F. LOWENSTEIN.

RADIOSIGNALING APPARATUS.

APPLICATION FILED JAN. 19, 1918.

1,339,772.

Patented May 11, 1920.

11 SHEETS—SHEET 1.

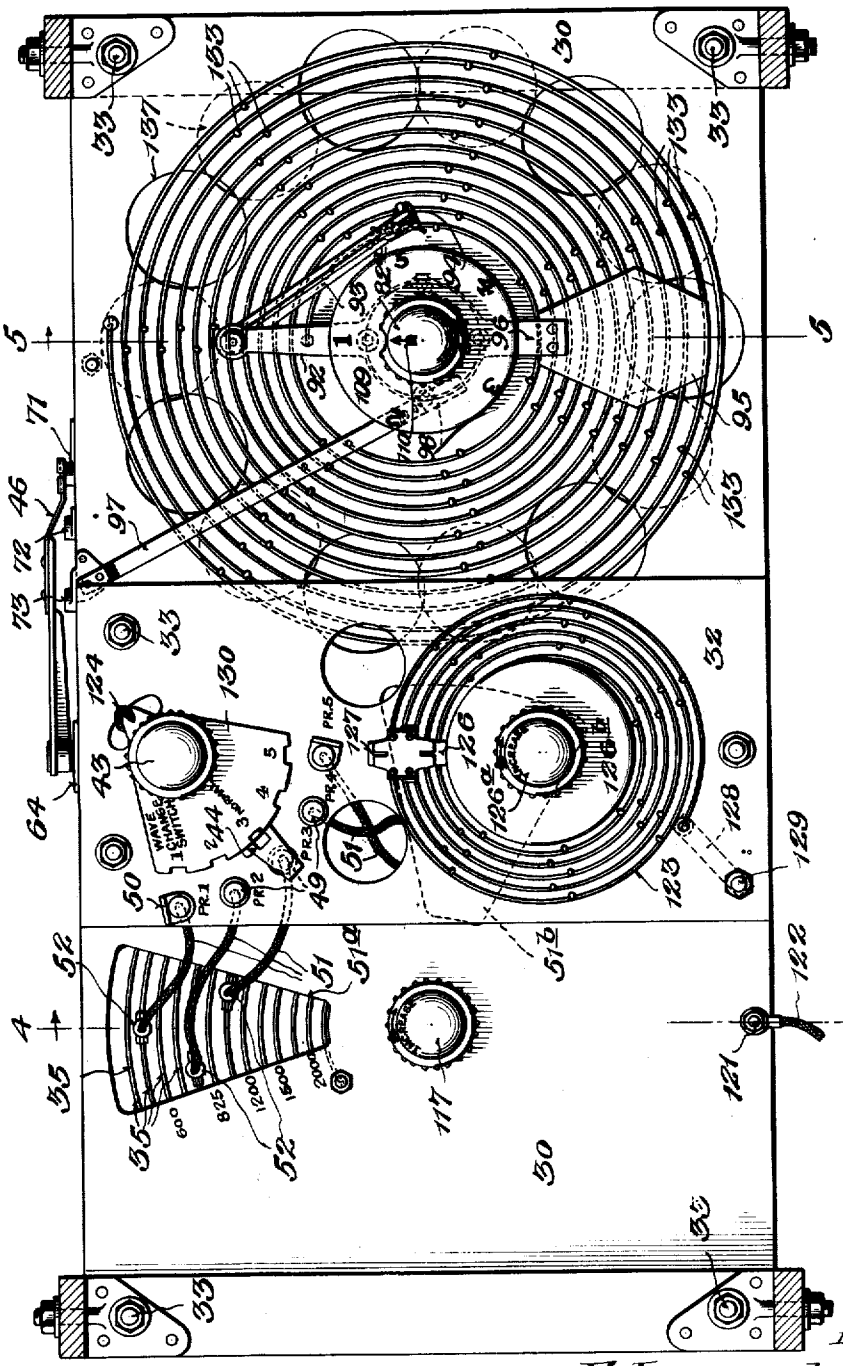


Fig. 1.

INVENTOR

F. Lowenstein,

By M. C. Massie

his Attorney

Witness:-

Chas. L. Griesbauer

F. LOWENSTEIN.

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11 SHEETS—SHEET 2.

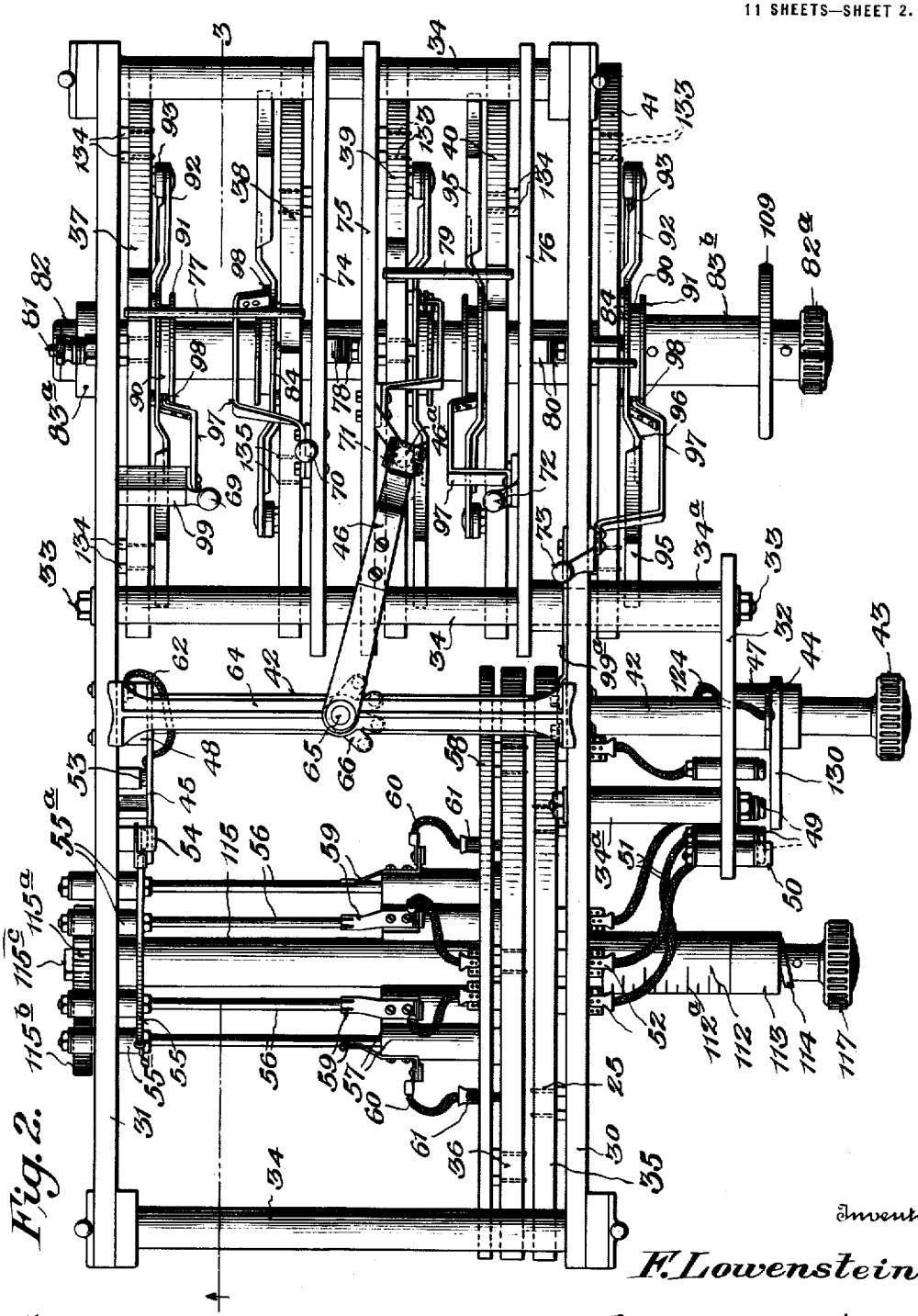


Fig. 2.

Inventor

F. Lowenstein,

Witness:-

Chas. L. Gristauer

By M. C. Massie

his Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 3.

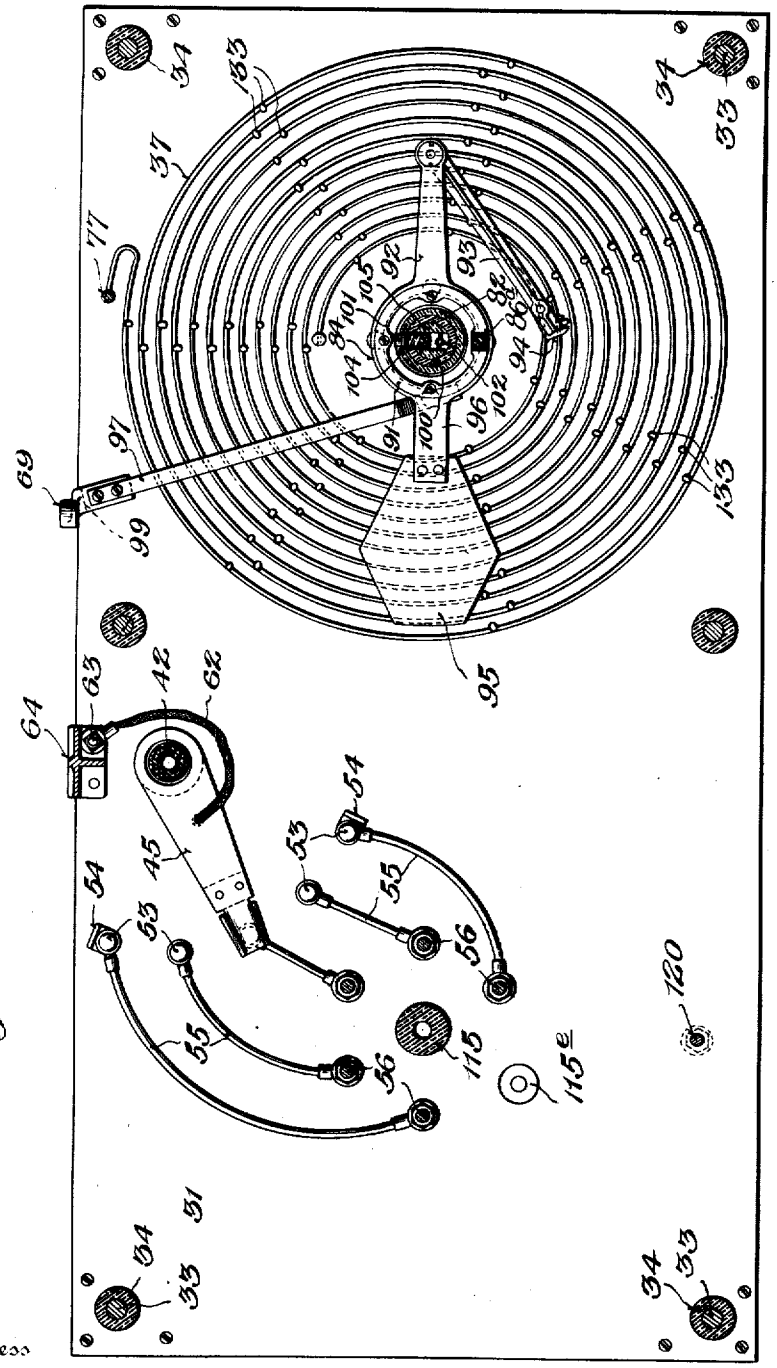


Fig. 3.

Witness

Chas. L. Grisbauer

Inventor

By F. Lowenstein,

M. C. Massie

his Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 4.

Fig. 4.

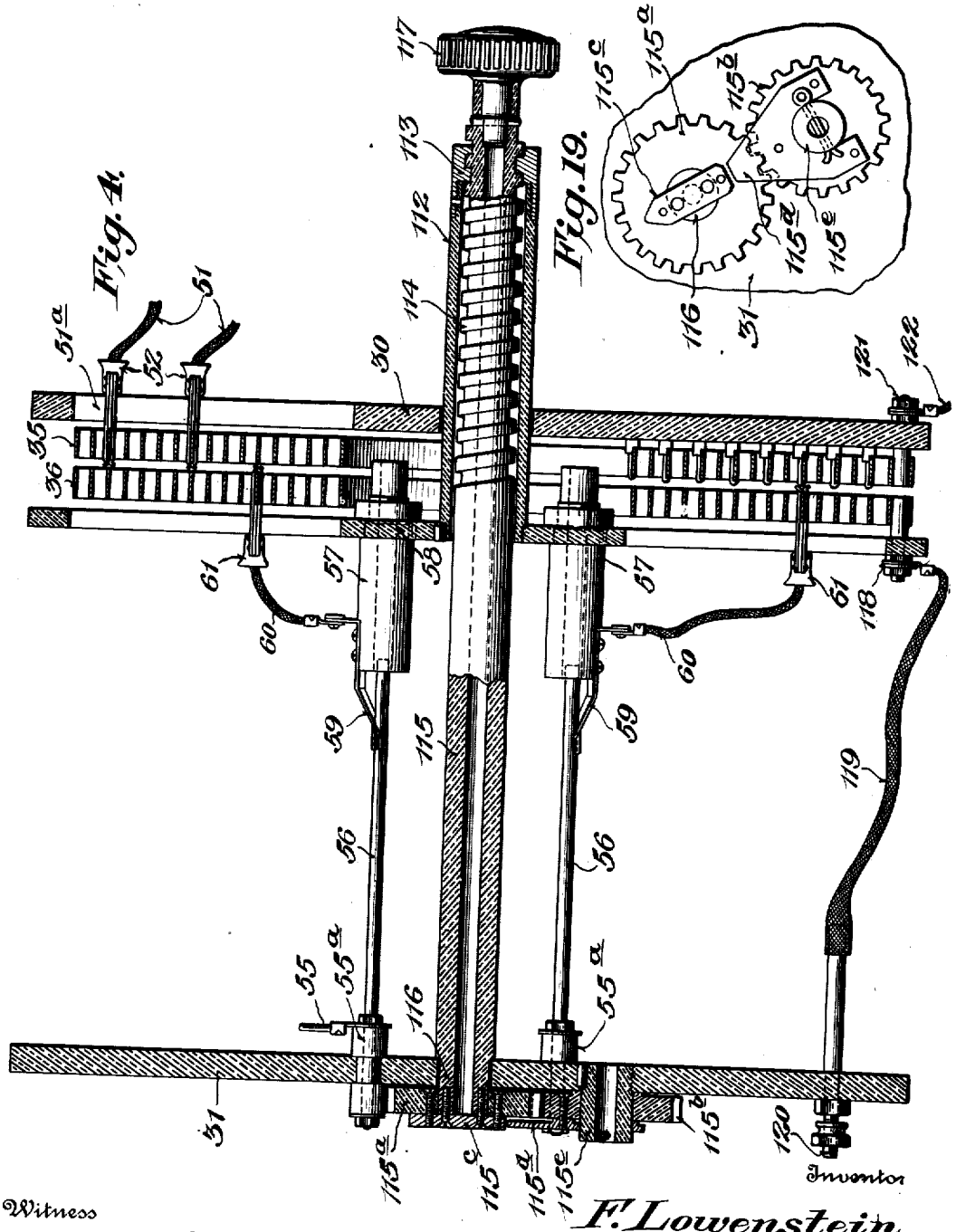


Fig. 19.

Witness

Chas. L. Griesbauer.

Inventor

F. Lowenstein,

By M. C. Massie

his Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 5.

Fig. 5.

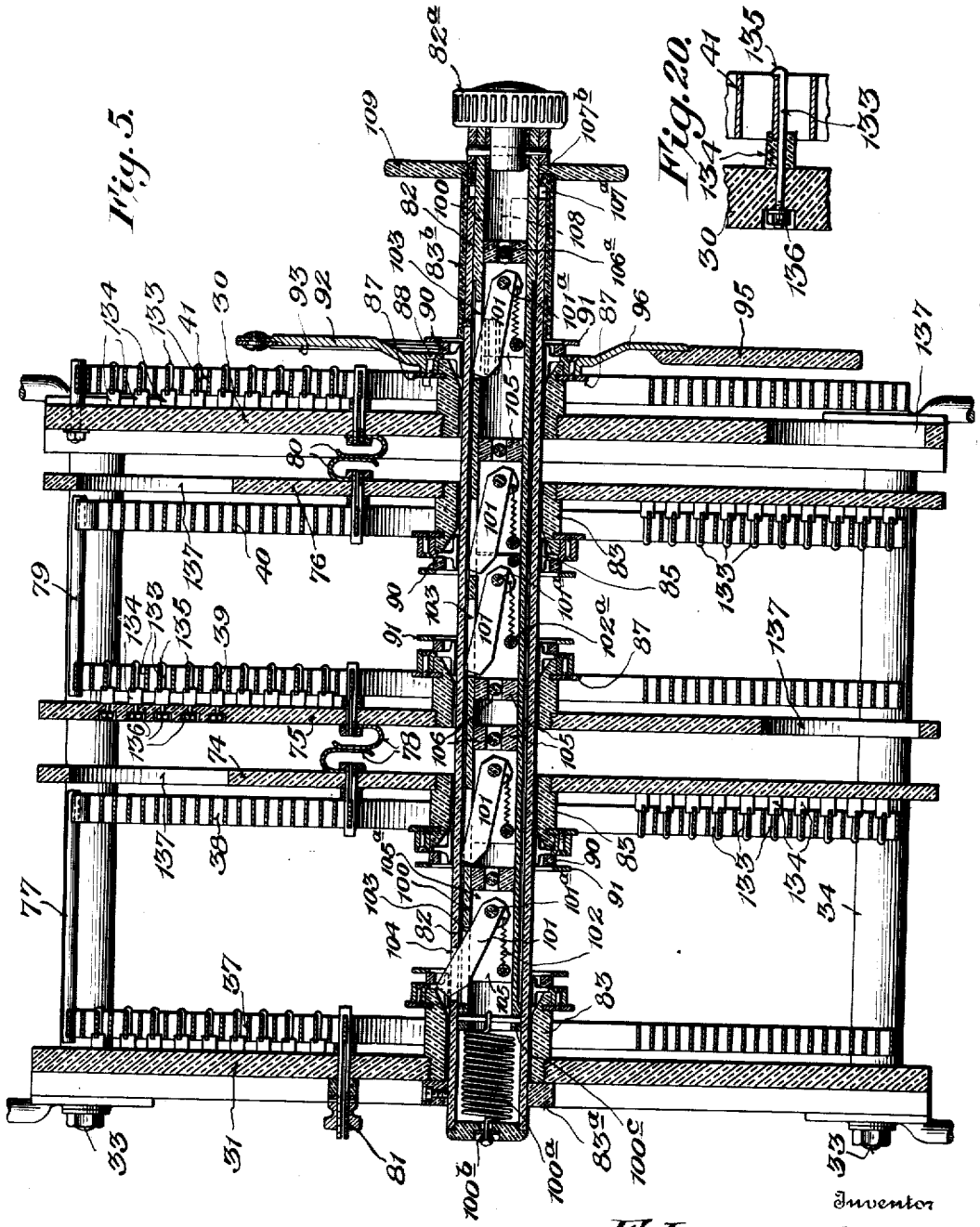


Fig. 20.

Witness

Chas. L. Griesbauer

Inventor

F. Lowenstein,

By M. C. Massie

his Attorney

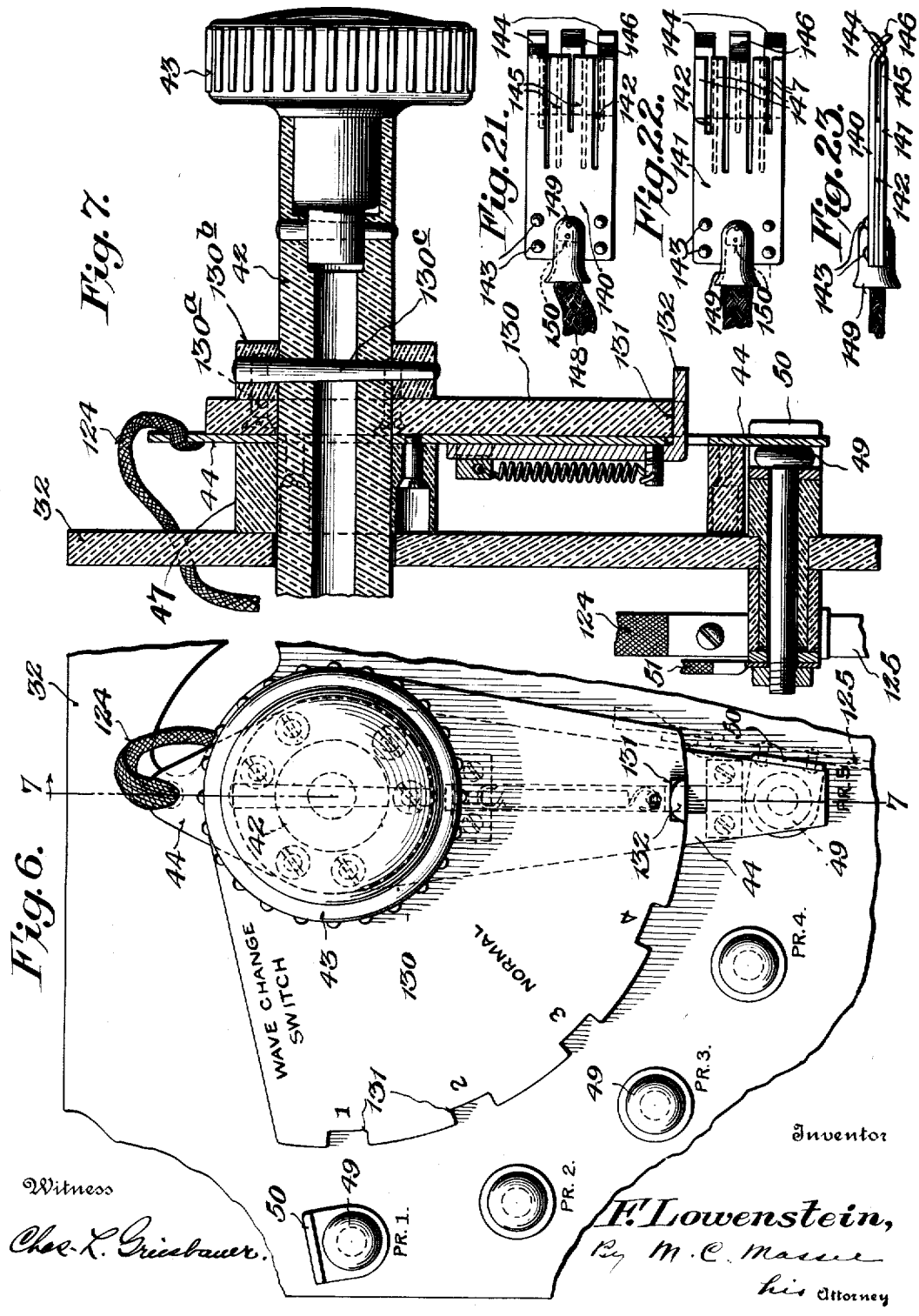
F. LOWENSTEIN.

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1,339,772. Patented May 11, 1920.

11 SHEETS—SHEET 6.



Witness

Chas. L. Griesbauer.

Inventor

F. Lowenstein,

By M. C. Masse

his Attorney

F. LOWENSTEIN.

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1,339,772. **Patented May 11, 1920.**

11 SHEETS—SHEET 7.

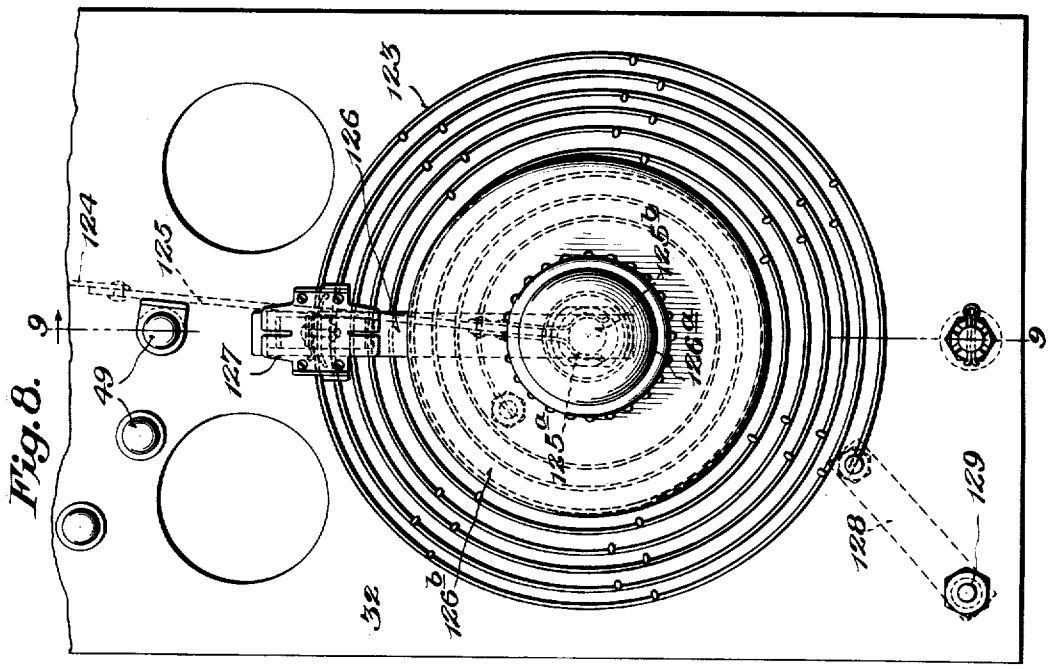


Fig. 8.

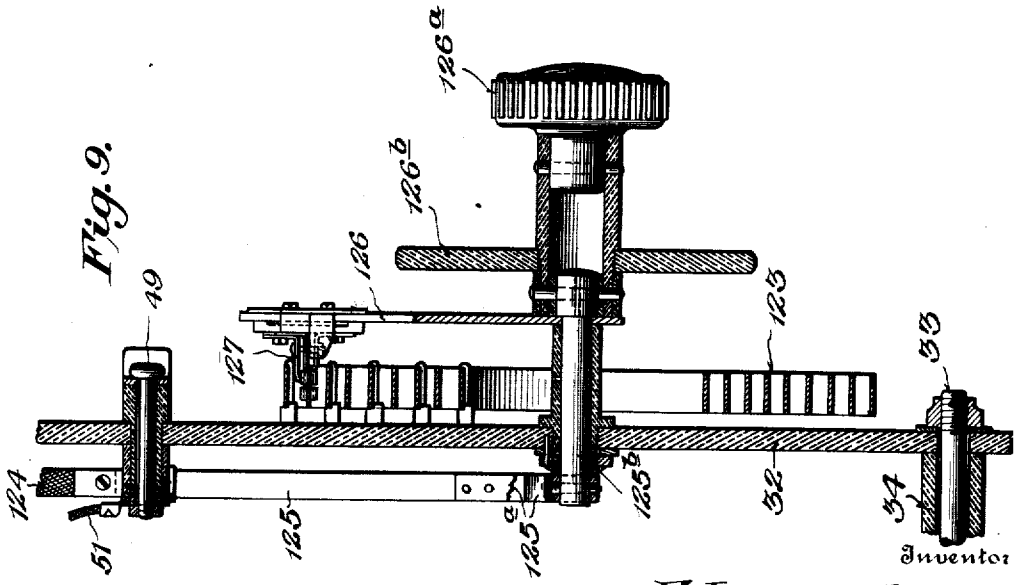


Fig. 9.

Witness

Chas. L. Griebauer.

Inventor

F. Lowenstein,

By M. C. Massie

His Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 8.

Fig. 10.

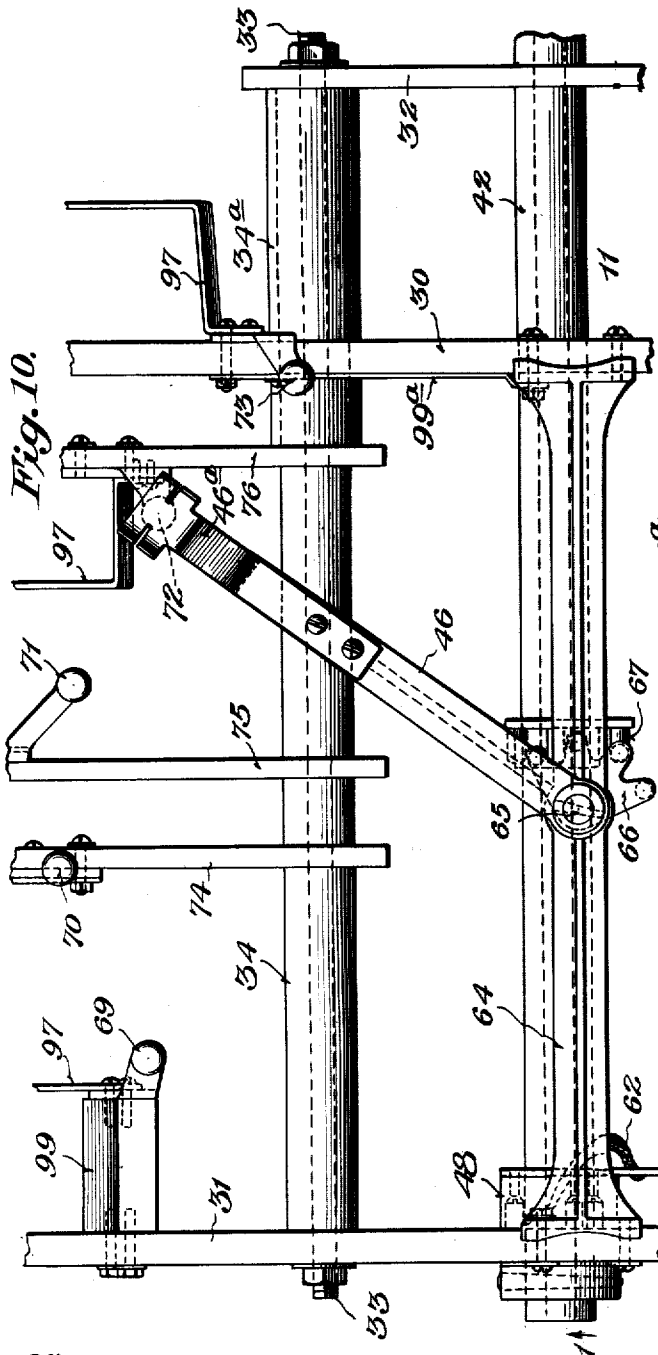
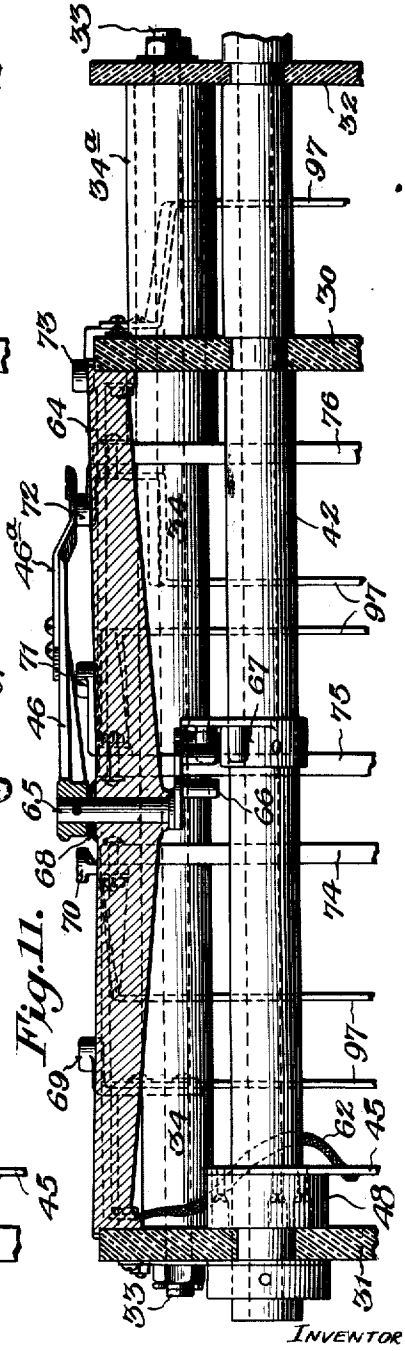


Fig. 11.



Witness

Chas. L. Griesbauer

INVENTOR

F. Lowenstein,

By M. C. Massie

his Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 9.

Fig. 12.

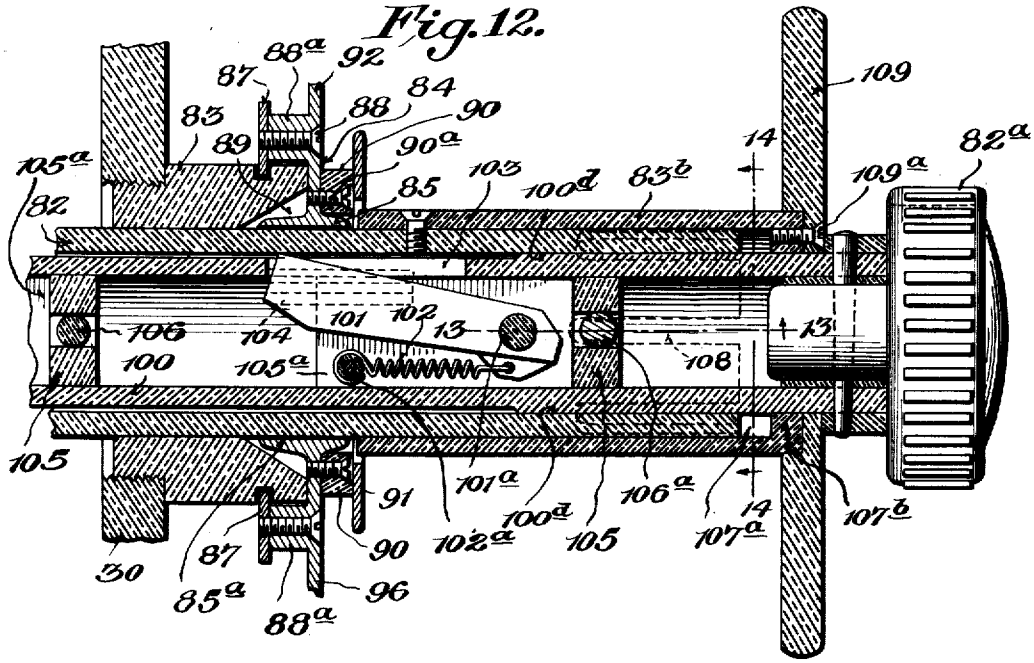


Fig. 13.

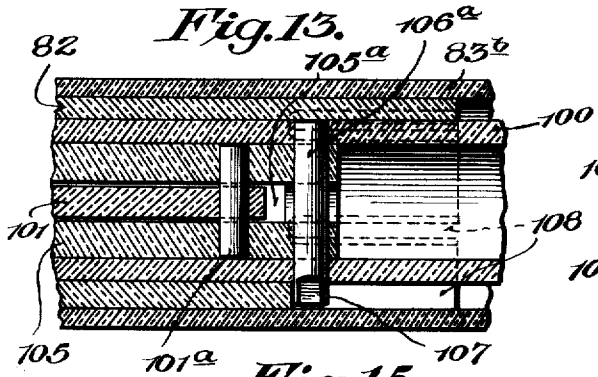


Fig. 14.

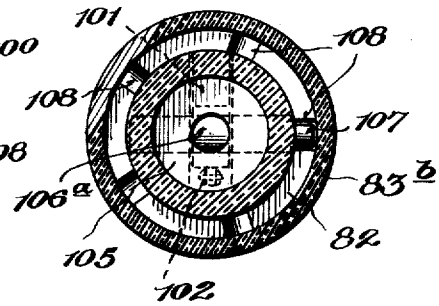
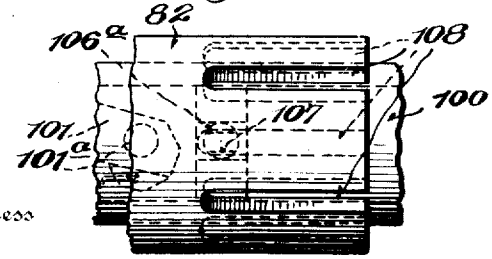


Fig. 15.



Witness

Chas. L. Griebauer

Inventor

F. Lowenstein,

By M. C. Massie

his Attorney

F. LOWENSTEIN.

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Patented May 11, 1920.

11 SHEETS—SHEET 10.

Fig. 16.

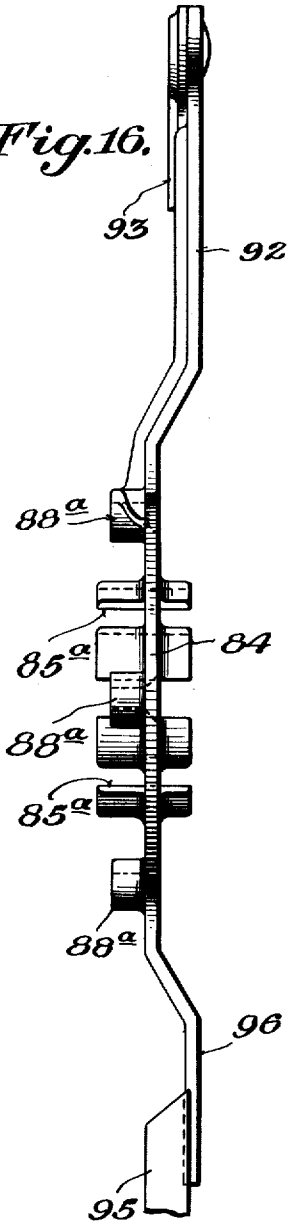


Fig. 17.

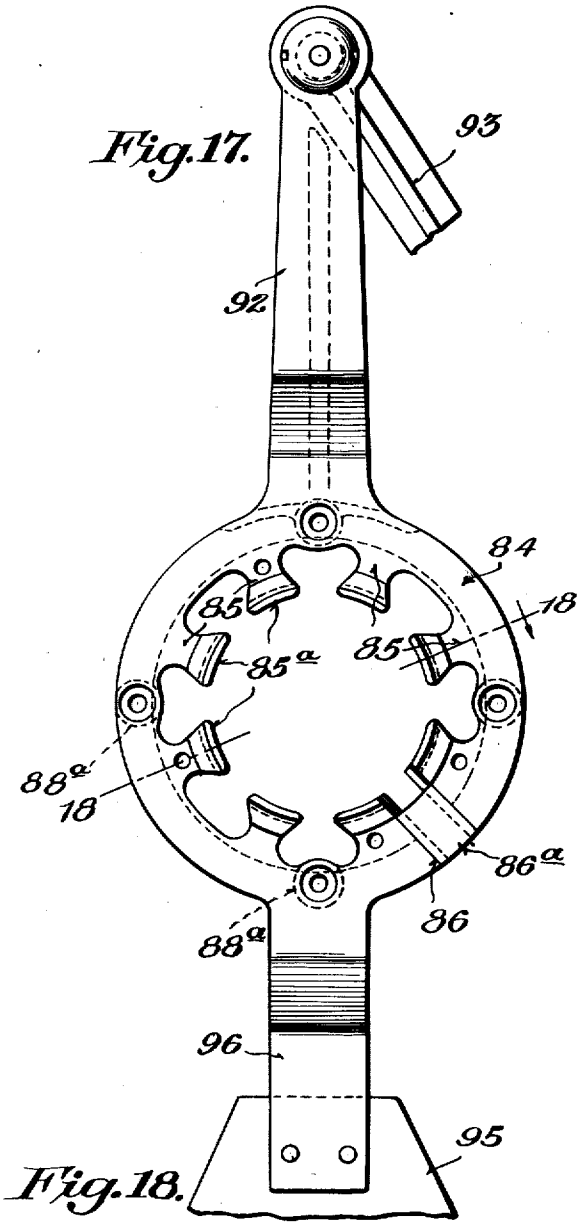
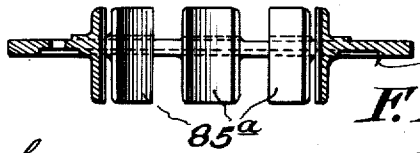


Fig. 18.



Witness

Chas. L. Griesbauer.

Inventor

F. Lowenstein,

By M. C. Massie

his Attorney

F. LOWENSTEIN.

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11 SHEETS—SHEET 11.

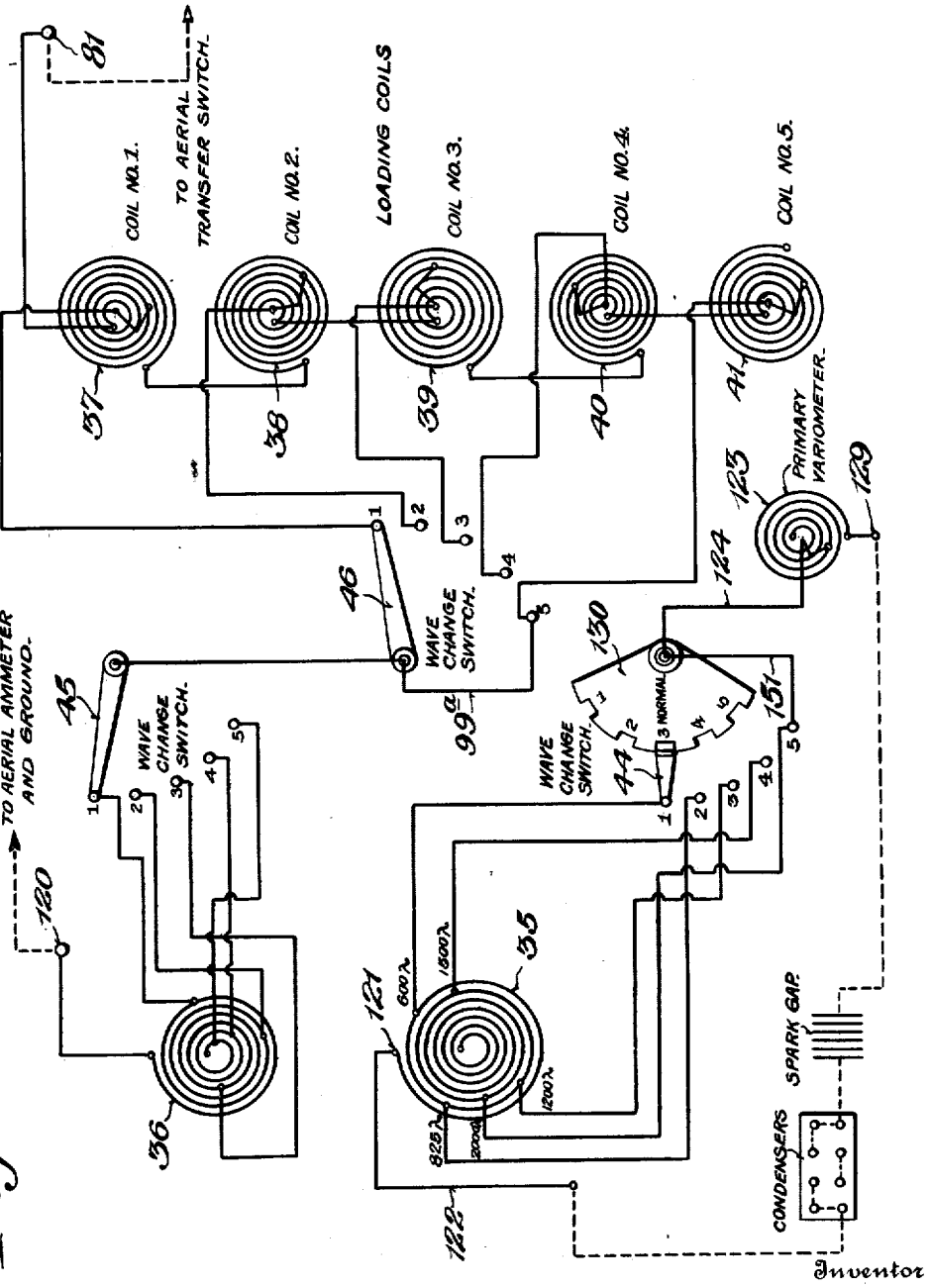


Fig. 24.

Inventor

F. Lowenstein,

Witness

Chas. L. Griesheimer.

By M. C. Mason

his Attorney

UNITED STATES PATENT OFFICE.

FRITZ LOWENSTEIN, OF BROOKLYN, NEW YORK.

RADIOSIGNALING APPARATUS.

1,339,772. Specification of Letters Patent. Patented May 11, 1920.

Application filed January 19, 1918. Serial No. 212,615.

To all whom it may concern:

Be it known that I, FRITZ LOWENSTEIN, a citizen of the United States, residing at Brooklyn, county of Kings, and State of New York, have invented certain new and useful Improvements in Radiosignaling Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to radio signaling apparatus of a type in which provision is made for rapidly changing the operating wave length, either in sending or receiving, by means of mechanism operable to actuate simultaneously a reactance-varying device in each of two coöperating oscillation circuits, such reactance-varying devices comprising variable inductance or variable capacity, or both. Apparatus of this general character is described and broadly claimed in my prior applications Ser. No. 569,324, filed June 28, 1910, and Ser. No. 10,592, filed February 25, 1915. The present disclosure relates to certain improved embodiments of the broad principles disclosed in said prior applications, and also includes other novel features of general application in this art.

For certain kinds of service, and especially in military operations, it is necessary to employ portable radio or wireless signaling apparatus which must be characterized by reasonably high power and efficiency, lightness, compactness, resistance to shocks and rough usage generally, and also by simplicity and convenience of operation. Some of these requirements are to a certain extent mutually conflicting, with the result that it is difficult to satisfactorily meet them all in one combined construction. For example, compactness, rigidity and massiveness of supporting structure, which are required for the portability, strength and durability essential to apparatus capable of withstanding rough treatment, are difficult to attain while complying with the requirement to guard against jumping of the current between high tension parts of high power apparatus. It is a primary object of the invention to provide apparatus which shall successfully meet all the requirements in question and which shall at the same time embody features of improvement desirable in and of themselves, whether employed or not in portable apparatus of the specific character to be more particularly hereinafter described.

By way of concrete illustration and in order that the invention may be fully understood by those skilled in this art, an especially desirable form of transmitter apparatus embodying the principles of the invention and shown in the accompanying drawings will be described in detail. It is to be understood, however, that the invention is not limited to a transmitter nor to the specific construction here chosen for purposes of explanation. In the drawings,

Figure 1 is a front elevation of the assembled apparatus;

Fig. 2 is a plan view of the same;

Fig. 3 is an elevation, partly in section on the line 3—3 of Fig. 2;

Figs. 4 and 5 are longitudinal sections on the lines 4—4 and 5—5, respectively of Fig. 1;

Fig. 6 is a front elevation of a part of the wave change mechanism, on an enlarged scale;

Fig. 7 is a section on the line 7—7 of Fig. 6;

Fig. 8 is an enlarged detail of the variometer coil and switch, in elevation;

Fig. 9 is a section on the line 9—9 of Fig. 8;

Fig. 10 is a plan view on an enlarged scale of a part of the apparatus shown in Fig. 2;

Fig. 11 is a view of the same in side elevation, partly in section on the line 11—11 of Fig. 10;

Fig. 12 is a sectional detail, on an enlarged scale, of a part of the selector mechanism shown in Fig. 5;

Figs. 13 and 14 are sections on the lines 13—13 and 14—14 of Fig. 12;

Fig. 15 is a fragmentary view in elevation of part of the selector mechanism shown in Figs. 13 and 14;

Figs. 16 and 17 are a side elevation and plan, respectively, of variable switch means employed on the loading coils;

Fig. 18 is a section on the line 18—18 of Fig. 17;

Fig. 19 is an enlarged detail, in elevation, of stop means for the transformer coupling changer;

Fig. 20 is an enlarged detail showing a

method of mounting the flat conductor of which the coils are formed;

Figs. 21, 22 and 23 are enlarged detail views of a terminal clip useful in tapping the transformer coils; and

Fig. 24 is a circuit diagram.

The transmitter here illustrated as a typical embodiment of apparatus within the scope of my invention, may be generally described as comprising an oscillation transformer having inductively related primary and secondary windings or coils, and loading coils in circuit with the secondary or coupling coil but substantially out of its inductive influence. Means are provided whereby the effective inductance values of the transformer primary and secondary, and of the loading coils, or, speaking more generally, the self induction of the two oscillatory circuits, may be varied rapidly and simultaneously in a predetermined manner to change the operating wave length without materially disturbing a previously established desired tune relationship between said circuits. In the particular form of apparatus shown in the drawings, the transformer primary and secondary coils, and the loading coils, together with the necessary operating and controlling means therefor, are here shown supported in compact arrangement as a mechanical unit by means of a substantial insulating framework. This framework comprises main front and rear plates or panels 30, and 31, respectively, and a smaller supplemental front plate or panel 32, all rigidly held together in proper spaced relation by longitudinally extending tie rods 33, here shown as of metal, incased in heavy insulating sleeves 34 which also act as spacing or distance members between the panels. The plates or panels are also of suitable insulating material. Most desirably, and as here shown, the several coils supported on this framework are flat helical coils of copper ribbon, commonly known as pancake coils. The oscillation transformer is mounted to one side of the center line of the framework and consists of the two parallel coaxial pancake coils 35 and 36, the primary coil 35 being stationarily mounted on the rear face of the main front panel 30, while the adjustable secondary or coupling coil 36 is mounted in such a way as to be movable toward and away from the primary by means hereinafter described, whereby the transformer coupling distance may be adjusted or varied as desired. In the drawings, the secondary is shown in the position for maximum close coupling. On the other side of the center line of the framework are supported the loading coils 37, 38, 39, 40 and 41, these loading coils being electrically connected in series with each other, and also arranged for connection in circuit with the transformer secondary and the antenna, in a manner to be hereinafter more fully described. The arrangement is such that the loading coils are within inductive range of each other, but are practically out of inductive range of the transformer. Five loading coils are employed in the present example, since this particular transmitter is designed for quick change operation over five different wave lengths, and it is convenient to have the loading inductance divided into the same number of sections.

The mechanism for rapidly changing wave lengths takes the form, in this instance, of manual operating means comprising a rotatable operating rod or shaft 42, of insulating material, provided with a hand knob 43, said rod serving to connect for movement in unison the primary switch arm 44, secondary switch arm 45, and loading inductance switch arm 46. The primary and secondary switch arms are secured, respectively, to insulating distance collars 47 and 48, collar 48 being best secured to the shaft 42, and collar 47 being loose on said shaft. The several switch arms or blades are respectively arranged for variable connection to the transformer primary and secondary, and the loading coils. Thus primary switch arm 44, connected to the shaft 42 by means to be hereinafter described, sweeps over a series of contacts 49, representing different effective inductance values of the transformer primary and corresponding in number to the number of wave lengths at which it is desired the transmitter shall be operable, five in this instance. Stops 50 are provided, one at each end of the series of contacts, which are mounted on the front panel 32, to suitably limit the movement of the switch arm. The contacts 49 are connected respectively by flexible conductors 51 leading through openings 51^a, 51^b, to spring clips 52, each of which can be adjustably set in any desired position on the primary coil. Similarly, the secondary switch arm 45 sweeps over a second series of five contacts 53, mounted on the rear frame plate 31, this second series of contacts being also provided with terminal stops 54. The contacts 53 are connected to tapping points on the movable transformer secondary by special means. As here shown, such means comprise conductors 55 connecting the respective contacts 53 with horizontal conducting rods 56, which are fixed to the rear panel and which extend forwardly and enter hollow insulating supporting sleeves or guides 57, carried by the movable insulating plate 58. Brushes 59 secured to the sleeves 57 bear upon the conducting rods 56, and are connected by flexible leads 60 to clips 61, five in number, which are adjustable in position on the turns of the transformer

secondary coil. The connecting terminals of conductors 55 are best mounted on insulating spacers 55ª, as shown.

The secondary switch arm 45 may be electrically connected in the secondary circuit of the transmitter in series with the loading inductance switch arm 46, in any suitable manner. In this instance, this connection is effected through a flexible lead 62 going to terminal 63 on the conducting bar 64, which latter extends between the panels 30 and 31, and thus also incidentally constitutes a bracing girder. As is shown most clearly in Figs. 10 and 11, the bar or girder 64 provides at a point intermediate its length a bearing for a vertical conducting spindle 65, to the upper end of which is pinned the switch arm 46. The lower end of the spindle carries a pin gear segment 66 with which a similar gear segment 67, carried by the wave change rod 42, meshes. A spring washer 68 placed between the hub of the switch arm 46 and the bar 64, insures good electrical contact between the switch arm and bar. The loading inductance switch arm 46 carries a brush 46ª which sweeps over a series of five contacts 69, 70, 71, 72 and 73, mounted in an arc above the frame, as shown. These contacts are respectively connected to adjustable tapping points on the loading coils, in a manner to be hereinafter described.

Loading coils 37 and 41 are supported, as shown, directly on the rear panel 31 and front panel 30, respectively. The intermediate loading coils 38, 39 and 40 are mounted on intermediate insulating plates 74, 75 and 76, respectively. As before stated, the loading coils are connected in series. In order to simplify the series connections, and at the same time not to interfere with the mutual inductive effect of the loading coils, the following arrangement is particularly convenient. The five coils viewed from one end of the series, are wound, alternately clockwise and counter-clockwise, and the leads connecting pairs of adjacent coils therefor extend alternately between adjacent coil peripheries and adjacent coil centers. Thus, the connection between coils 37 and 38 is through conducting rod 77 which extends between the outer peripheries of these coils. Coils 38 and 39, on the other hand, are connected through coöperating spring contacts 78, each of which is secured to the central or innermost turn of its corresponding coil. In a similar manner, conducting rod 79 connects the outer peripheries of coils 39 and 40; while coöperating spring contacts 80 connect the centers of coils 40 and 41. At 81 is a binding post whereby the center of coil 37 may be connected directly or indirectly to an antenna. Any other convenient arrangement and connection of the loading coils may of course be employed.

As before stated, provision is made for connecting each of the several loading coils with its respective contact in the series of contacts 69 to 73, over which the loading inductance switch arm 46 sweeps. This provision is such that the loading coils are successively cut into or out of the secondary circuit by the switch arm 46, as the shaft 42 is turned to change the operating wave length. In this way, the proper amounts of primary and coupling inductance, and the proper number of loading coils, for each of the five selected wave lengths, are placed in circuit by simultaneously shifting the three switch devices. It is also desirable that provision be made for varying the proportion of any loading coil actively in circuit easily and rapidly in accordance with operating conditions at the different wave lengths for which the wave change mechanism may be set. The following arrangement is particularly suitable for the above purposes. A hollow shaft or sleeve 82 of insulating material extends axially through the series of loading coils and through the plates 30, 37, 74, 75 and 76, and is revolubly supported in suitable insulating bushings or hubs 83 which are screwed into the several plates. Stop collar 83ª at the rear and sleeve 83ᵇ at the front hold sleeve 82 against longitudinal movement. For each loading coil there is a conducting arm or switch device rotatably supported by the corresponding bushing 83. This contact arm comprises a central spider 84 having inwardly extending spaced radial fingers 85, terminating in broad cylindrical surfaced ends 85ª concentric with and closely adjacent sleeve 82 which fits loosely therewithin. The spider is radially slotted at 86 to prevent eddy currents, the gap being closed by a piece of insulating material 86ª. Without some such precaution, overheating may occur in operation. The spider is rotatably supported on the hub 83 by means of washers or disks 87, which are secured thereto by screws 88 in bosses 88ª, and which fit easily within a coöperating peripheral groove or track on the hub, the broad ends of fingers 85 of the spider projecting into the recess 89 formed in the end of the hub 83 adjacent said spider. A spacing ring 90 of insulating material is secured to the spider 84 by screws 90ª; and by means of similar screws (not shown) the metal slip ring 91 is secured to ring 90, said slip ring being electrically connected, as by one or more of said screws, to spider 84. The slip ring is slotted, similarly to the spider 84, to prevent eddy currents; but the slotting is in a different angular position from the slotting of the spider, for reasons which will presently appear. A conducting arm 92, integral with spider 84, extends radially to a point about midway be-

tween the innermost and outermost turn of the loading coil, at which point another conducting arm 93 is hinged to it. The arm 93 carries at its free end a clip or slider 94 which is movable along the conducting ribbon of which the loading coil is formed, so that by rotation of the spider, this clip can be moved to any desired position on the pancake coil. In order to guard against accidental movement of the clip along the conductor by reason of shocks or jars, a counterpoise 95, may be attached to arm 95 of the spider. The employment of a hinged or jointed contact-making arm of the character described has special advantages in connection with large coils like the loading coils here shown, when the conditions of operation are such that the potential in the outer turns of such coils is very high due to auto-transformation. This condition is most pronounced when operating at short wave lengths; and for the arrangement of coils here shown is most likely to occur in coils 37, 39 and 41, especially in coil 37. By means of the hinged arm, the difference in potential between the coil conductor and arm 92 never exceeds that due to approximately one-half the total number of coil turns. It will be noted that the contact arm for coil 37 is spaced farther from the coil than are the arms of the other coils. This is on account of the particularly high potentials in coil 37, and the spacing would have to be still greater were it not for the hinged arm arrangement.

Each spider is connected to its corresponding switch contact 69, 70, 71, 72 or 73, by means of a conducting bar 97, which carries a brush 98 confined between slip ring 91 and the revoluble spider 84, the arrangement being such that the brush always makes good electrical contact with both. Since the slotting of the spider and the slip ring to prevent eddy currents is not at opposite or adjacent points, the brush 98 is always electrically connected to the spider either by direct contact or through the slip ring. It will be noted that each of the bars 97 is disposed tangentially with respect to the spider with which it makes contact. By this arrangement the force occasioned by friction between the brush 98 and the spider is exerted longitudinally of the bar instead of transversely; and this is an important consideration especially in the specific form of apparatus here chosen for illustration, where the bars 97 are positively held at their upper ends only. The bars 97 are bent outwardly as shown, extending in a radial direction but well spaced away from the loading coil, then going to a point of connection with the contact corresponding to the particular loading coil in question. Thus, coil 41 is connected to contact 73, and so on for the other loading coils. Because of the high potentials normally existing in the end loading coil 37 in operation, it is desirable to mount its switch terminal 69 on a relatively long insulating spacer 99. It has been found undesirable to leave as dead ends those portions of the loading inductance not actively in the secondary or aerial circuit. Accordingly the last loading coil 41 has its contact stud 73 always connected to the loading switch 46 through lead 99^a going to girder 64. This shunts the unused portions of the loading inductance and avoids unduly high potentials.

Means are provided for selectively retaining any one of the rotatable spiders 84 and its hinged contact arm in order to adjust the position of the contact clip or slider on the corresponding loading coil. A convenient and satisfactory mechanism for this purpose is here shown. It comprises a selector tube or hollow shaft 100 of insulating material, within the sleeve 82, and slidably movable longitudinally therein within limits. This inner tube or shaft 100 contains suitably mounted therewithin five pivoted latches or dogs 101, one for each loading coil, each latch controlled by a spring 102 which tends to force the tail of the latch outwardly through a longitudinal slot 103 provided in the tube, the five slots 103 being in alinement as shown. Normally these latches are held inoperative by their contact with the inner surface of the surrounding sleeve 82, but upon rotation of the inner tube 100 relatively to the outer sleeve through different predetermined angles, each of the alined slots in the inner tube may be made to register with a slot 104 in the outer tube or casing 82, as will be more fully explained later, whereupon the particular latch in question is thrust outwardly by its controlling spring to engage between a pair of the inwardly projecting fingers 85 on the spider whose arm governs the clip or slider on the corresponding loading coil. In this position, illustrated for example at the extreme left in Fig. 5, the latch mechanism for coil 37 is thus in operative position; and with the two tubes 82 and 100 thus coupled together and also coupled to the spider 84, turning of the operating knob 82^a will result in shifting the sliding contact around on the helical conductor of coil 37 into any desired position. Any practical method of mounting the latches 101 within the tube 100 may be adopted, but that here shown is simple and effective. Short lengths of heavy walled insulating tubing 105 of the proper diameter, are sawed through longitudinally for the greater part of their length to provide chambers 105^a. Within each of these chambers one of the latches 101 is pivoted on cross pin 101^a, its controlling spring being anchored to a cross piece 102^a. In assembling the selector mechanism, each

of these mounting blocks or tube-sections, with its latch in place, is inserted into the tube 100, and after being pushed into proper position is secured in place by means of a pin passing through the unsawed end of the block and into the walls of tube 100. In the apparatus of Fig. 5 these securing pins are most desirably of insulating material, as indicated at 106, for all the blocks except that at the extreme right, the securing pin 106^a for the latter being of stronger material, such as steel, and also differing slightly from the others in form, for reasons which will presently appear.

In order to provide for easily selecting and operatively positioning the particular latch 101 corresponding to the loading coil whose slider it is desired to adjust, means are provided for rapidly and accurately bringing into registry the particular pair of coöperating slots 103, 104, through which that latch is adapted to project. In the apparatus here shown, the front end of the outer selector tube is provided with five longitudinally extending slots 108, angularly spaced to agree with the spacing of the slots 104, which may be equiangular, as here, for convenience. The pin 106^a is elongated to provide a reduced projection at 107 (Fig. 14), adapted to enter any one of the five slots 108 selectively. By pulling the inner tube 100 outwardly until the selector pin projection 107 clears the end of selector sleeve 82, where it can move freely in the annular space 107^a between the end of the sleeve 82 and the flange 107^b of the outer sleeve 83^b, then rotating the tube relatively to sleeve 82 to place the end of the selector pin opposite a selected slot 108, and finally permitting the sleeve 100 to be drawn back by its controlling spring 100^a, one of the five pairs of coöperating slots 103—104 is thereupon brought into registry, the proper latch member operates, and the telescoping selector tubes are thus coupled together and to the contact spider of the particular loading coil whose slider it is desired to adjust. For convenience, an indicator dial 109 is secured as by screws 109^a to flange 107^b, and carries the numerals 1, 2, 3, 4 and 5, which correspond to the several loading coils. A pointer 110 on the operating knob 82^a coöperates with the dial. Thus by pulling out the sleeve 100 and then setting the pointer or arrow to point to the proper number on the indicating dial, the latch mechanism for coupling the operating knob to the corresponding loading coil automatically comes into operation, when the sleeve 100 is allowed to be drawn back into place by its controlling spring 100^a. In this connection it should be noted that said controlling spring is swiveled at 100^b to the end of sleeve 82, thus permitting free relative rotational movement between the sleeve 82, and the inner tube 100. Furthermore, to insure free relative movement between selector tube 100 and sleeve 82, these members actually contact only at bearing surfaces 100^c and 100^d.

Turning now to the transformer construction, any suitable means may be provided for shifting the movable secondary or coupling coil 36 toward and away from the primary coil to vary the coupling distance, and in the particular construction shown, the movable supporting plate 58 carries fixed thereto a long axial sleeve 112, which terminates in an internally threaded member 113, preferably of metal, the threads of this member being engaged by external threads 114 of an operating rod 115 of insulating material, this rod being rotatable within the sleeve 112 and in a bearing provided at 116 in the rear panel 31. Rotation of the rod can be readily effected by means of knob 117. It will be seen that by rotating the knob in one direction the sleeve 112 will be forced toward the rear and will carry with it the movable plate 58 with coil 36 mounted thereon; while turning the knob in the opposite direction will move the secondary coil toward the primary coil. The coupling distance may be read off on a scale 112^a provided on the sleeve 112. Suitable stop means should be provided to prevent forward and rearward movement of the coupling coil or transformer secondary beyond predetermined extreme positions for maximum loose coupling and maximum close coupling. This stop means is desirably of such character as to guard against jamming or forcing of the movable parts. As here shown, this is accomplished by means of a gear stop device mounted at the rear of the apparatus and consisting of intermeshed pinions 115^a, and 115^b, which carry, respectively, stop members 115^c and 115^d. Pinion 115^a, secured to shaft 115, has 24 teeth; while pinion 115^b which is loose on stud 115^e, has 22 teeth. The pinions and stop members are so related that the operating shaft 115 may be turned through ten complete revolutions from either limiting position of the secondary coil. The stop members then come into locking engagement and prevent further movement.

Terminal 118 connected to the outer turn of the secondary coil of the transformer may be connected through flexible lead 119 and binding post 120 to ground through a suitable ammeter (not shown). The outer turn of the primary transformer coil may be connected to the condensers in the primary circuit through binding post 121 and lead 122. The variable connection to the transformer primary, represented by the primary switch arm 44, is connected to an adjustable point on the variable inductance or variometer coil 123 by flexible lead 124 and con-

ducting bar 125 (Figs. 6–9), which latter carries a double brush 125ª bearing against a contact collar on rotatable conducting shaft 125ᵇ, to which shaft is secured switch arm 126 of the variometer. This switch arm is a simple radial arm carrying a contact clip 127 which engages the conducting ribbon of the variometer coil and which is also longitudinally slidable on the arm 126 as the latter is rotated by means of hand knob 126ª. The operating handle may be provided with a guard plate 126ᵇ. This simple type of contact shifter can be used in this location because the variometer coil is composed of comparatively few turns, and hence there are no dangerous potentials in the outer turns under operating conditions. The outer turn of the variometer coil may be connected to the other side of the closed oscillating circuit, in this instance at the spark gap, through lead 128 and binding post 129. This variometer provides a small value of variable inductance which is required in tuning the primary circuit to intermediate wave lengths occurring between the turns of the large primary coil.

Returning now to the mechanical connection of the primary arm 44 of the wave change switch to the wave change shaft or rod 42, this may be effected in any convenient manner. Where the set is to be always used with a standard aerial of say 450 meters, the arm 44 may be permanently fixed on said shaft. But where the set may have to operate with aerials of longer or shorter periods than the standard aerial, it is important to provide means whereby the relation of the primary switch arm of the wave changer to the secondary switch arm 45 and loading inductance switch arm 46 may be varied. Various expedients may be adopted for this purpose. In the arrangement here shown, the switch arm 44 is adjustable on the shaft 42 into different angular positions in the following manner. A sector 130 of insulating material is fixedly mounted upon shaft 42. As here shown said sector is secured by means of screws 130ª to a collar 130ᵇ, which in turn is secured by pin 130ᶜ to the shaft 42. The sector is provided at its outer margin with notches 131, which may be conveniently numbered 1, 2, 3, 4 and 5 as shown in Fig. 6. A manually operable spring catch 132, radially slidable on the rear face of switch blade 44, is adapted to engage the notches 131, so that the switch blade may be shifted to any one of the numbered positions and held in place by the engagement of catch 132 in the corresponding notch. When the switch blade is in the No. 3, or "normal" position, the wave change switch is arranged to connect in the aerial circuit the proper coupling and loading coil inductance for any one of the five predetermined wave lengths when the aerial employed is of the standard period. Should the aerial be of shorter period, an additional coil can be added to the aerial circuit by shifting the primary switch blade from "normal" position to No. 2 notch. With the blade in No. 1 notch, two loading coils are added. This will permit tuning of the set for use with an aerial of approximately 300 meters. When the set is required to operate with aerials of more than 450 meters, the primary switch blade is shifted from the "normal" to No. 4 notch, which decreases the inductance in circuit with the aerial coil. A shift from "normal" to No. 5 notch effects a decrease by two loading coils.

Referring again to the mounting of the loading coils, the arrangement described has important practical advantages as above pointed out. But this entails having two supporting plates 74 and 75, between coils 38 and 39; and, similarly, two plates 76 and 30, between coils 40 and 41; the coils of each pair being thus mounted back to back. Each coil is mounted on its supporting plate by means of studs 133, which extend through the supporting plate and through spacers 134, desirably of insulating material, notched as shown to receive the ribbon conductor, each stud being hooked at 135 to engage the conductor, and being threaded at the other end for engagement by a securing nut 136, which is received in a countersink on the back of the supporting plate. The backs of the plates in the two pairs, 74—75 and 76—30, are necessarily rather close together in this design of apparatus, and hence special precautions are taken to prevent current jumping across from the mounting studs of one coil to the studs or even to the turns of the adjacent coil. This is likely to occur only, in the outer portions of coils whose peripheries are not directly connected, where the potential differences are often very high. Jumping across between the mounting studs is guarded against by staggering the studs in some way. As here shown, the studs of each coil are arranged in six radial sets or series, and the sets are staggered in the successive plates so that the stud sets of adjacent coils do not come opposite. But there is nevertheless the tendency in the outer coil turns for current to jump from the studs of one coil to the turns of the next adjacent coil; and since the dielectric constant of any solid insulating material is higher than that of air, this tendency would be furthered by the presence of the supporting plate interposed between such studs and coil turns. Accordingly, apertures 137, circular in the present example, are formed in circular series in each of the supporting plates 74, 75, 76 and 30 opposite the outer coil turns and between the radial

sets of studs. It is apparent therefore that in each pair of coils in question, the studs supporting the outer turns are separated from the outer turns of the next adjacent coil by an unobstructed air space. At the same time almost none of the strength and rigidity inherent in the use of solid supporting plates, so essential especially for apparatus intended for military purposes, is sacrificed.

A novel detail of considerable practical importance is the construction of the contact clips shown at 52 and 61 for adjustable connection of the primary and secondary contact studs to the transformer coils 35 and 36. As shown in Figs. 4, 21, 22 and 23, each contact clip is a laminated structure comprising three resilient metal strips 140, 141, and 142, which are secured together by rivets 143. The strip 140 is longitudinally slotted to form four fingers, of which the two outside fingers 144 extend beyond the two intermediate fingers 145, and are bent at their projecting ends, as shown. The strip 141 is slotted in such a way as to provide five fingers, of which the central finger 146 extends beyond the others and is bent similarly to fingers 144 but oppositely thereto. The two pairs of fingers 147 on either side of finger 146 are of substantially the same length as fingers 145, and like them are tapered or beveled at their free ends. The strip 142, lying between strips 140 and 141 is considerably shorter than the two outer strips and is not slotted. Viewing the contact clip from one edge, it will be seen that the double bends in the fingers 144 and 146 are such that said fingers appear to converge or intersect and then diverge again. The distance between the line of convergence and the free end of intermediate plate 142 is substantially equal to the width of the copper ribbon of which the pancake coils 35 and 36 are wound. The end of a lead 148 may be connected to the clip by means of a bifurcated socket 149 which slips over the opposite end of the clip between the rivets, at which point the clip may be notched as shown at 150. After inserting the end of the lead in the socket, both the socket and the lead may be firmly soldered to the clip to form an integral construction.

The manner of employing this type of clip is sufficiently obvious. By presenting the ends of the fingers 144 and 146 to the edge of the ribbon conductor, so that the divergent ends straddle the conductor edge, and then pushing the clip firmly into place, the fingers 144 and 146 first are moved apart to guide the conductor edge accurately between the coöperating sets of contact fingers 145 and 147, and then spring toward each other again to engage the farther edge of the ribbon conductor. In the meantime the first mentioned edge of the conductor has come into abutment with the end of the intermediate strip 142. It is evident that this arrangement provides a clip which can be accurately and rapidly applied to the conductor, and which embraces the same firmly enough to adequately guard against accidental displacement.

The electrical relation between the various parts of the apparatus has been indicated in the foregoing detailed description, and said relation is also clearly indicated diagrammatically in Fig. 24 where the parts previously referred to in this description bear the same reference characters, so far as necessary. For the sake of clearness the mechanical connection between the switch arms 44, 45 and 46 is not shown in this diagram. A short-circuiting connection 151 between primary stud No. 5 of the wave change mechanism and the pivoted end of switch blade 44, shunts all unused turns of the primary transformer coil. This provision is made to eliminate high potentials and consequent brushing of the primary circuit. In connection with the wave change mechanism as previously described, the diagrammatic showing of Fig. 24 indicates that operating the wave change shaft to increase or decrease the wave length, always increases or decreases all three of the variable inductance factors, namely, the primary inductance, coupling inductance, and loading inductance. This is not necessarily so, however, in the case of the coupling inductance. In tuning the circuits for the different wave lengths, it frequently happens that the adjustable taps on the secondary or coupling coil, have to be set in such manner that the coupling inductance both increases and decreases during a complete movement of the wave changer in either direction over the entire range of wave lengths. Of course the primary and secondary inductances, considered as entireties, always increase or decrease for increase or decrease in wave length. I have also found that by a suitable adjustment of the various parts and connections, the several tapping points on the secondary or coupling coil can be concentrated within a comparatively short length of the conductor composing said coil, in some instances on a single turn of said conductor. It is possible even to use but a single tapping point on the coupling coil, thus eliminating the secondary switch arm 45; but with such an arrangement the operator is required to adjust the coupling at the different wave lengths more than is necessary when several tapping points are used in the coupling coil.

The manner of operating the transmitter apparatus herein described is sufficiently obvious to those skilled in the art from the foregoing description, but will nevertheless

be briefly summarized. Assuming the set to be employed with a standard aerial, the operator first adjusts the apparatus for operation at five definite wave lengths which in practice may be 600, 825, 1200, 1500 and 2,000 meters. The proper positions of the adjustable contact clips 52 on the primary coil 35, corresponding to the selected wave lengths, may be closely approximated by reference to the scale appearing at the left of the sector opening in panel 30, as shown in Fig. 1. In order to effect the complete adjustment, it is necessary to tune the cooperating oscillation circuits for each of the five operating wave lengths. For instance, with the switch blade 44 set at "normal" in notch No. 3 of sector 130, the wave changer is moved if necessary to place switch blade 44 on primary contact stud 1. In this position of the wave changer, switch blades 45 and 46 will also contact with the No. 1 studs of their respective series. The general method of tuning the circuits for any given wave length is well understood by those skilled in the art and requires no detailed explanation here except as regards manipulation of the specific apparatus shown. In order to make the necessary adjustment of inductance in the aerial circuit for tuning at the first wave length, 600 meters, the operator pulls out the selector rod, turns the handle until the arrow 110 points to the numeral 1, indicating the first loading coil, and then releases the handle, said handle being thereupon coupled to the movable switch arm of loading coil No. 1 by operation of the selective latch mechanism hereinbefore described. The selector handle may then be rotated to increase or decrease the aerial inductance to the necessary extent. The coupling of the circuits may be adjusted by rotating the coupling handle 117 in either direction. The foregoing operations are repeated for all five wave lengths, the wave change device being of course operated to bring the switch blades 44, 45 and 46 into contact with the remaining studs of their respective series successively, and the aerial inductance being adjusted in each case by selecting and shifting the rotary contact arm on the particular loading coil corresponding to the wave length for which adjustment is being made. When the transmitter has been tuned, and coupled in the above manner at all five wave lengths, the operator may shift from one wave length to any other of the selected wave lengths by moving the wave change switch to the primary stud corresponding to the wave length desired. This is not only an advantage in the general operation of the set, but may be used in secret transmission by coding the wave lengths according to a prearranged schedule.

Where it is necessary to adjust the transmitter for operation with aerials of either longer or shorter periods than the standard aerial above assumed, the procedure for tuning and coupling is in general the same. However, if the aerial is of longer period than the standard, and assuming it is desired to tune the circuit for a wave length of 1200 meters, that is, with the wave change switch blade 44 on primary stud No. 3, the operator shifts said switch blade to No. 4 notch, but leaves the blade in contact with No. 3 stud. This decreases the aerial inductance by one loading coil, and the selector rod must be moved to adjust No. 2 loading coil. If resonance is not obtained within the range of this coil, the switch blade is shifted to No. 5 notch while remaining on No. 3 stud. This decreases the aerial inductance by two loading coils, and the selector rod is then moved to adjust No. 1 coil. Similarly, if the aerial is of shorter period than standard, switch blade 44 is set in No. 2 notch, and then in No. 1 notch if necessary, resulting in the addition of one and two loading coils, respectively, and the selector rod being moved to connect with No. 4 or No. 5 loading coil, as the case may be, to effect final adjustment of the aerial inductance.

From the foregoing, it will be seen that the additional adjustments necessitated by operation with aerials which are not standard, amount mechanically to changing the normal relation between the simultaneously movable primary and secondary switch blades or arms. This necessarily reduces to some extent the range of wave lengths over which the wave change mechanism can be operated, as compared to its operation with a standard antenna, but otherwise the general principle of simultaneous variation of electrical values in the coöperating circuits simultaneously is not altered.

It is obvious that the set can be adjusted for operations of wave lengths intermediate those arbitrarily selected above for purposes of illustration. The clips on the primary transformer coil can be shifted if necessary to give the exact number of primary turns required for each desired wave length, and the circuits can then be tuned for each such selected wave length in the manner already described. This having been done, the wave change mechanism will then connect in the circuits the proper primary turns, coupling inductance, and aerial inductance necessary for the indicated primary wave lengths.

By careful adjustment of the transmitter for the different wave lengths selected, only very slight adjustment of the coupling, if any, is necessary in shifting from one wave length to another.

Certain features shown and disclosed, but not claimed, in the present application are

disclosed and claimed in a copending divisional application, Serial No. 341,990, filed December 2, 1919.

What I claim is:

1. Radio transmitter apparatus comprising in combination, substantially parallel main front and rear plates or panels arranged a suitable distance apart and connected together to form a unitary supporting structure, a pancake inductance coil stationarily mounted on the front panel and constituting a transformer primary, a plate intermediate said main plates and parallel therewith and mounted for movement forwardly and rearwardly, a second pancake inductance coil constituting the transformer secondary mounted on said intermediate plate in inductive relation to the primary coil and substantially coaxial therewith, means for moving said intermediate plate to vary the transformer coupling distance, a plurality of substantially parallel pancake coils electrically connected in series and constituting loading inductance, said coils being mounted upon said supporting structure in parallel spaced arrangement on an axis substantially parallel to that of the transformer coils, a set of contacts electrically connected to adjustable taps on said primary transformer coil, a second set of contacts electrically connected to adjustable taps on said secondary transformer coil, a third set of contacts each electrically connected to an adjustable tap on one of said loading coils, a separate movable switch member for each set of contacts, the secondary coil switch member and the loading coil switch member being electrically connected in series, and means mechanically connecting the three switch members and operable to move them simultaneously whereby the inductance values of the primary, secondary and loading coils in circuit may be varied in a predetermined manner.

2. Radio transmitter apparatus comprising, in combination, a rigid supporting structure, a flat coil stationarily mounted thereon and constituting the primary of a transformer, a second flat coil constituting the transformer secondary mounted on said structure substantially coaxially with the primary coil and movable toward and away from the same, a plurality of flat loading coils electrically connected in series supported by said structure on a common axis substantially parallel to the transformer axis but to one side thereof, a set of contacts electrically connected to adjustable taps on said primary coil, a second set of contacts electrically connected to adjustable taps on said secondary coil, both sets of contacts being arranged in planes substantially parallel to the transformer coils, a third set of contacts arranged in a plane transverse to said transformer and loading coils, each of said third set being electrically connected to a variable point on one of said loading coils, a switch coöperating with each said set of contacts, the switches for the second and third sets being connected in series, and means connecting all said switches mechanically and operable to move them in unison.

3. Radio transmitter apparatus comprising, in combination, an oscillation transformer, a plurality of loading coils in circuit with the transformer secondary, three sets of contacts of which two sets are connected, respectively, to adjustable tapping points on the transformer primary and secondary and are in parallel arrangement, while the third set is connected to adjustable tapping points on the loading coils, and has its constituent contacts lying in a plane transverse to the first two sets, separate switches coöperating respectively, with the three sets of contacts, and means mechanically connecting said switches and operable to move them all in unison.

4. Radio transmitter apparatus comprising, in combination with a supporting structure, a transformer having flat primary and secondary coils coaxially mounted on said structure, the secondary coil being movable with respect to the primary coil to vary the coupling distance, a set of contacts mounted near one end of said structure, adjacent the transformer primary and connected to tapping points on said primary, a second set of contacts mounted near the opposite end of said structure and connected to tapping points on the transformer secondary, switches respectively coöperating with said sets of contacts, an operating shaft mechanically connecting said switches and rotatable to move them both, a plurality of flat loading coils in circuit with the transformer secondary and mounted on said structure at one side of the transformer, a third set of contacts, each contact mounted adjacent a loading coil and electrically connected thereto, said third set of contacts extending intermediate the ends of said structure, a switch coöperating therewith, and means connecting said switch with said operating shaft.

5. Radio transmitter apparatus comprising, in combination, a variable transformer consisting of relatively movable primary and secondary coils, loading inductance coils in circuit with the transformer secondary and located in substantially non-inductive relation to said transformer, a substantially unitary structure supporting the foregoing parts, control means for varying the coupling distance between the transformer primary and secondary, switches movable to vary the inductance of the transformer primary and secondary, respectively, a third switch movable to vary the number

of loading coils in circuit, operating means common to all three said switches for moving them in unison to effect predetermined changes in wave lengths, an adjustable tapping contact on each loading coil for determining the effective inductance value thereof, and selecting mechanism operable to adjust such tapping contact on any of the loading coils at will, said control means, operating means, and selecting mechanism all being manually operable from one end of said supporting structure.

6. Radio transmitter apparatus comprising, in combination, a substantially unitary supporting structure, transformer primary and secondary coils mounted thereon, a coupling changer operable to alter the coupling distance between said coils, a variometer in circuit with said primary coil, loading inductance in circuit with said secondary coil, interconnected switches operable to simultaneously vary the effective inductance values of the transformer and loading inductance in a predetermined manner, means for fine adjustment of said loading inductance, and separate manual controls, all grouped in closely adjacent positions on said structure, for operating said coupling changer, said variometer, said interconnected switches, and said means for fine adjustment, substantially as and for the purposes set forth.

7. Radio signaling apparatus comprising, in combination, coöperating oscillatory circuits each including reactance-varying means, a member associated with each said means and movable to actuate the same, and controlling means connecting said members and operable to move them simultaneously and thereby to change the wave length in both circuits according to a predetermined reactance relation between said circuits, the connection of said controlling means to said members being adjustable to alter said predetermined reactance relation and to permit simultaneous operation of said members by said controlling means according to the altered relation.

8. Radio signaling apparatus comprising, in combination, coöperating oscillatory circuits, one of which is arranged for connection to an antenna, wave change means common to said circuits and operable to vary the electrical values thereof simultaneously according to a predetermined relation between said values in the circuits, said relation being based on operation of the apparatus with a given antenna as a standard, said wave change means being adjustable to establish another relation between said values, based on operation of the apparatus with an antenna differing substantially from the standard, and being operable to vary the electrical values in the circuits simultaneously according to the changed relation.

9. Radio signaling apparatus comprising, in combination, coöperating oscillatory circuits each including a variable inductance, sets of contacts connected to tapping points on the respective inductances, a switch device for each said set movable to engage the contacts thereof and thereby to vary the proportion of the corresponding inductance in circuit, and means mechanically connecting said switch devices and operable to move them simultaneously to engage functionally related contacts, one in each set, in a series of successive pairs, the arrangement being adjustable to permit another series of pairs of functionally related contacts, differing from the first mentioned pairs, to be engaged by said switch devices when the latter are simultaneously moved by such mechanical connecting means.

10. Radio transmitter apparatus comprising, in combination, an oscillation transformer, loading inductance in circuit with said transformer, a set of contacts connected to tapping points on said transformer, another set of contacts connected to tapping points on said loading inductance, switch members respectively coöperating with said sets of contacts and connected for simultaneous movement to engage functionally related contacts, one in each set, in successive pairs, and means whereby the relation of said switch members may be altered in such manner that said switch members are connected for simultaneous movement to engage functionally related contacts, one in each set, in pairs differing from the first mentioned pairs.

11. Radio signaling apparatus comprising, in combination, coöperating oscillatory circuits each including an inductance, a switch device in each circuit movable to include in that circuit different proportions of the corresponding inductance, controlling means connecting said switch devices and operable to move them to increase or diminish simultaneously the effective inductance of each circuit in definite steps, said switch devices being adjustable with respect to each other to permit altering the relation between the proportions of the respective inductances included in circuit at different steps.

12. Radio signaling apparatus comprising in combination, primary and secondary windings of an oscillation transformer, loading inductance in series with said secondary winding, switch devices operable respectively to vary the effective inductance values of said primary and secondary windings and said loading inductance, and operating means connecting said switch devices for simultaneous movement to change the operating wave length in a predetermined manner, the connection of said switch devices to said operating means being adjust-

able to establish different desired relations between the inductances of the primary and secondary circuits, said operating means being still operable to move said switch devices simultaneously after such adjustment.

13. Radio signaling apparatus comprising in combination, primary and secondary windings of an oscillation transformer, a set of contacts connected to adjustable tapping points on the transformer primary, and corresponding in number to the different operating wave lengths desired, a second set of contacts, equal in number to the first set, connected to adjustable tapping points on the transformer secondary, an equal number of flat loading coils in relatively close parallel arrangement and electrically connected in series, a third set of contacts, one for each loading coil, each respectively connected to a movable contact arm on its corresponding loading coil, three separate switch devices coöperating, respectively, with the three sets of contacts, the switches for the second and third sets being electrically connected in series, an operating rod arranged to move all three switches simultaneously to engage successive groups of contacts, one in each set, and means whereby the relative positions of said switch devices may be varied to alter the number of loading coils in the secondary circuit for given positions of the primary switch device.

14. Radio signaling apparatus comprising, in combination, coöperating oscillatory circuits each including variable inductance, a switch device for each said inductance movable to vary the effective proportion thereof in circuit, an operating number mechanically connecting said switch devices for simultaneous movement in a series of steps to include different proportions of both inductances in the respective circuits, the proportion of primary and secondary inductance in circuit at each step having a predetermined functional relation, and one of said switch devices being adjustable with respect to said operating member in such manner as to permit changing said predemined relation.

15. Radio signaling apparatus comprising, in combination, operatively associated primary and secondary inductances and circuit connections therefor, switch members respectively movable to alter by definite steps the effective proportions of said inductances in circuit, an operating rod to which one of said switch members has a relatively fixed connection, and means adjustable to connect the other switch member to said shaft in different positions relatively to the first switch member, whereby said switch members may be moved simultaneously in different relations.

16. Radio signaling apparatus comprising, in combination, a primary transformer coil, a secondary coupling coil movable with respect to the primary coil to vary the coupling distance, a stationary terminal whereby said coupling coil may be connected in a circuit, and a wiping brush connection between said coupling coil and said terminal.

17. Radio signaling apparatus comprising in combination, a primary transformer coil, a secondary coupling coil movable with respect to the primary coil to vary the coupling distance, a set of stationary contact studs connected by leads to tapping points on said primary coil, a second set of stationary contact studs, stationary conducting rods connected thereto, and brushes mounted to move with said coupling coil and bearing, respectively, on said rods, said brushes being connected by leads to tapping points on said coupling coil.

In testimony whereof I hereunto affix my signature.

FRITZ LOWENSTEIN.