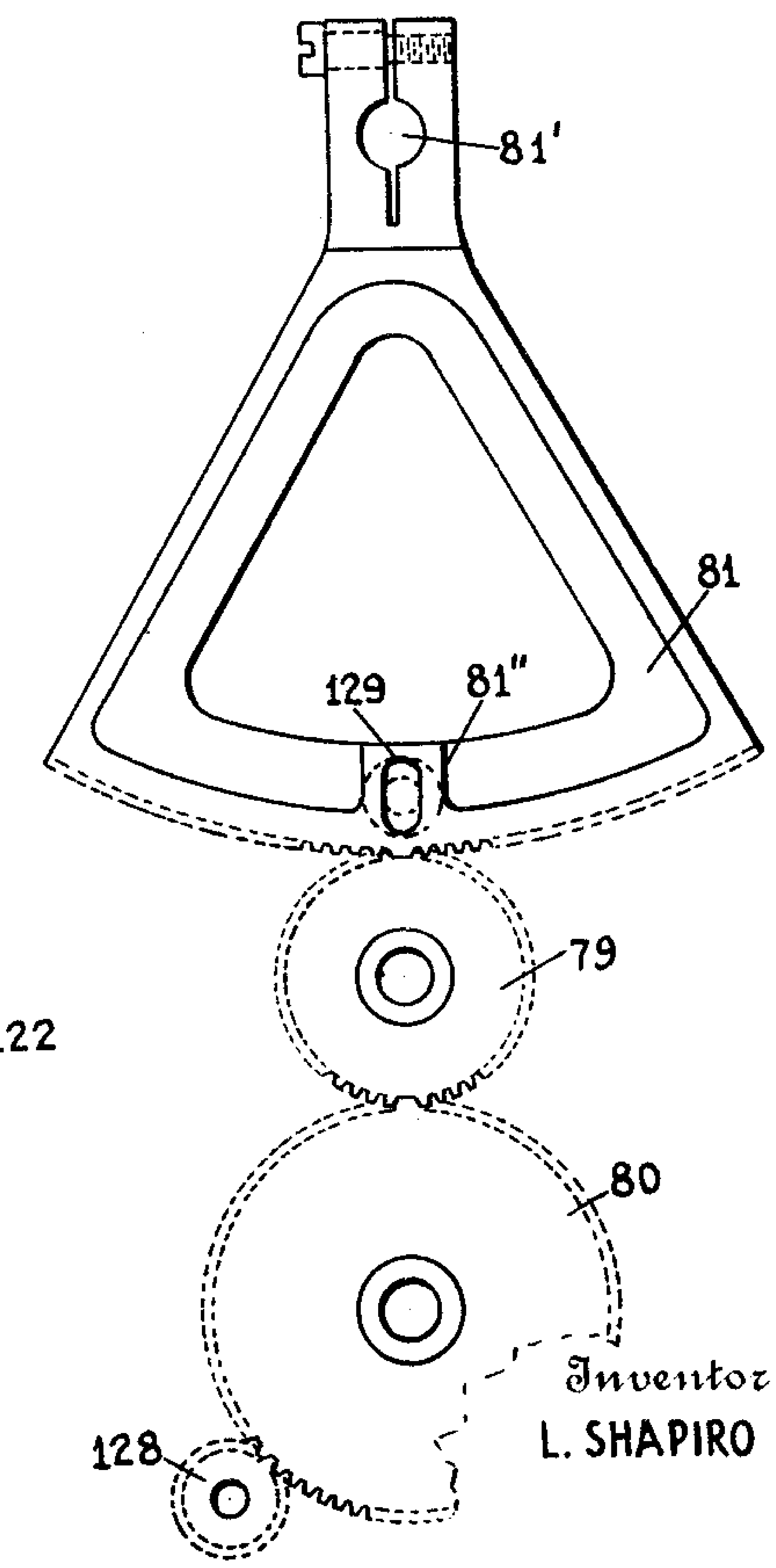

Fig. 8

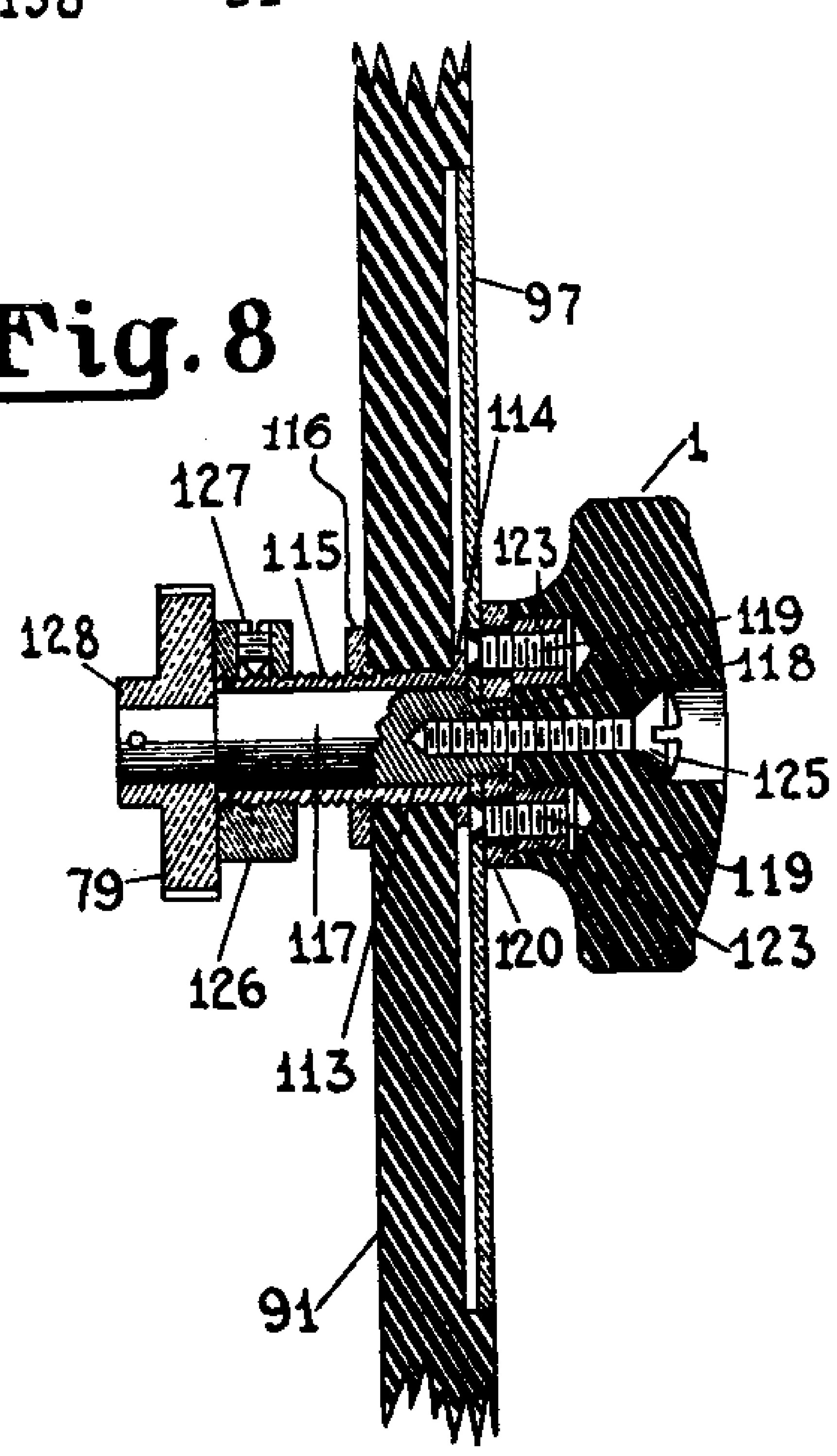

Fig. 9

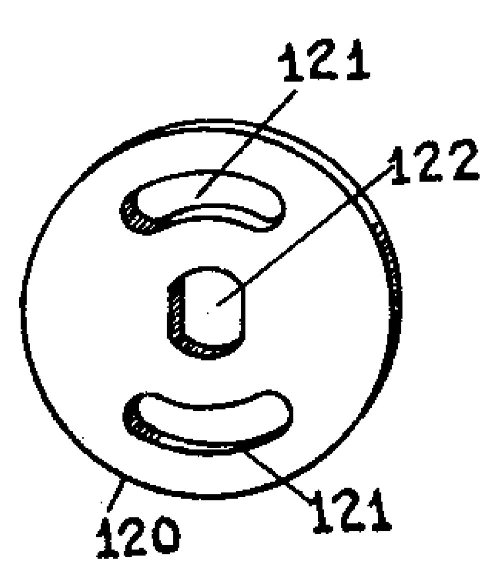

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Fig. 11

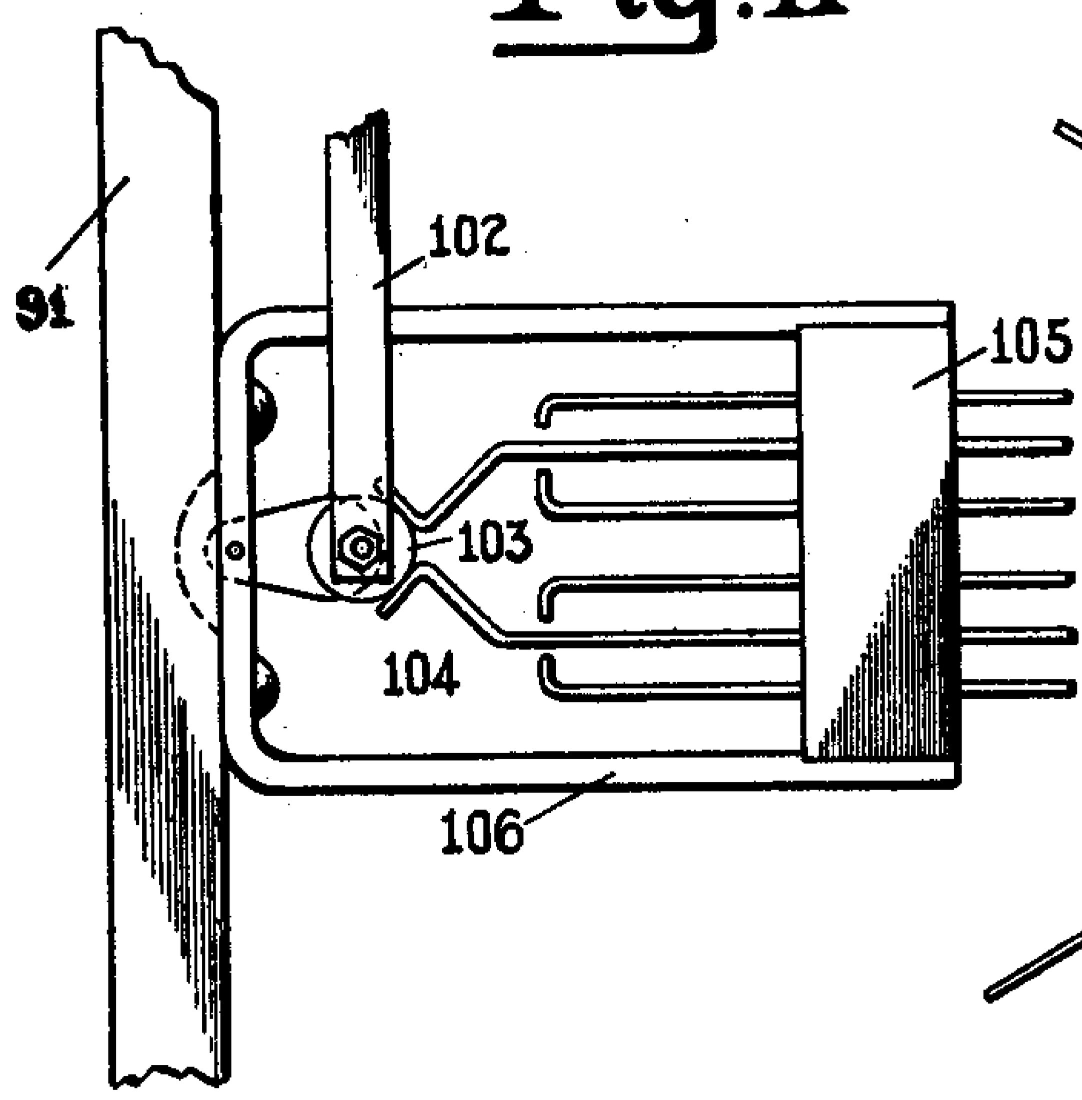

Fig. 14

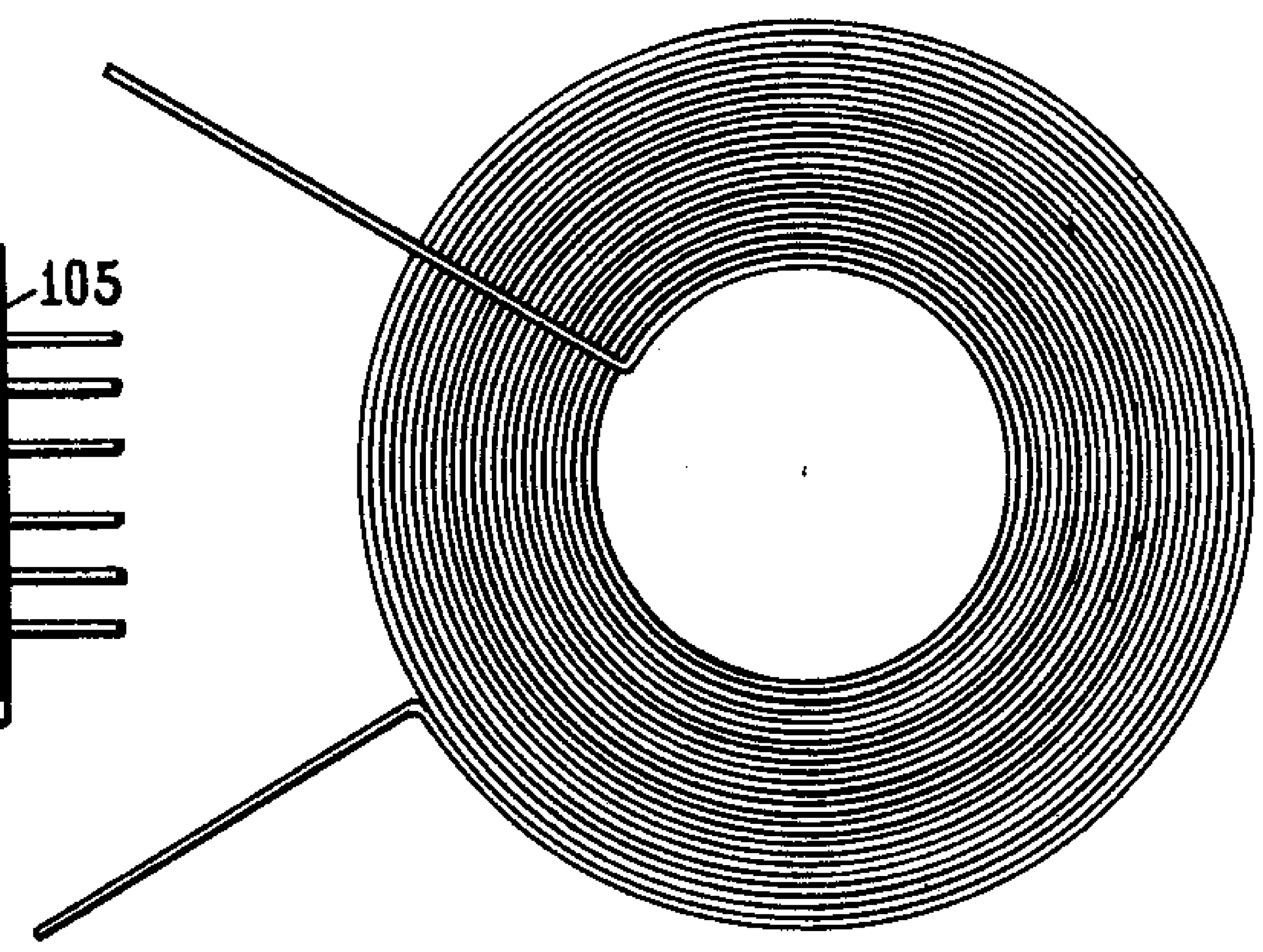

Fig. 13

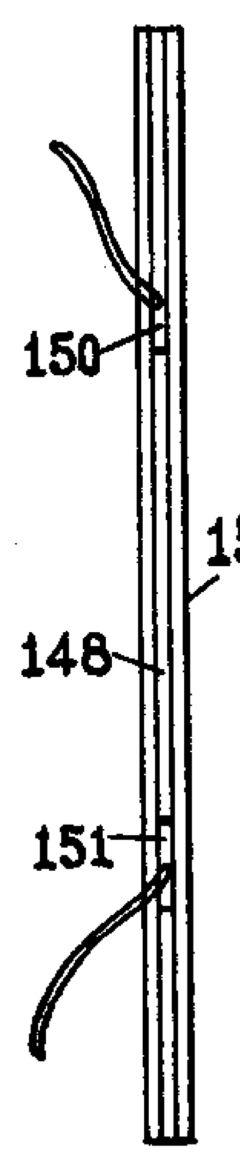

Fig. 12

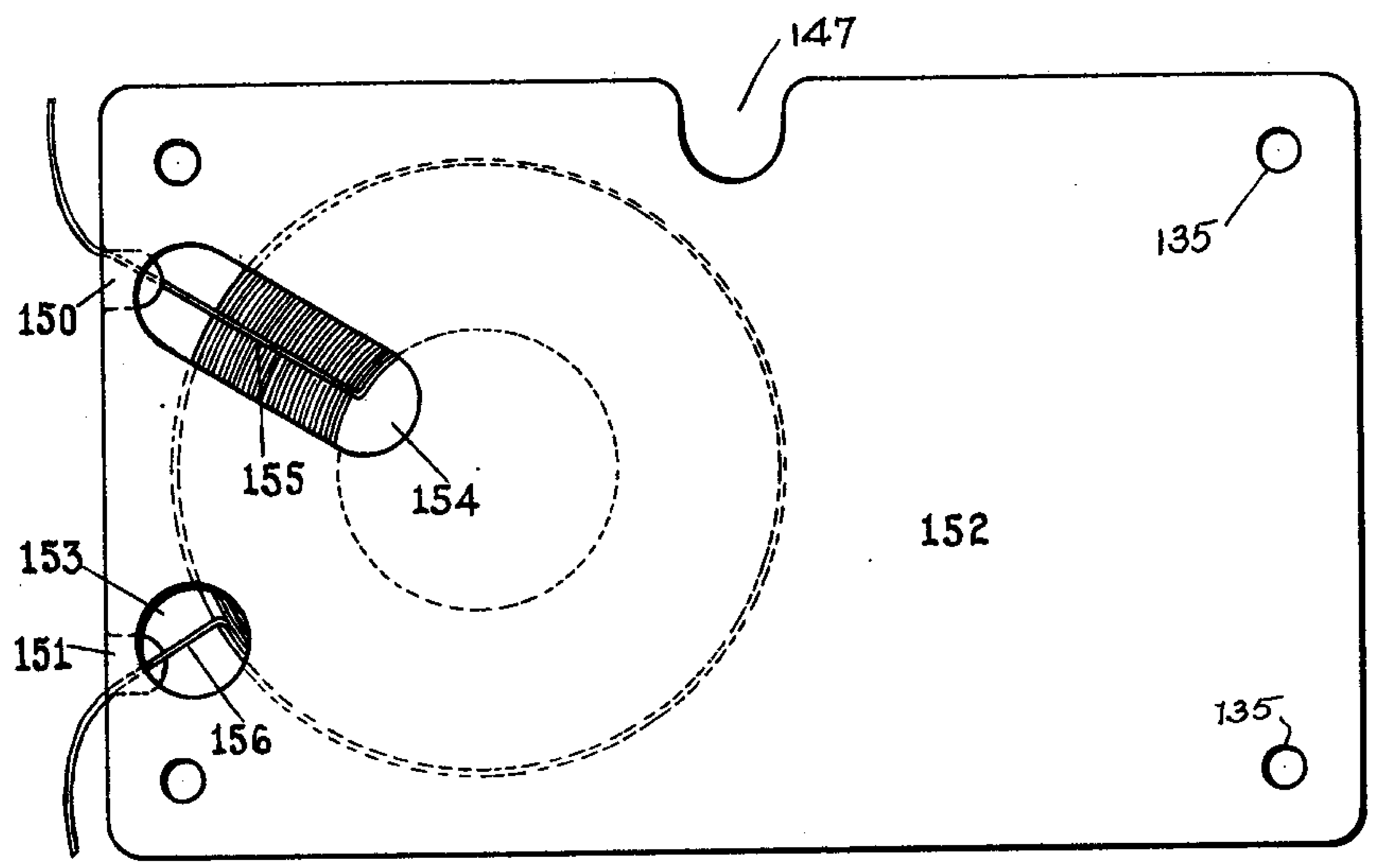

Fig. 15

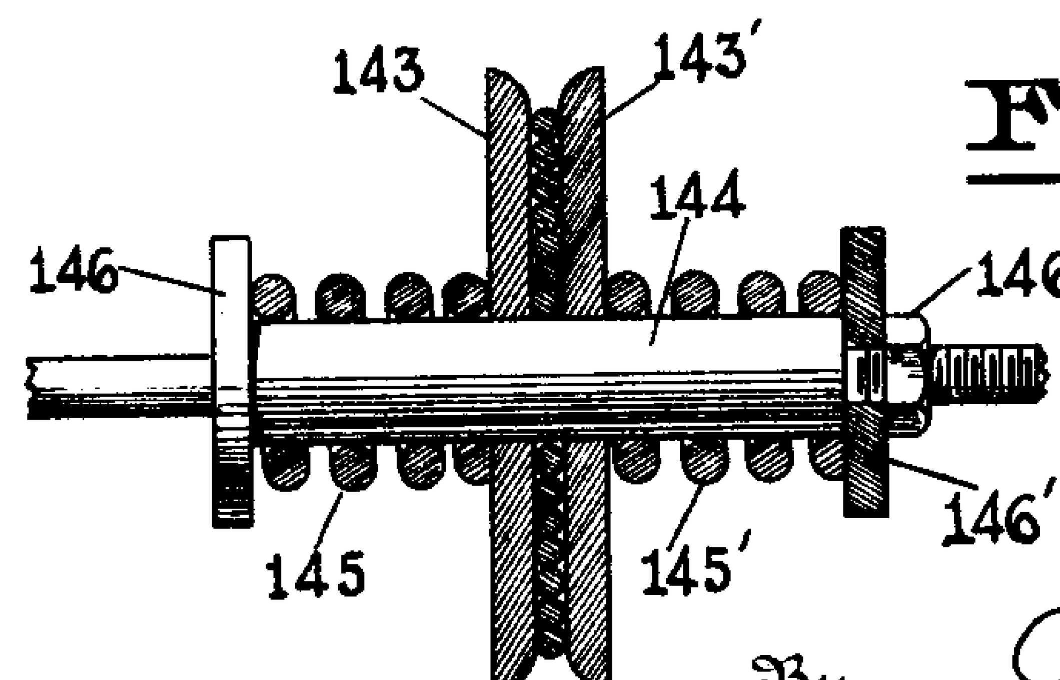

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Fig. 16

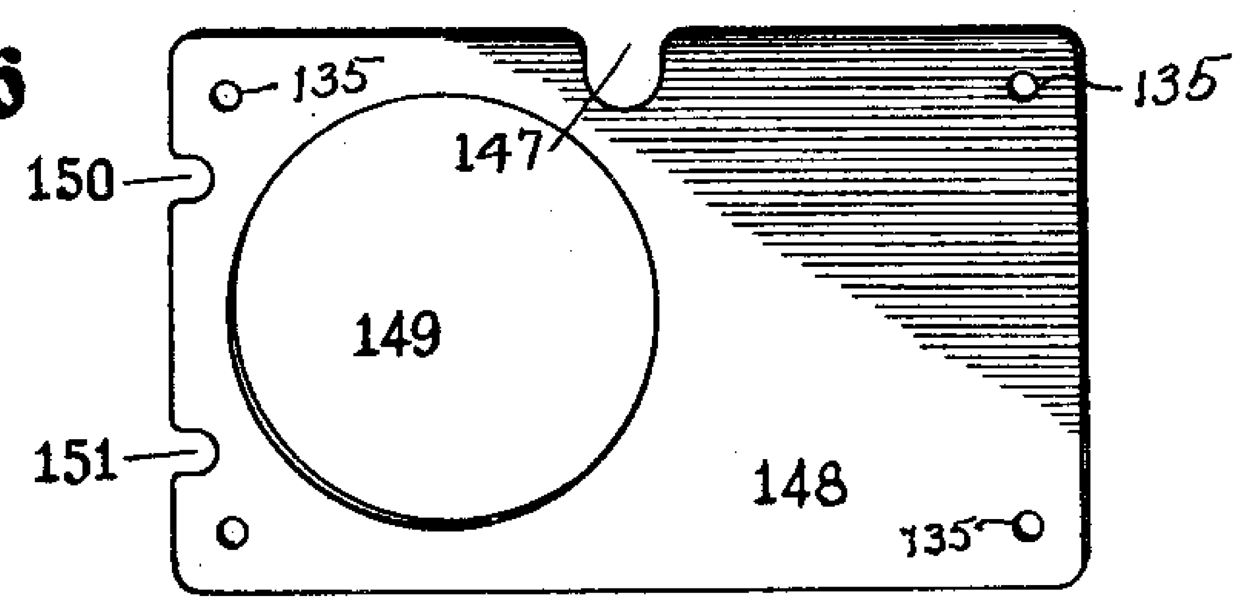

Fig. 17

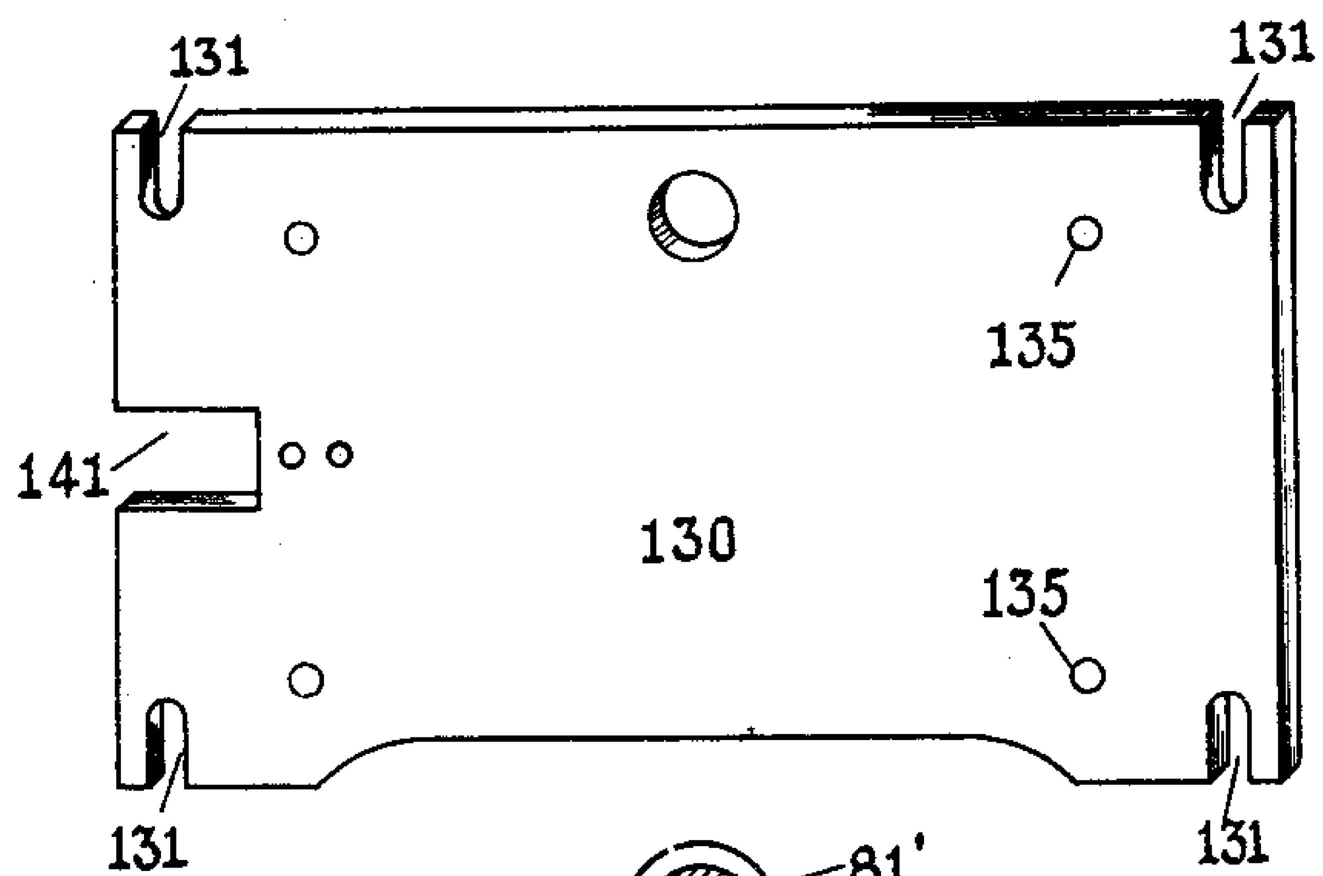

Fig. 18

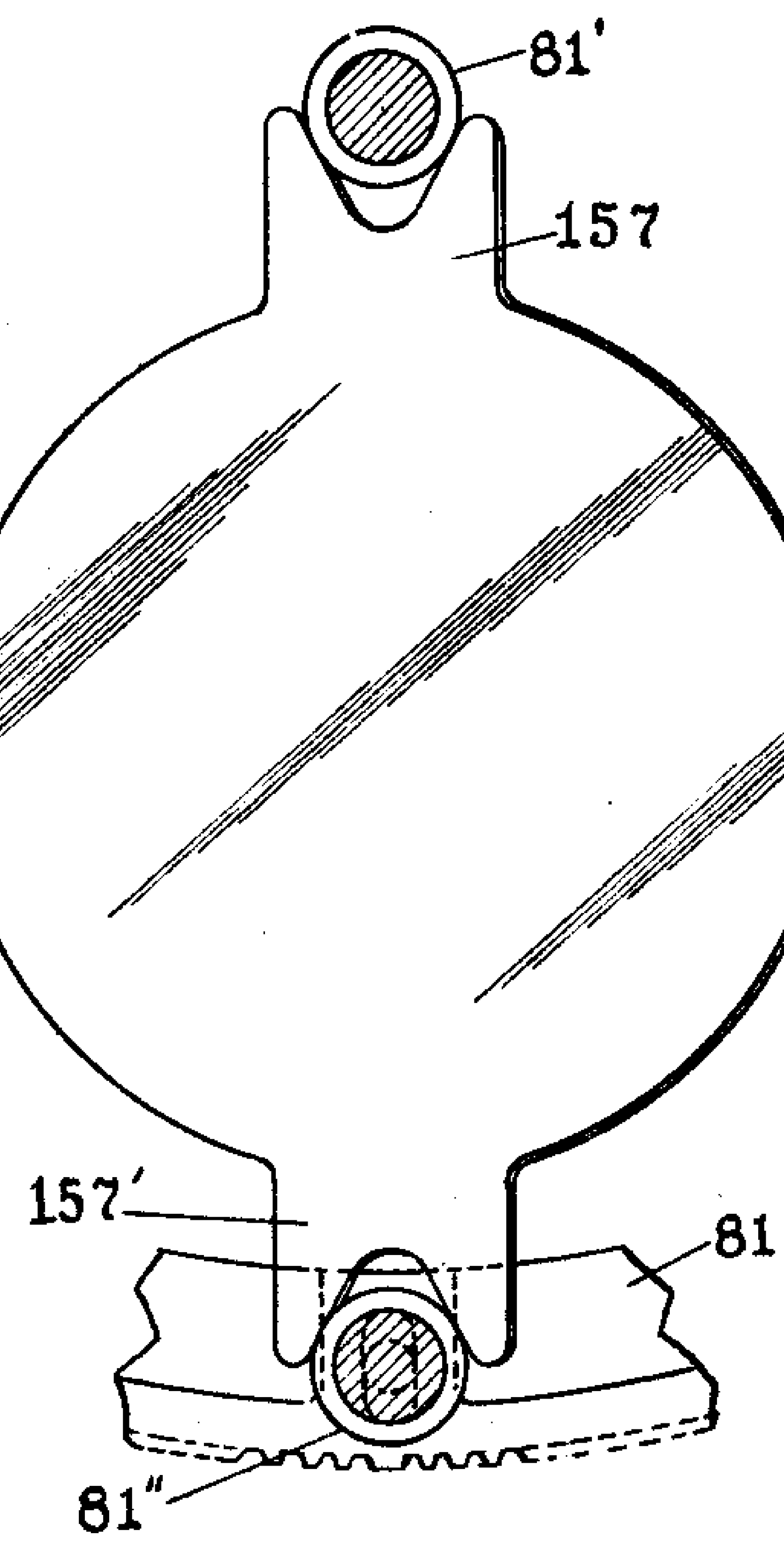

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Fig. 21

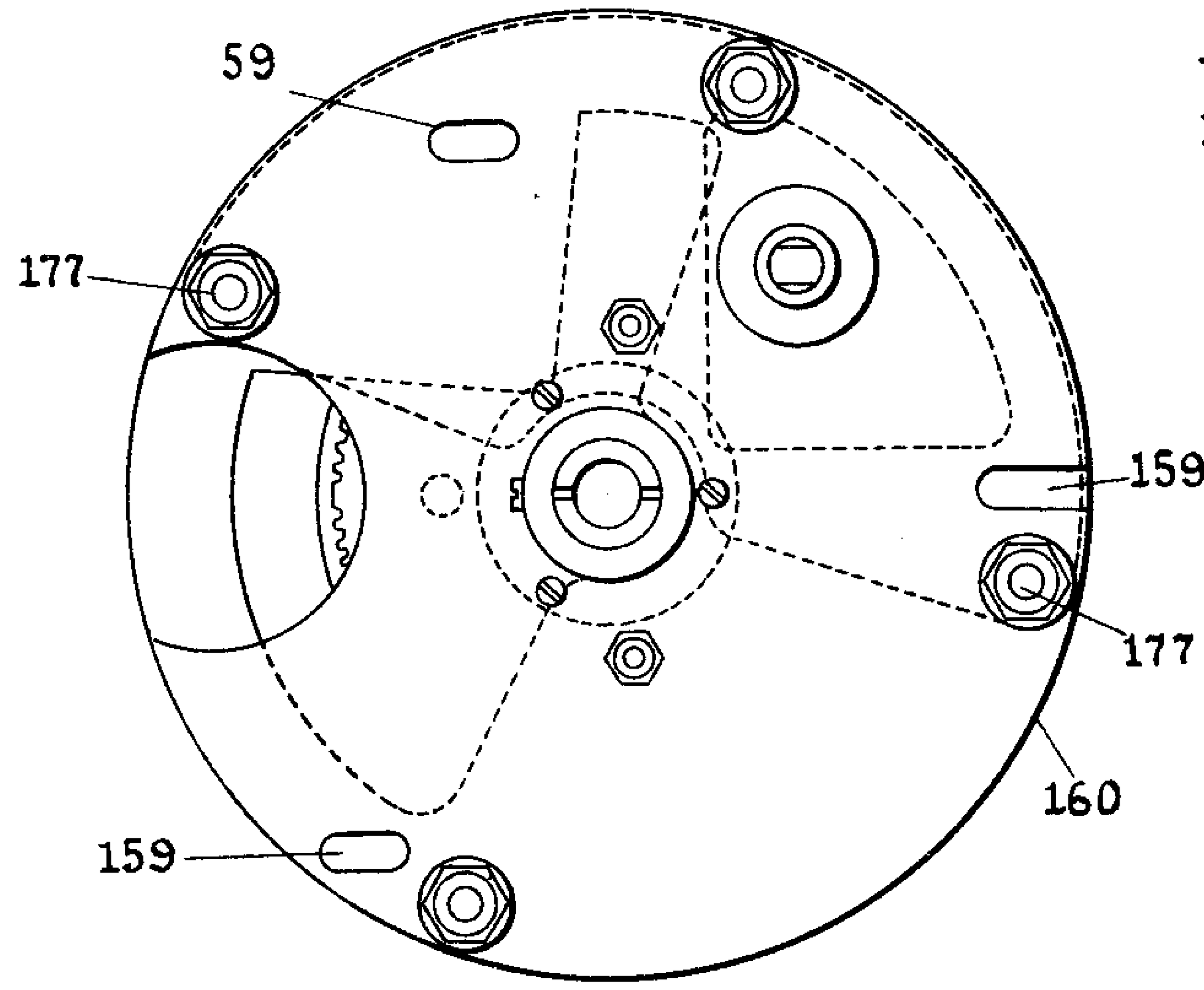


Fig. 19

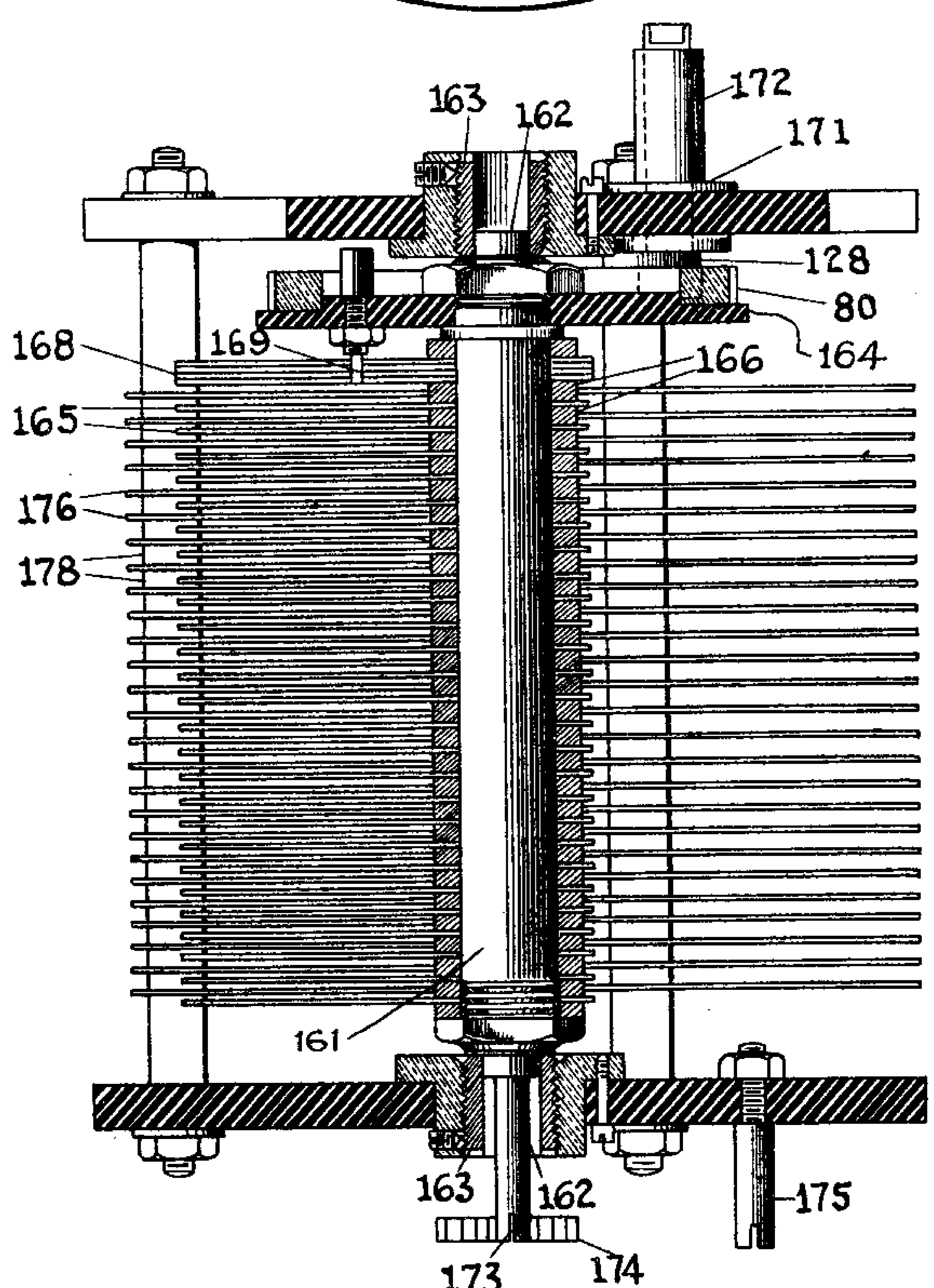
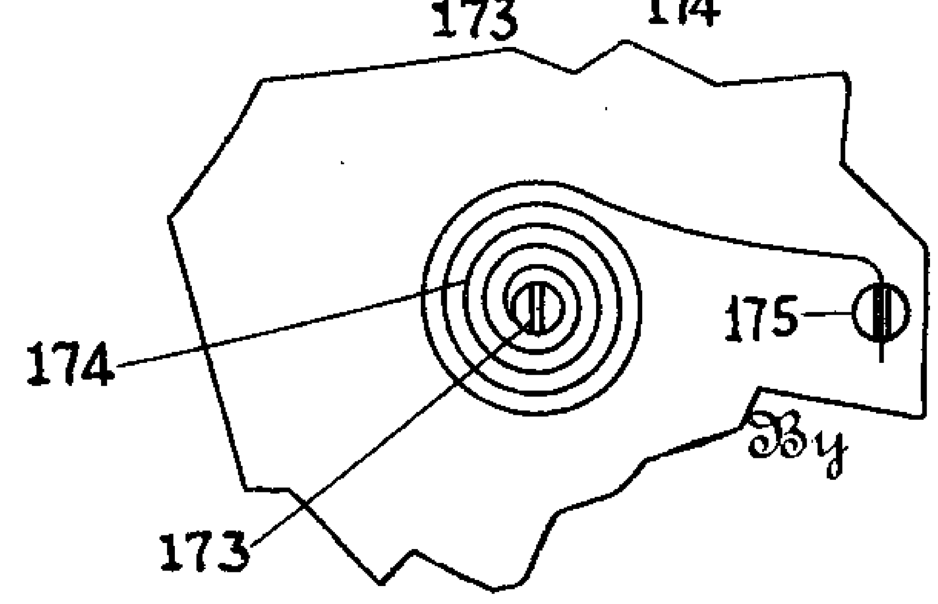


Fig. 20



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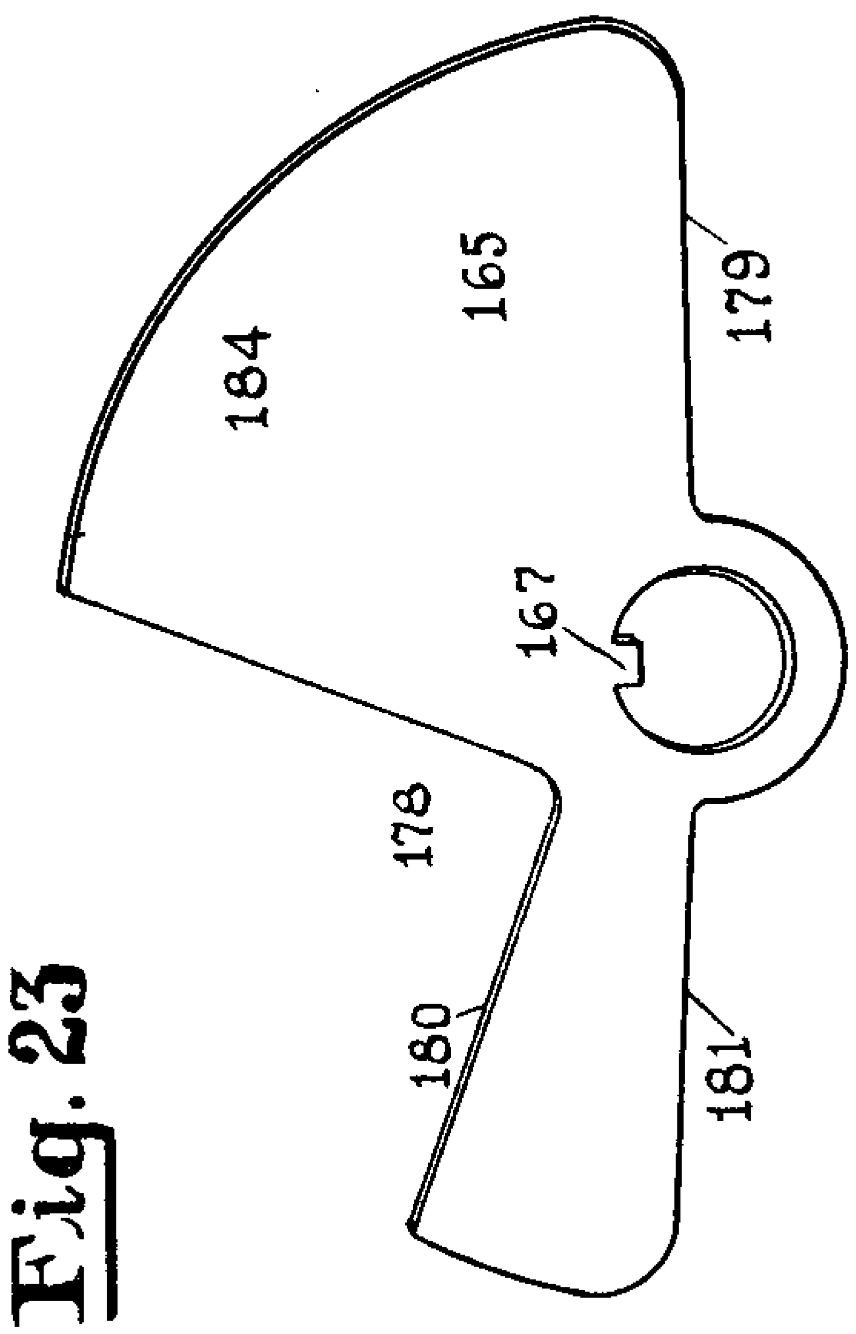

Fig. 23

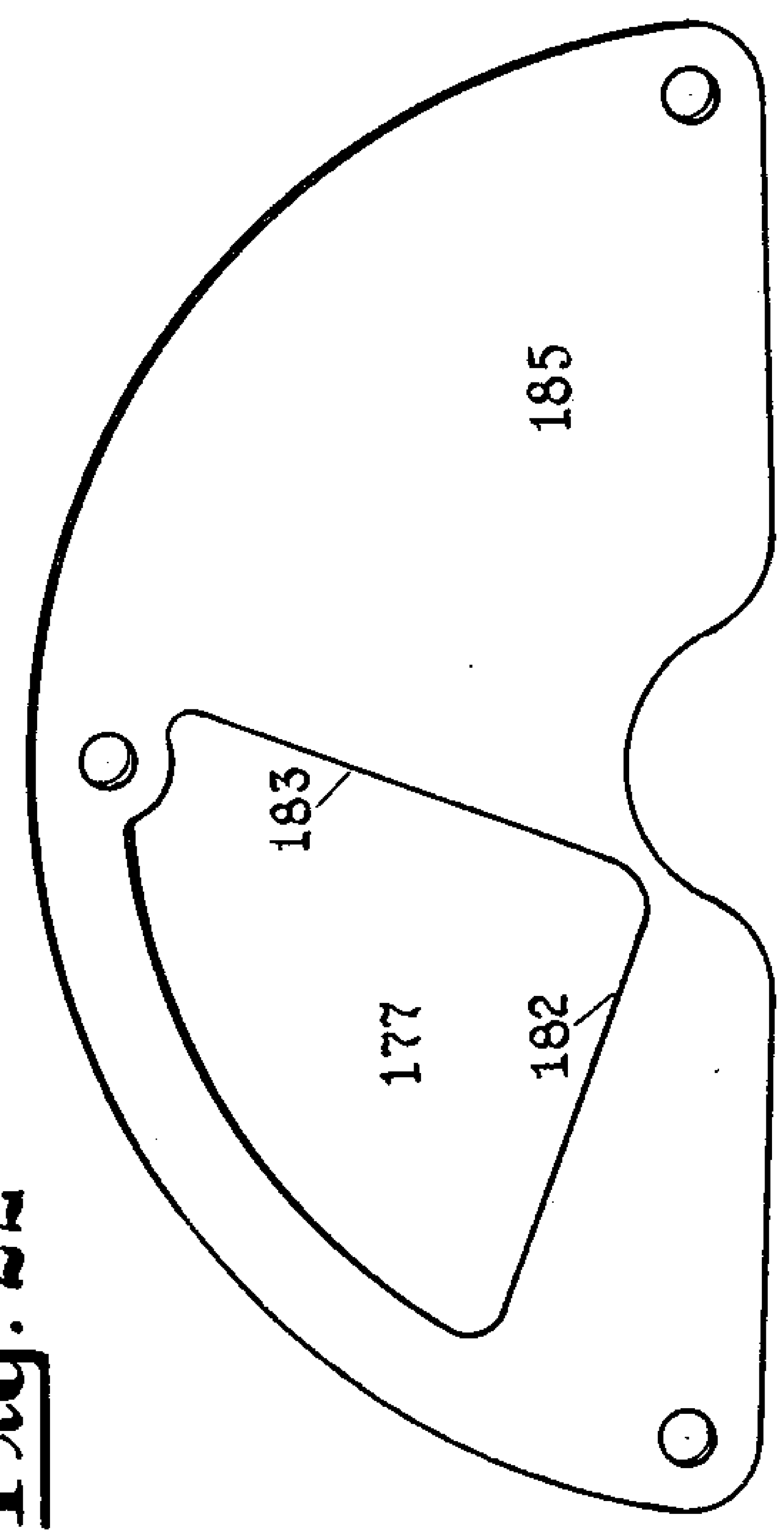

Fig. 22

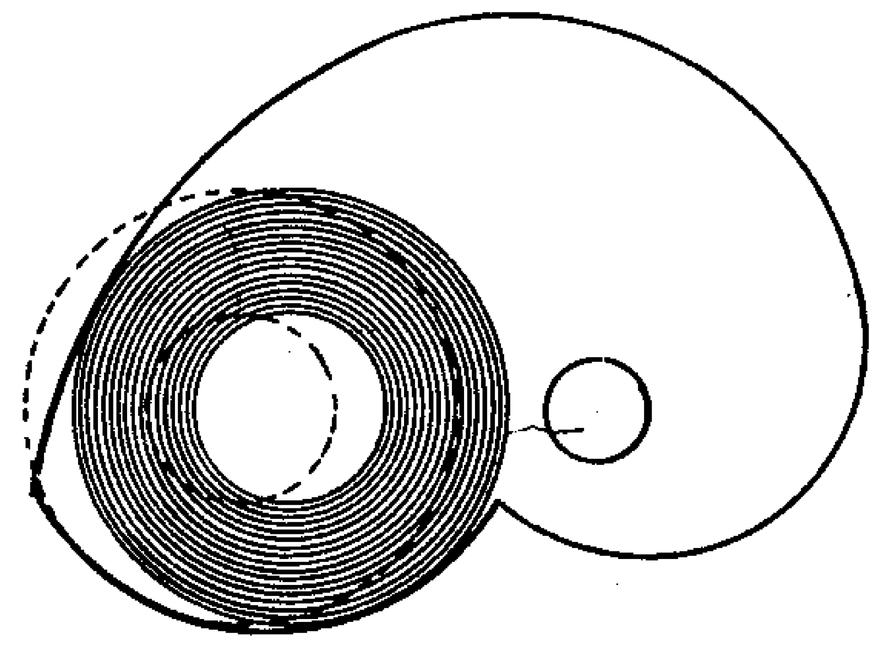

Fig. 27

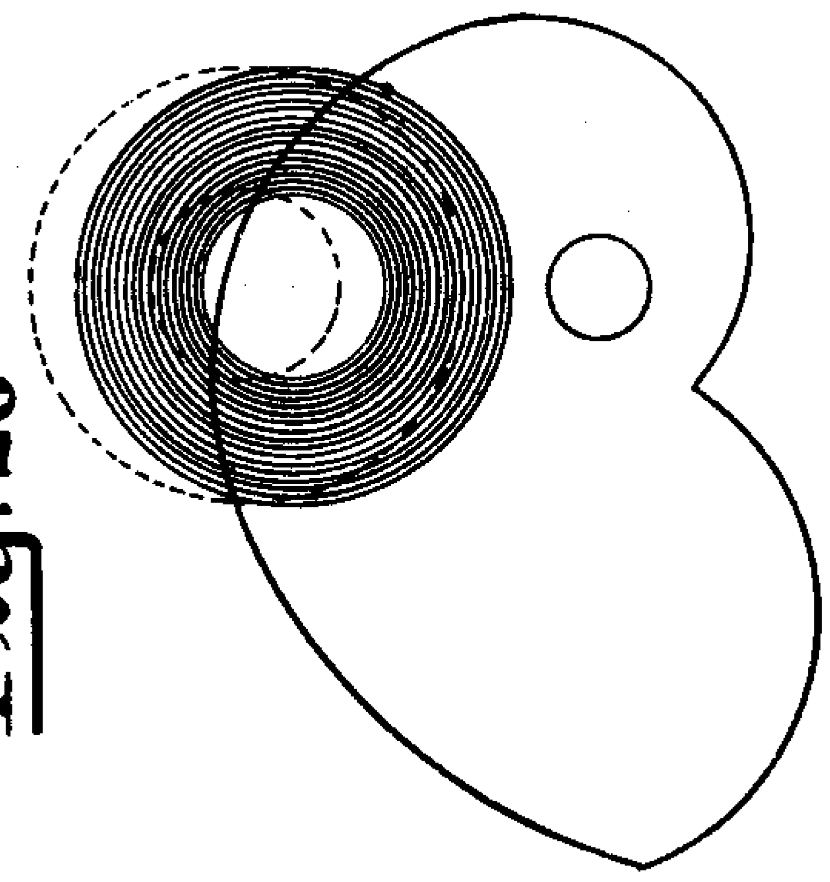

Fig. 26

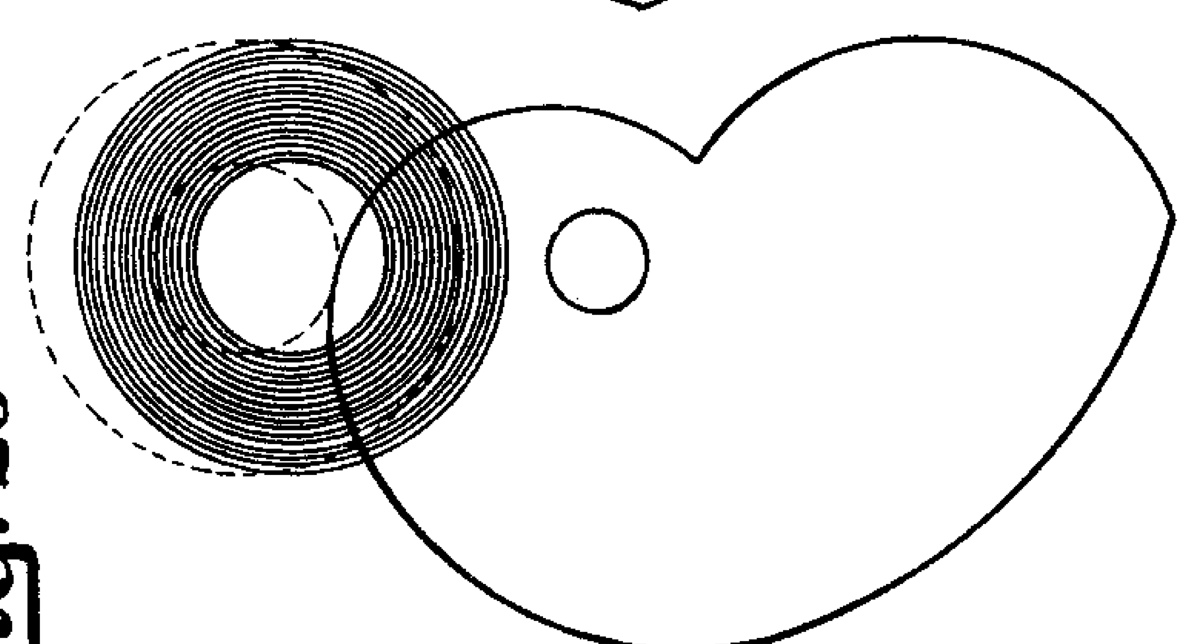

Fig. 25

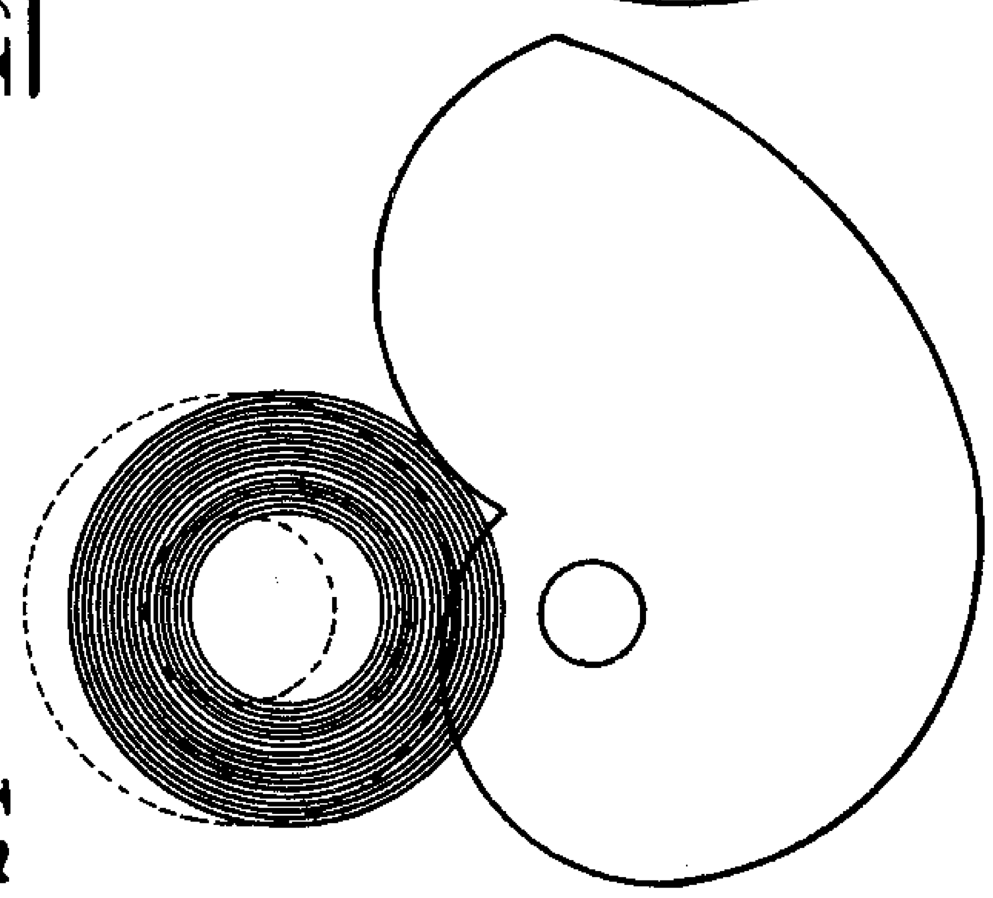

Fig. 24

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Fig. 29

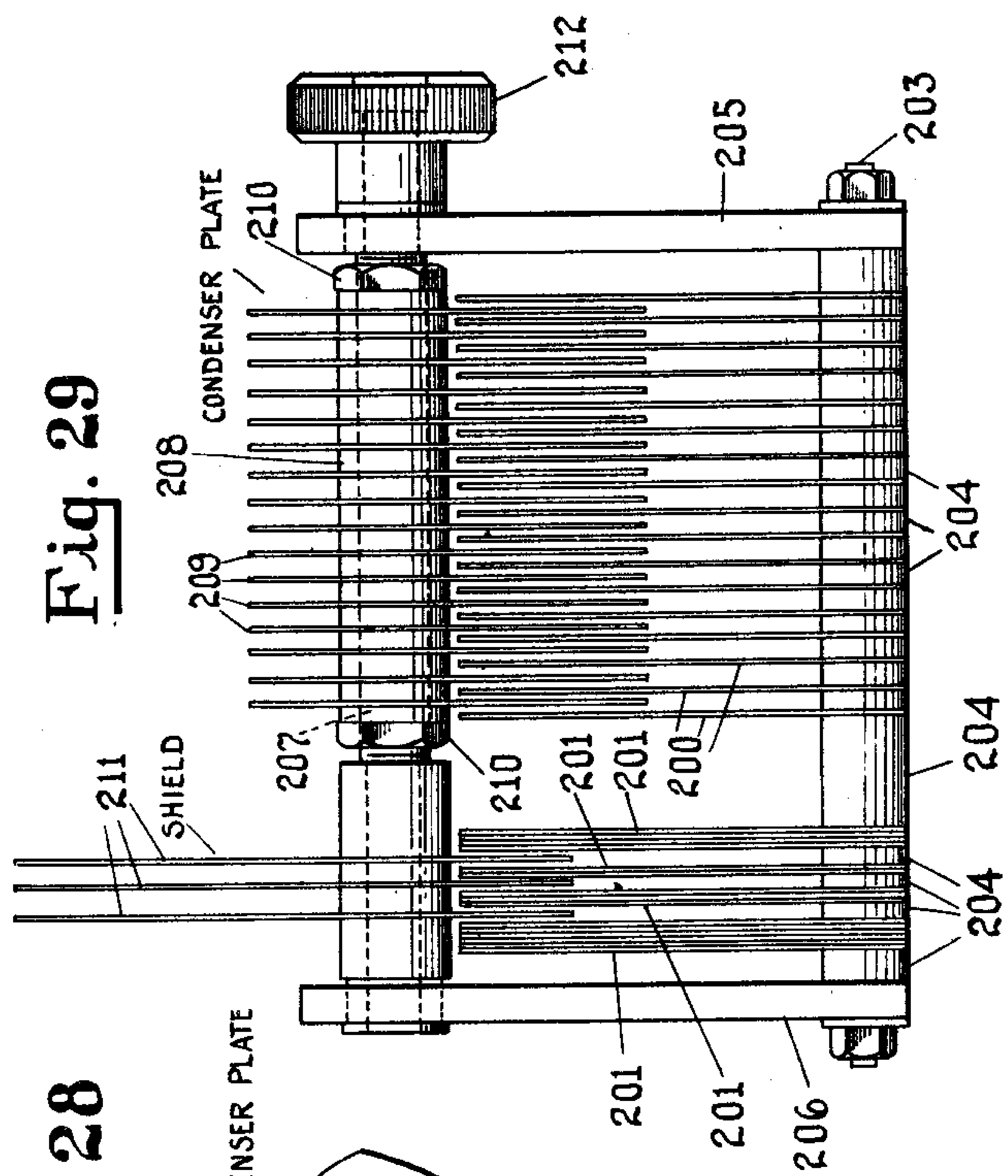


Fig. 28

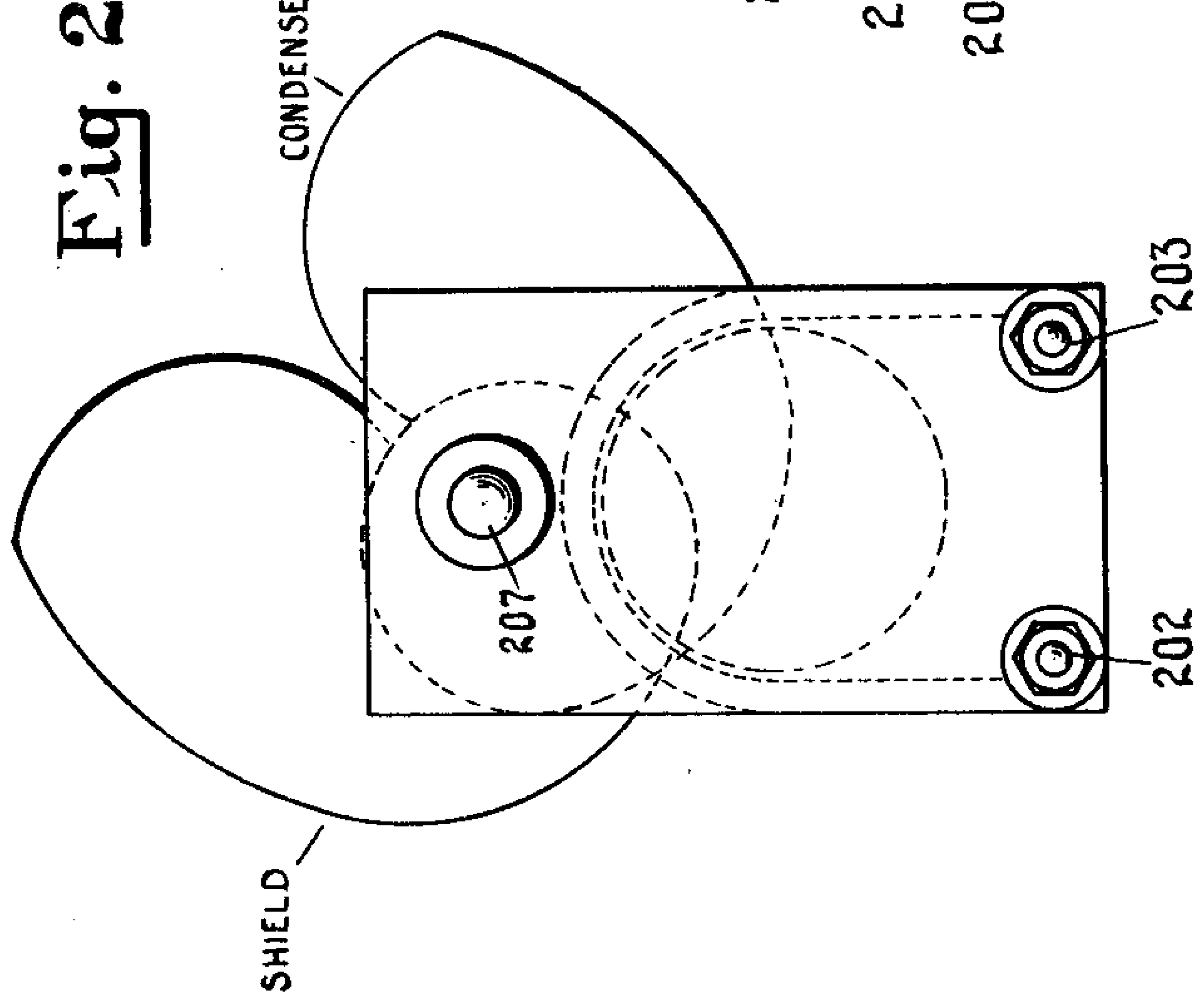


Fig. 31

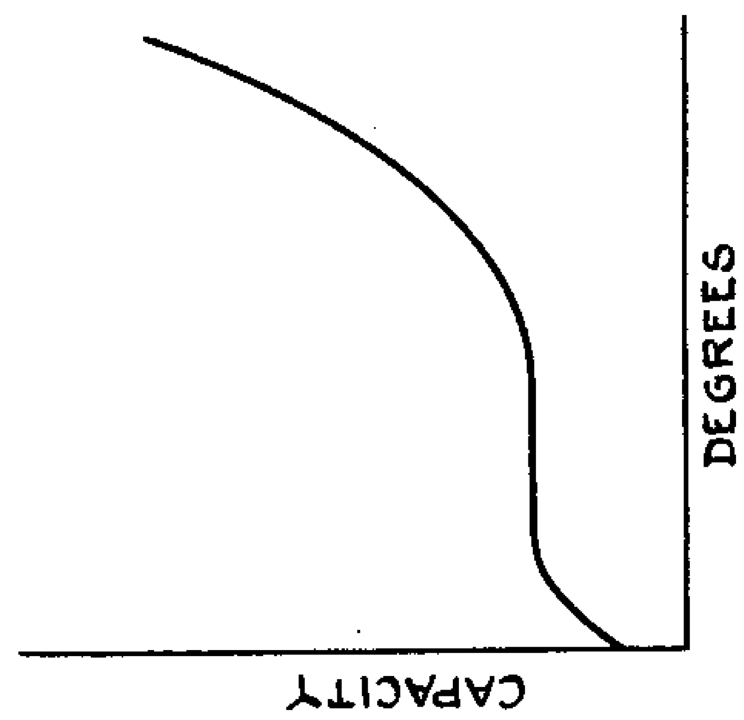
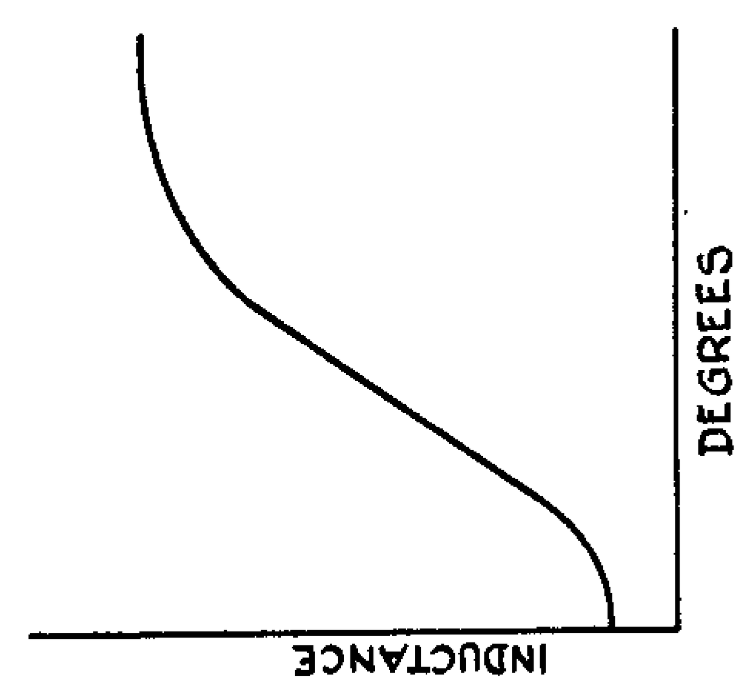


Fig. 30



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Patented May 9, 1933 **1,907,594**

UNITED STATES PATENT OFFICE

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RADIO RECEIVING APPARATUS

Application filed May 5, 1923. Serial No. 637,024.

The present invention relates to radio receiving apparatus and particularly to an arrangement which may be readily used by a person comparatively unskilled in the use of radio signalling apparatus to accomplish reception of damped, undamped or interrupted continuous waves of long and short wave lengths. Certain features of the apparatus to be disclosed herein are described and claimed in a copending application of A. N. Goldsmith, Serial No. 619,847 filed February 19, 1923, and patented on April 9, 1929, as U. S. Patent No. 1,708,539.

In various kinds of service, such as that of the Marine and Signal Corps, it is desirable to be able to receive signals of the various kinds mentioned above and to shift from the reception of one to the other without delay. It is also desirable in the interest of economy and portability to accomplish this without duplication of apparatus. It is furthermore desirable to simplify the tuning so that the adjustments necessary are as few as possible and the operation is sufficiently simple so that little training is required.

One of the objects of the present invention is to secure an arrangement fulfilling the above requirements. Further objects of the invention are to secure improved structural features such as the inductance and coupling units, the arrangement and structure for varying the tuning, the disposition of the component parts and other arrangements which will be referred to in detail hereinafter.

The novel features which I believe to be characteristic of my invention are particularly set forth in the appended claims, the invention, itself, however, both as to its construction and mode of operation, together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a diagram of the circuit arrangement.

Fig. 2 is a simplified diagram showing the circuit arrangement when receiving continuous waves.

Fig. 3 is a simplified diagram showing the circuit arrangement when receiving interrupted or modulated continuous waves and spark or damped waves.

Fig. 4 is plan view of the receiving apparatus with the top, sides and rear end removed.

Fig. 5 is a side view of the arrangement shown in Fig. 4.

Fig. 6 is a front view.

Fig. 7 is a detail view showing the pointer construction.

Fig. 8 is a fragmentary cross section showing a suitable construction of the main adjusting knob, bearing and gear.

Fig. 9 is a detail of a collar used in the adjusting mechanism of Fig. 8.

Fig. 10 is a fragmentary view of the gearing arrangement.

Fig. 11 is a detail illustrating a suitable construction of a switch for the circuits.

Fig. 12 is a plan view of one of the coil units used in the arrangement for the primary and secondary coupling, the feed back, and as a shield.

Fig. 13 is an end view of the unit of Fig. 12.

Fig. 14 is a plan view of the coil and Fig. 15 is a diagram showing a convenient method of winding the coil.

Fig. 16 is a view of the sheet for holding the coil.

Fig. 17 is a view of one of the panels between which the coil units are mounted.

Fig. 18 is a plan view of a shield plate used for varying the inductance of the coils in tuning, parts of the supporting and gearing mechanism being shown.

Fig. 19 is a detail view partly in cross section showing certain features of the construction of the condenser.

Figs. 20 and 21 are views of the condenser.

Figs. 22 and 23 are plan views showing the special shape of the stationary and movable plates of the condenser.

Fig. 24 is a diagram of a modified shield for a coil for use with a variable condenser having any desired shape of plates, and

Figs. 25, 26 and 27 show the shield and coil in successively different positions.

Fig. 28 is a front view and Fig. 29 is a side view of a modification in which the condenser and shields are on the same shaft.

Figs. 30 and 31 are curves showing inductance of the shield and the capacity of the condenser for various angular positions.

The arrangement in accordance with the invention is adapted to receive telegraph signals either on continuous waves or spark transmission. As is well known a receiver of spark transmission is also adapted to receive radio telephony and interrupted continuous wave telegraph communications and the arrangement is therefore a universal receiver as far as the kind of transmission is concerned. Means are also provided for readily receiving short or long waves of either character. As shown in Fig. 1, only a single adjuster is utilized for tuning. This consists of the adjusting knob 1 which is mechanically connected to a variable condenser 2 and a variable inductance 3 (Figs. 2 and 3) consisting of a number of coil units 3^{S1}, 3^{S2}, 3^{L1}, 3^{L2}, 3^{L3}, 3^{L4}, 3^{L5}, 3^{L6}, 3^{L7}, 3^{L8}, 3^{L9}, and 3^{L10} (Fig. 1) forming the antenna coupling coil.

A single member 4, such as a knob enables the reception to be changed to either continuous wave telegraphic reception (C. W.), to spark reception or its equivalent. Similarly a single member 5 enables reception of either long or short waves. The adjustments mentioned are all that are essential, although with vacuum tubes it is also advantageous to provide an adjustment of the filament voltage, for example by means of member 6 which acts in conjunction with rheostat 7. As the members 4 and 5 are double throw switches they do not require tedious adjustment by trial. The operation of the apparatus therefore require trial adjustment of knob 1 and adjustment of rheostat 7 to secure the optimum signal strength. As only one main adjustment is required I term my device a "Unicontrol receiver".

The particular embodiment of the invention illustrated by the apparatus shown in the drawings comprises terminals 8 and 9 to which the antenna 10 and ground 11 are respectively connected. The antenna terminal 8 is connected to one terminal of the variable condenser 2 through lead 8′ and the ground terminal 9 through lead 9′ to the negative terminals of a filament battery 12 and a plate battery 13 for supplying current to vacuum tubes in a manner which will be more fully described hereinafter. Between the antenna and ground the antenna circuit is through variable condenser 2 leads 27, 28 and coils 3^{S1}, 3^{S2} and 3^{S3} to a pivot terminal 14 of a double pole double-throw switch 15 which is controlled by the member 5. For short waves the antenna circuit will be completed to the ground terminal when the arms of switch 15 are moved upward, the connection being through switch terminals 16, 16′ which are connected by a short circuiting wire, pivot terminal 14′ and conductors 17, 18 and 19.

The antenna circuit for long waves is the same as for short waves except that by throwing the arms of switch 15 downward the additional coil units 3^{L1}, 3^{L2}, 3^{L3}, 3^{L4}, 3^{L5}, 3^{L6}, 3^{L7}, 3^{L8}, 3^{L9}, and 3^{L10} are inserted between terminals 20 and 20′ by way of conductors 21 and 22.

Three vacuum tubes are utilized for the reception, preferably of a miniature type (peanut tubes) requiring a small filament current which may be obtained, for example from two standard one and one-half volt six inch dry cells. The first tube in accordance with the invention is utilized for C. W. reception as an oscillator for generating a heterodyne to give a beat note and for spark reception as a radio frequency amplifier. All of the filaments are heated from battery 12 by connecting one end of each filament to conductor 18 which leads to the negative terminal by way of conductor 19 and by connecting the other ends of the filament to conductor 49 which leads to rheostat contact 6. The filament circuits are opened and closed by means of one arm of a three pole double throw switch 31 which has a pivot terminal 30″ connected through conductor 70 to the positive terminal of the filament battery 12. Conductor 70 is connected to conductor 71 by either terminal 32″ or 72″ of switch 31, the latter terminals being connected together. The rheostat is connected between conductor 71 and conductor 49.

For the four possible combinations, viz. (1) short wave C. W., (2) long wave C. W., (3) short wave-spark and (4) long wave-spark, the circuits are as follows:—

(1) *Short wave, C. W.*—From grid of tube 23 through conductor 73 to pivot terminal 24 of two pole double throw switch 25 to switch terminal 26 when the arms of said switch are moved up by member 4, through conductor 28 to and through primary coils 3^{S1}, 3^{S2} and 3^{S3} and to ground through the short wave switch 15 the circuit therethrough being the same as that of the antenna. As simplified in Fig. 2 the circuit is from grid of tube 23 through coil 3 to ground. The condenser 2 and the antenna capacity to earth together with the primary coils form an oscillation circuit in the grid circuit which determines the frequency of the oscillations generated by the valve. This is one important feature of the invention as by this means a single tuned circuit determines the tuning of the aerial and the heterodyne. If a frequency of 600,000 cycles (500 meters) is being received and a note of 1,000 cycles is desired the heterodyne

frequency-determining circuit which also determines the antenna tuning, is tuned to 599,000 cycles. It will be seen that the antenna is slightly detuned, but this is unimportant compared to the simplification obtained by using only a single tuned circuit. The output or plate circuit of tube 23 in which the heterodyne frequency is repeated comprises conductor 29, pivotal terminal 30 of a three pole double throw switch 31 controlled by arm 4, upper terminal 32 of switch 31, conductor 33, coil units 34^{T1}, 34^{T2}, 34^{T3} 34^{T4}, 34^{T5}, and 34^{T6} in inductive relation to coils 3^{L1}, 3^{L2}, 3^{L3}, and 3^{L4} to provide a feed back between the grid and plate circuits, coil unit 35 forming additional feed back coupled to primary coil 3^{S3}, conductor 36, terminal 32′ of switch 31, conductor 37, plate battery 13, conductor 19 and conductor 18 connected to the filament of the valve 23. It will be noted that transformer 38 between the first and second tubes is not utilized for this connection. The received signal with the superimposed heterodyne is impressed on the grid of a second tube 39 serving as a radio frequency amplifier through the following circuit; grid of 39, conductor 40, pivot terminal 24′ of switch 25, terminal 26′, conductor 41, secondary coil units 42, 43 inductively coupled to primary coil unit 3^{S1}, conductor 44, pivot terminal 45 of a second double pole double throw switch 46 controlled by member 5, upper terminals 47, 47′ connected by a shorting wire, conductors 48 and 49, to the filament of valve 39. An additional coil unit 62 which serves as a shield between the primary and secondary is arranged between the coil unit 3^{S1}, and coil unit 43 and has one terminal open and the other connected to ground through conductors 63, 64 and the conductors 18 and 19. This method of shielding which is especially convenient and efficient prevents undesired capacity coupling effects. The output or plate circuit of the second valve 39 is coupled to the input or grid circuit of a third valve 50 by means of a second transformer. The primary 51 of the latter is connected to a lead 53 extending from the plus terminal of plate battery 13 and its secondary 52 is connected to conductor 49 extending from the potentiometer contact 6. The primary and secondary windings are preferably connected by means of condenser 54, the transformer for example, being made of resistance wire in accordance with the invention disclosed in the application of H. J. Round, Serial No. 370,175, filed March 31, 1920, U. S. Patent 1,759,593, issued May 20, 1930, which provides resistance and inductive coupling between the tubes. The third tube is connected to operate as a detector, for example by utilizing a grid condenser 55 and a grid leak 56. Telephone terminals 57 and 58 are connected respectively to the plate of valve 50 and conductor 53 by means of conductors 59 and 60, a telephone condenser 61 also being connected between said terminals. To summarize the circuit for short wave C. W. utilizes (1) an oscillator for generating a heterodyne, the oscillating circuit thereof being the same as the oscillating circuit of the antenna; (2) a radio frequency amplifier and (3) a detector.

(2) *Long wave C. W.*—When the controlling member 5 is moved so that the arms of the switches 15 and 46 are down the variable inductance 3 is increased through switch 15 by including the coil units 3^{L1} to 3^{L10} between the terminals 20 and 20′ as previously described, thus giving the necessary inductance for long waves to the antenna circuit, which in this case is also the heterodyne oscillator circuit as described with reference to short wave C. W. By means of switch 46, additional secondary coil units 65, 66 and 67 inductively related to coil unit 3^{L10} are connected between pivot switch terminals 45 and 45′. The latter connect through the arms of switch 46 with switch terminals 68, 68′ and in this manner the inductance of the secondary circuit is increased. The secondary circuit is otherwise the same as for short waves. A second shield coil unit 69 having an open terminal and a grounded terminal is located between coil units 67, and 3^{L10}. Said coil unit 69 is connected in the same manner and serves the same purpose as coil unit 62. The same seven coil units 34^{T1}, 34^{T2}, 34^{T3}, 34^{T4}, 34^{T5}, 34^{T6} and 35 are used for the feed back or tickler for the long as well as the short waves. As the circuit arrangement and the operation on long wave C. W. is the same as on short wave C. W. except in the particulars described, further description will be unnecessary.

(3) *Short wave, spark.*—When the member 4 is moved so that the arms of double pole double throw switch 25 and three pole double throw switch 31 are moved down to the position for spark reception, the following changes will be made in the circuit as compared with that for short wave, C. W.

(*a*) The grid of tube 23 will be disconnected from the circuit of the primary coil units 3^{S1} etc. and connected through conductor 73, pivot terminal 24, terminal 74, conductor 75, terminal 26′, conductor 41 to the secondary coil units 43, 42, conductor 44, through the short wave switch 46 to the rheostat 7, conductor 71, terminals 32″ and 30″ of switch 31 to the positive terminal of the filament battery 12.

(*b*) The plate of tube 23 will be disconnected from the feed back coil units 35, 34^{T6}, 34^{T5}, 34^{T4}, 34^{T3}, 34^{T2}, 34^{T1}, leaving the circuit of the tickler element open between terminals 30, 32 and 30′, 32′ and out of service. The plate will be connected through conductor 29, terminal 72 conductor 76 to the primary 38′ of transformer 38 which is connected to the plus terminal of the plate battery 13.

Changes (*a*) and (*b*) convert the first tube from an oscillator into a radio frequency amplifier.

(*c*) The grid of the second tube is disconnected from the secondary coils 43, 42 and the conductor 40 leading from this grid is connected to terminal 74′ which has a lead 77 connected to the secondary 38″ of transformer 38. Transformer 38 is a radio frequency transformer of the same type as 51, 52, 54 and likewise has a condenser 78 across the windings.

The grid, plate and filament circuits of tube 50 are the same for spark as for continuous wave signals and the function is the same.

Briefly stated the circuit arrangements convert the tube circuits from oscillator, amplifier and detector for C. W. to amplifier, amplifier and detector for spark signals, and utilize all of the elements for both C. W. and spark except the feed back coils and one radio frequency transformer.

Long wave, Spark—The circuit arrangement in this case is the same as that for short wave spark, except that the inductance 3 is increased by connecting coil units 3^{L4} to 3^{L10} in the antenna circuit by means of switch 15 as described for long wave C. W.; and likewise by increasing the inductance of the secondary by connecting coil units 65, 66, 67 in the secondary circuit by means of switch 46.

By means of the wave length and the wave character switches, the arrangement may be readily changed to permit reception of waves of the desired character in either the range designated as short (300 to 900 meters) or that designated as long (800 to 3,000 meters).

The more accurate tuning will then be done by adjusting the knob 1. This will simultaneously vary the capacity and inductance. The variation of the capacity is obtained by rotation in one act of the condenser plates by means of gears 79, 80 and the variation of the inductance 3 by means of the rotation of good conducting sheet metal shields connected to gearing 79, 81.

In the illustration five shields are used, viz. 82 located between coil units 3^{S1} and 3^{S2}; 83 located between 3^{S2} and 3^{S3}; 84 located between 3^{L4} and 3^{L5}; 85 located between 3^{L6} and 3^{L7}; and 86 located between 3^{L8} and 3^{L9}. Shields 82 and 83 effect the variation of the inductance of the short wave primary coil and 84, 85 and 86 come into action only for long wave reception.

In the subsequent description an improved type of coil unit useful for this type of variable inductance as well as for other purposes will be described in detail as it constitutes an important feature of the invention.

The apparatus shown in the diagram may all be conveniently contained in a rectangular box 80, (Figs. 4, 5 and 6) the top, sides and rear being removable from the front 91 and base 91′ upon which the apparatus is mounted in order to permit of inspection. A convenient arrangement for fastening the separate portions comprises a long rod 92 (preferably one on each side of the case) extending from the front to the rear where it passes loosely through a hole in a member 93 which is fastened to a frame work 94. The end of the rod is threaded and screws into a suitably located nut in the rear end of the casing. This arrangement permits the rods to be loosened to allow the separation of the casing, without withdrawing and reinserting the rods which is a troublesome matter in a casing containing numerous wires and considerable apparatus.

As shown in Fig. 6, two knobs are provided in the upper part on the front panel of the casing, one for shifting to "Spark", "Off" and "C. W". and the other to "Long waves" "Off", and "Short waves" as indicated on the plates 95, 96. As the knobs correspond to members 4 and 5 of Fig. 1 they are designated by the same reference characters. A dial 97 mounted on the front of the cabinet is rotated by the adjusting knob 1 and has two scales, one for long waves and the other for short waves, the divisions being substantially equal for equal wave length differences. A pointer 98 cooperates with the scale and is moved up and down by means of the knob 5 which has a pivotal extension 99 (Fig. 4). Said pivot extension is connected by a link 100 to a pivoted link 101 (Fig. 7) attached to the pointer and also a link 102 (Fig. 11) having a roller 103 for operating a structure 104 embodying both switches 15 and 46 of Fig. 1. In Fig. 11 a side view of two double throw switches is shown, the six wires fastened in the insulating block 105 of a member 106 comprising one half of each of switches 15 and 46. The other six wires are like those shown and the same type of switch is used for the two and three pole double throw switches 25 and 31.

The knob 4 also has a pivoted extension 107 connected to a link 108 (Fig. 4) which controls a switch structure 109 in the rear of the cabinet, which corresponds to switches 25 and 31 of Fig. 1.

The two telephone terminals 57, 58 are mounted on the front of the cabinet. Besides the parts mentioned as shown in Fig. 6, a second knob 110 is provided for fine adjustments. The front view of the apparatus (Fig. 6) shows clearly the simplicity of the adjustments compared with that of the usual commercial device for similar purposes.

In Fig. 7 a detail of a convenient form of index pointer and connection is shown comprising a housing 111, pointer 98 slidably fitting in the housing said pointer having a portion cut away at the top and drilled to receive a staple 112 which connects with link 101. This simple arrangement permits the members to be linked together and the link to be retained by the housing when it is attached to the casing.

Figs. 8 and 9 show details of an assembly of the main dial knob. 113 is a bearing fitting in the front end 91 of the cabinet. The bearing has a shoulder 114 beneath the dial and a threaded end 115 protruding into the cabinet. A nut 116 cooperating with the threaded end permits the bearing to be clamped in the cabinet. The dial 1 has a central circular opening somewhat smaller than shaft 117 and a projection 118 flattened on opposite sides extends through said opening. Two diagonally-opposite, threaded pins 119 are riveted at one end to the dial and filed off smoothly. It is desirable to adjust the dial without rotating the shaft and moving the members geared thereto to enable proper initial settings to be made. An advantageous structure for this purpose, as shown, utilizes a collar 120 provided with semi-circular slots 121 (Fig. 9) for the pins 119 and has an opening 122 registering with projection 118 of the shaft. The pins 119 are fastened to the dial and are moved in slot 121 to the desired position so that the dial indicates the existing wave length and the position is then fixed by means of clamping nuts 123 threaded on pins 119. The knob is then attached to the shaft by means of a screw 125 by registering the nuts 123 with suitable depressions drilled in the knob. A collar 126 is threaded on the bearing and a gear 79 which actuates the adjustable elements as hereinafter described is fixed on a small diameter end 128 of the shaft. The longitudinal position of the shaft relative to the bearing is adjustable by changing the location of collar 126 which is fixed to the bearing by means of set screws 127. To prevent these from being entirely removed and lost the threads of the openings in the collar may be burred inwards after the set screws, which are short ones, have been inserted.

The fragmentary view of Fig. 10 shows the gearing arrangement. The gear 79 connected to the main adjusting knob 1 meshes with a larger gear 80 (about two to one ratio) connected with the variable condenser 2. As approximately 180° of rotation of the variable condenser is required for changing from maximum to minimum, the rotation of the knob from maximum to minimum will be almost 360° and the dial 97 will be graduated around substantially the entire periphery. A smaller gear 128 meshing with the large condenser gear 80 enables fine adjustments to be made by means of the knob 110 which is connected to it. A segmental gear 81 which controls the movement of the shields 82, 83, 84, 85, 86 also meshes with gear 79. The shields are fitted between the pivot shaft 81′ and a bar 81″ which is bolted to the middle of the segment gear, slot 129 being provided to permit adjustment of the bar.

In the assembled structure as shown in Figs. 4 and 5, the coil units are mounted in a rack in the front of the upper portion of the cabinet. Fig. 17 shows the front panel 130 by means of which the units are secured to the front 91 of the cabinet. The frame has four slots 131 for receiving bolts 132 which pass through the front of the cabinet and tubular spacers 133 thus supporting the rack some distance from the front of the cabinet. All of the coil units described with reference to Fig. 1 are held between front panel 130 and a rear panel 134 by means of bolts passing through suitable holes 135 in the panels. A number of tubular spacers 136, 137, 138 and 139 (Fig. 4) are placed on the bolts to separate the various sections of the coil unit assembly. The pivot shaft 81′ for segment gear 81 is fitted in bearings in the front and rear panels 130 and 134 and projects through the front sufficiently to permit the segmental gear to be clamped thereto. To mesh the gear 79 and segment 80 in a proper manner the entire coil rack and segment gear may be moved due to the provision of the slots 131. An insulating bushing 140 surrounds certain portions of the pivot shaft 81′ to prevent electrical connection with the shields 82, 83, 84, 85 and 86. At one side each of the panels 130 and 134 are slotted at 141 to receive an insulating strip 142 having a number of holes in which conductors are inserted for making connections to the coil units and with the other parts of the electrical circuits.

A particular feature of the mechanical construction of the receiver is the method of construction of the coil units which is shown in Figs. 12 to 16. The coils are flat preferably of a single layer and spirally wound as shown in Fig. 14. A convenient method of winding such coils shown in Fig. 15 utilizes a pair of adjacent circular plates 143, 143′ bevelled on the periphery of the adjacent faces. The plates are slidably mounted on a rotatable shaft 144 and pressed together by means of springs 145, 145′ fitted between the plates and collars 146, and 146′ on the shaft. A turn of wire which has a thin covering of insulation will be coiled on the shaft which will then be rotated at a suitable speed and the wire will be pressed into the space between the plates and drawn down against the preceding turn. The spring pressed plates effectually prevent overlapping of the turns and a flat coil may be quickly wound to the desired size. A portion of the inner turns will be unwound to form a lead 155 as shown and the second lead 156 will also be bent to the position shown. The relative location of these leads will be carefully fixed. The coil will then be removed and impregnated with a suitable compound such as rosin and beeswax to give it sufficient mechanical strength to permit handling.

The coil unit is held in a support comprising three sheets of insulation such as bakelite of about the same thickness as the coil. Each sheet is provided with holes 135 for the suporting rods to pass through and a notch 147 for the shaft 81′. To assemble the unit one of the sheets having the contour mentioned is placed on the bench, and a second sheet 148 (Fig. 16) is placed thereon, a layer of adhesive being applied to the adjacent surfaces. Sheet 148 which is the coil holder has a circular opening 149 adapted to receive the coil and a pair of notches 150, 151 at the side for outlets for the terminals. The third sheet (Fig. 12) 152 has a small circular opening 153 and an inclined slot 154. This sheet after applying adhesive thereto is placed on the coil unit sheet 148. As shown in Fig. 12, space for the terminal 155 extending from the inner turn of the coil is provided by slot 154 so that the terminal wire does not prevent the sheets from lying flat against each other. As shown in Fig. 12 slot 154 of plate 148 and notch 150 overlap slightly and the terminal 155 is drawn through this overlapping space and thence extends through notch 150 of the central plate to provide a lead as shown in Fig. 13. The other terminal 156 extends into opening 153 and similarly through an overlapping space between it and notch 151 and out through the notch 151. In this manner a flat durable coil unit is obtained with no exposed wires except the leads. These coil units may be connected up in various ways and used for various purposes for example, as previously described.

Wherever movable conducting metal shields are used these will be placed between the units during assembly. An improved construction is shown in Fig. 18 to prevent binding and friction which occurs due to slight variations in the thickness of various portions of an assembly of coil units. If the shields are fixed to the shafts 81′ or 81″ it has been found that even with good mechanical workmanship it is difficult to move the shields readily due to binding. In the present construction the shields have lugs 157, 157′ on opposite sides with V-shaped notches the distance between the notches being such that the discs are quite loose between shafts 81′ and 81″. No rigid connection will be utilized between the shields and the shafts, so that the shields during their rotation are free to assume a horizontal position in which the friction is least.

In the illustration the shaft 81′ is the pivot shaft about which the shields are turned by the movement of the stub shaft 81″ which is bolted to the segment gear 81. This enables the shield to be moved in such manner that it overlaps various sections of the coil. The shield acts as a short-circuited secondary to the coil unit and the inductance is progressively reduced as the shield is moved to cover various sections of the coil.

Although the variable condenser is quite similar to the ordinary rotating plate variable condenser it will be described more or less in detail as several novel features are embodied therein. It is fastened to the front of the cabinet below the coil unit rack by means of bolts 158 in much the same manner as the coil unit. The bolts pass through slots 159 in the front support 160 of the condenser (Fig. 21) which is spaced from the front of the cabinet. The provision of the slots permits the condenser to be moved so that its gear 80 will mesh properly with the main gear 79.

Considerable difficulty is encountered in properly aligning the bearings of a variable condenser and in some cases when the bearings in use get out of alignment the rotation of the movable plates is seriously hindered. In the construction shown the condenser shaft 161 has two portions 162 which fit in the bearings 163 located at each end. Instead of having a considerable length of the shaft in contact with the bearings each end 162 is formed as a short stub which has for example, a bearing surface only about ¼ of an inch long. Should the bearings get out of alignment slightly the binding effect produced will be greatly minimized by having a small bearing surface.

The gear 80 is fixed on the shaft 161 by fastening it to an insulating plate 164 fixed on one end of the shaft. The movable plates 165 (Fig. 23) are keyed to the shaft in the usual manner and separated by washers 166. The keys 167 being near the center of the shaft considerable force must be applied thereto to rotate the plates and loose play results in due time with the ordinary construction which is undesirable in a condenser for this purpose as the condenser setting will not be correct for the dial reading. This is avoided in the present construction by providing a block of several plates 168 at one end of the condenser having openings at some distance from the center of the shaft for receiving a pin 169 which is screwed into the openings. When the shaft 161 is rotated through gears 79 and 80 the force necessary to turn it will be applied through the pin 169 and this being a considerable distance from the center the wear will be decreased and the loose play for a given amount of wear will be lessened.

Gear 128 is located in the condenser and adjacent to the gear 80, the front panel 160 of the condenser, having a bearing 171 for receiving the shaft 172 of this gear. The rear end of the shaft 161 has a projecting end 173 of small diameter slotted to receive a coiled spring 174 which has its other end fitted in a slot of the post 175 so that a slight spring pressure is exerted against the rotation of the condenser in one direction.

The stationary plates 176 are assembled on rods 177 with spacers 178 so as to lie between the movable plates.

If the condenser capacity and the induction both vary in uniformity as they are rotated through a certain angle the wave length variation will not vary proportionally through the entire range. The markings on the dial corresponding to equal changes of wave length will therefore progressively change, being large at one end very small at the other. In Figs. 22 and 23 I have shown one method of substantially equalizing the spacings of the scale readings. The fixed plates 176 and the rotating plates are especially shaped so that for each spacing, for example, 10°, on the scale the wave length changes, the same amount, for example, 100 meters. That is, knowing the inductance of the tuning coil (which with the shield inductance shown is not a straight line function) at each point I compute the necessary capacity for the wave length desired at that position of the dial. A suitable shape of movable plate or stationary plate or combination of both is then plotted which in various positions gives the necessary overlapping surface area in each position. In Figs. 22 and 23 both the stationary and the movable plates are specially formed, the stationary plate having a segmental opening 177 and the movable plate having a somewhat similar segmental opening 178. If the plates are in position so that the openings correspond the condenser is in maximum position. During the first part of the rotation toward the right the capacity decreases rapidly as the forward ends 179 and 180 are both moving away from their cooperating surfaces. After rear end 181 passes edge 182 of the stationary plate the variation is more gradual as the movement of the portion 180—181 has substantially no effect. By the time edge 180 reaches the edge 183 the large segment 184 only slightly overlaps the large segment 185 of the stationary plate. The variation of capacity through the remainder of the 180° movement then proceeds at a slower rate.

In Figs. 24, 25, 26, 27 a coil unit is shown with a special shaped shield adapted to be utilized with the ordinary variable condenser having semi-circular plates. The gearing will be such that the condenser rotates 180° while the shield rotates approximately 270°. By this modification the same result may be obtained as with the special condenser just described. In the initial position (Fig. 24) the inductance is maximum as the shield scarcely overlaps any portion of the coil. During the first 90° rotation the inductance is decreased as determined by the extent of overlapping shown in Fig. 25. In the next 90° the inductance decreases further as determined by the degree of overlapping shown in Fig. 26 and during the third 90° decreases rapidly to a minimum.

In the modification shown in Figs. 28 and 29 the movable shields for varying the inductance and the movable condenser plates for varying the capacity are both located on the same shaft. The movable shields are of substantially the same shape as those shown in Figs. 24 to 27 and a similarly shaped movable condenser plate is also used to secure equal wave length variations for equal amounts of rotation. Such an arrangement may be utilized in the apparatus heretofore described to eliminate the necessity for gearing and may also be utilized as a tuner in any receiving set. The arrangement will also utilize 270° dial and have the advantage of greater rotation in passing from minimum to maximum and equal wave length changes for equal rotation. The stationary condenser plates 200 and the coil units 201 are mounted on two supporting rods 202, 203 and spaced apart by suitable distances by washers 204. Front and rear end members 205, 206 are fastened to threaded ends of the rods by means of nuts. As shown in dotted lines in Fig. 28 the upper ends of these stationary members are semi-circular and the lowest ends are square so as to permit the members to be fitted on the supporting rods. The rotatable elements are mounted on a shaft 207 located in bearings near the top of the end members and spaced from the supporting rods a sufficient distance to permit the rotating elements to be turned. Any appropriate means may be used for fastening the shields and condenser plates to the shaft. The arrangement shown utilizes spacing washers 208 between the condenser plates 209 and clamping nuts 210 on a threaded portion of the shaft, which obviates the disadvantage of keyways and keys and permits lateral adjustment. The shields 211 which are keyed to the shaft are then located in the proper position by means of washers which may be loose enough to permit some lateral movement, and avoid binding. The construction of the coil units may be similar to that shown in Fig. 12 and therefore need not be particularly described. A single adjusting knob 212 will be fitted to the shaft in any appropriate manner.

In Figs. 4 and 5 a desirable arrangement in the cabinet for all of the apparatus is shown. The condenser and coil unit rack with the gearing are located in the front as described. At the rear the rectangular frame 94 is provided which is divided into two parts by an intermediate V shaped strip 190. The plate battery 13 is fitted into the lower portion in an upright position so that it may be readily inserted and removed. In the upper portion the two dry cells forming the filament battery are inserted, these preferably lying on their sides. Two shelves 191, 192 are attached on top of the frame 94. The shelf 191 has the two transformers 38′ and 51, attached thereto and the condensers 54 and 54′ are attached on top of the transformers. The switch 109 is also mounted on this shelf in the position shown. On the other shelf are located sockets 193, 194 and 195 for the three vacuum tubes which are mounted in an upright position. The filament rheostat is also fastened to 192 in an upright position. The arrangement shown gives a compact receiving unit and when the top and sides are removed all necessary portions are easily accessible.

Having described my invention, what I claim is:

1. A receiving system comprising a plurality of electron discharge tubes, input and output circuits connected to each tube, a detuned antenna, the input circuit of one of said tubes being inductively coupled to said antenna, the output circuit of said tube being coupled to the input circuit of a succeeding tube, the preceding tube thereby acting as an amplifier of modulated waves, and a single switching means for simultaneously coupling the output circuit of the preceding tube to the antenna and inductively connecting its input circuit to the antenna whereby the said preceding tube acts as a heterodyne for detecting continuous waves.

2. A radio receiving system comprising a detuned antenna, a vacuum tube having an input circuit coupled to said antenna and an output circuit, a second vacuum tube, a single switching means for coupling the output circuit of the first tube having an input and output circuit with the input circuit coupled to the antenna or to the input circuit of the second tube whereby said first mentioned tube acts as a heterodyne for detecting continuous waves when the output circuit of said tube is coupled to the antenna, or as an amplifier for the amplification of modulated waves when its output circuit is coupled to the input circuit of the said second vacuum tube.

3. A radio receiving system comprising an antenna, a pair of tubes, one of said tubes having an input circuit comprising a coil connected in the antenna, and a corresponding output circuit coupled to said coil, a second input circuit coupled to the antenna adapted to be connected to the second of said tubes, a second alternative input circuit for said second tube, and switching means when in one position for disconnecting the grid of said first mentioned tube from said antenna and the input circuit of said second mentioned tube from said second tube, and in another position for connecting the input circuit of said second tube as the input circuit for said first mentioned tube and for connecting said alternative input circuit to said second tube, whereby said first mentioned tube acts as a heterodyne when said switching means is in its first mentioned position, and as a radio frequency amplifier when said switching means is in its second mentioned position.

4. In radio receiving apparatus the combination of tunable receiving circuits, a plurality of vacuum tubes, a single adjusting member for selecting a desired tuning in a given band and a single switch for changing the circuit connections to receive spark or continuous waves and utilizing all of the tubes when either spark or continuous waves are received.

5. In radio receiving apparatus the combination of tunable receiving circuits, a plurality of vacuum tubes, a single adjusting member for selecting a desired tuning in a given band, a switch for shifting the tuning band and a second single switch for changing the circuit connections to receive spark or continuous waves and utilizing all of the tubes when either spark or continuous waves are received.

6. In radio receiving apparatus the combination of tunable receiving circuits, a single adjusting member for selecting a desired tuning in a given band, a switch for shifting the tuning band, a dial connected with said adjusting member having a plurality of scales, and an indicator connected with said switch and cooperating with said dial for indicating the band to which the switch is shifted.

7. In radio receiving apparatus the combination of tunable receiving circuits, a single adjusting member for selecting a desired tuning in a given band, a switch for shifting the tuning band, a dial connected with said adjusting member and having a plurality of scales, an indicator connected by link work with said switch indicating the band to which the switch is shifted on said dial, and a second single switch for changing the connections of the receiving circuits to receive spark or continuous waves.

8. A receiver comprising a source of radio frequency signal energy, a detector stage in-

cluding a tube, an amplifier stage, including a tube, having its output coupled to the detector input, a third tube arranged to couple said source to the amplifier input during desired periods of reception, and means for coupling both the amplifier input and the input electrodes of the third tube to said source during other periods of reception.

9. A receiver comprising a source of radio frequency signal energy, a detector stage including a tube, an amplifier stage, including a tube, having its output coupled to the detector input, a third tube arranged to couple said source to the amplifier input during desired periods of reception, and means for coupling both the amplifier input and the input electrodes of the third tube to said source during other periods of reception, said last means additionally coupling the output electrodes of the third tube to said source.

10. A receiver comprising a source of radio frequency signal energy, a detector stage including a tube, an amplifier stage, including a tube, having its output coupled to the detector input, a third tube arranged to couple said source to the amplifier input during desired periods of reception, and means for coupling both the amplifier input and the input electrodes of the third tube to said source during other periods of reception and additional means for varying at will the signal range of said source.

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