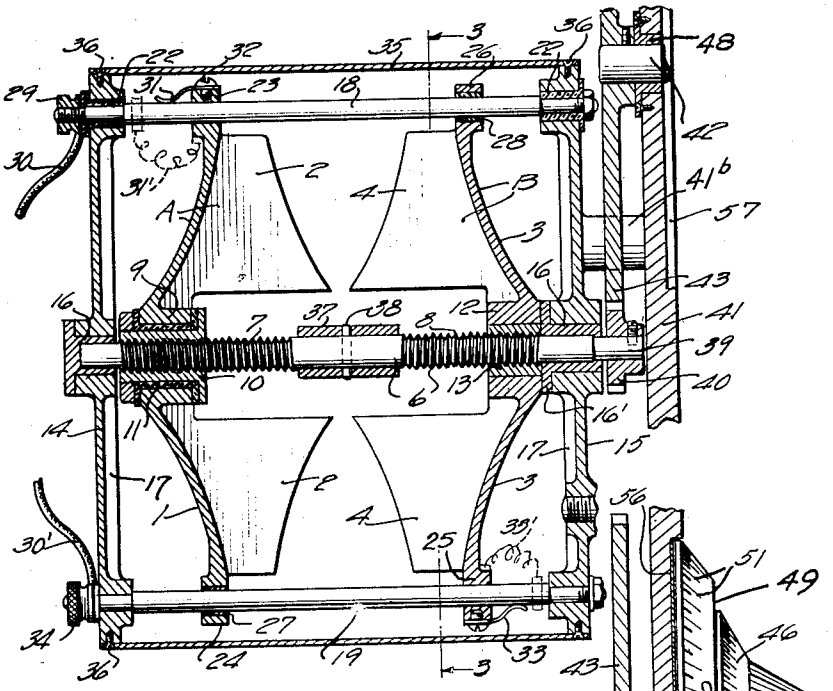
Dec. 3, 1929. A. A. THOMAS 1,737,741

ELECTRIC CONDENSER

Filed Aug. 24, 1925 4 Sheets-Sheet 1

FIG. 1.



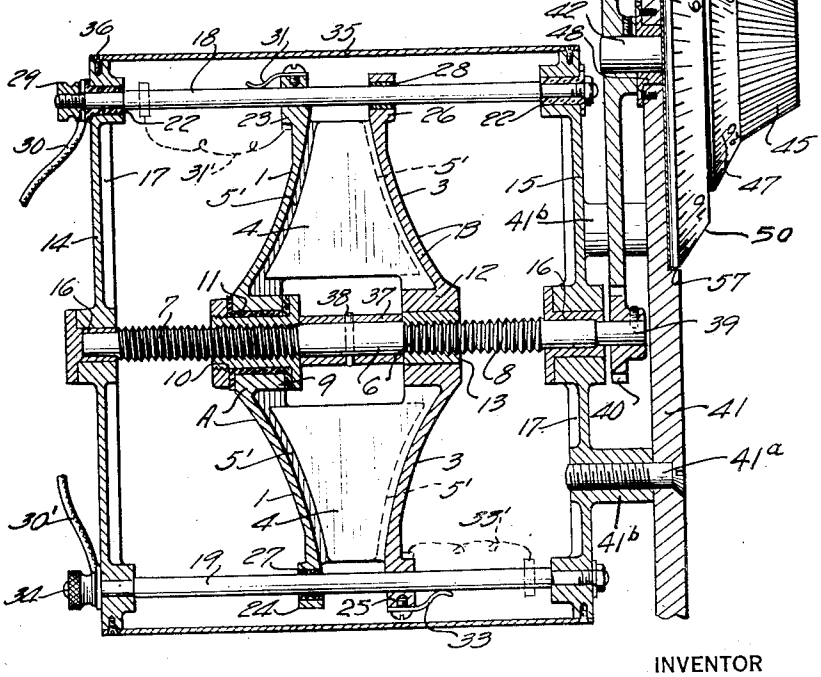


FIG. 2.

INVENTOR

Adolph A. Thomas

Dec. 3, 1929. A. A. THOMAS 1,737,741

ELECTRIC CONDENSER

Filed Aug. 24, 1925 4 Sheets-Sheet 2

FIG. 3.

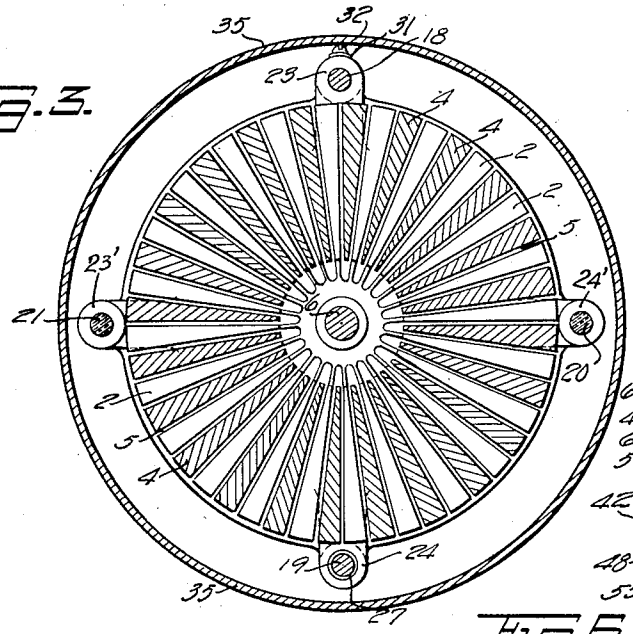
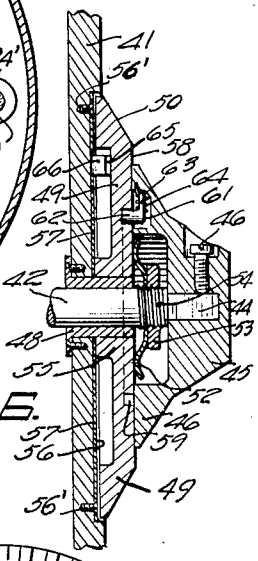


FIG. 6.



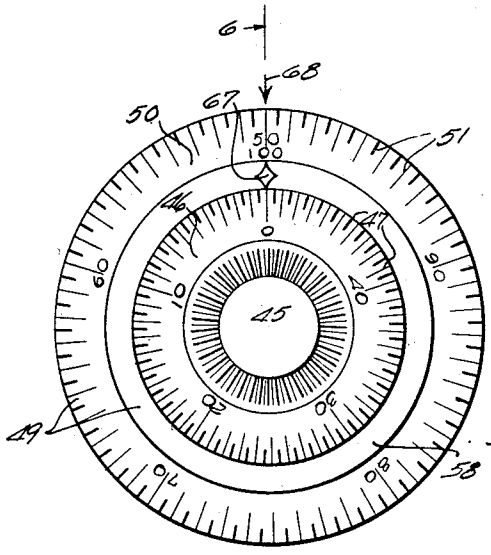


FIG. 4.

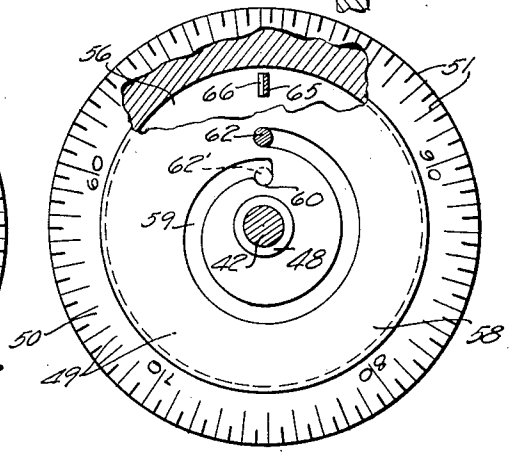


FIG. 5.

INVENTOR

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Dec. 3, 1929. A. A. THOMAS 1,737,741

ELECTRIC CONDENSER

Filed Aug. 24, 1925 4 Sheets-Sheet 3

Fig. 7.

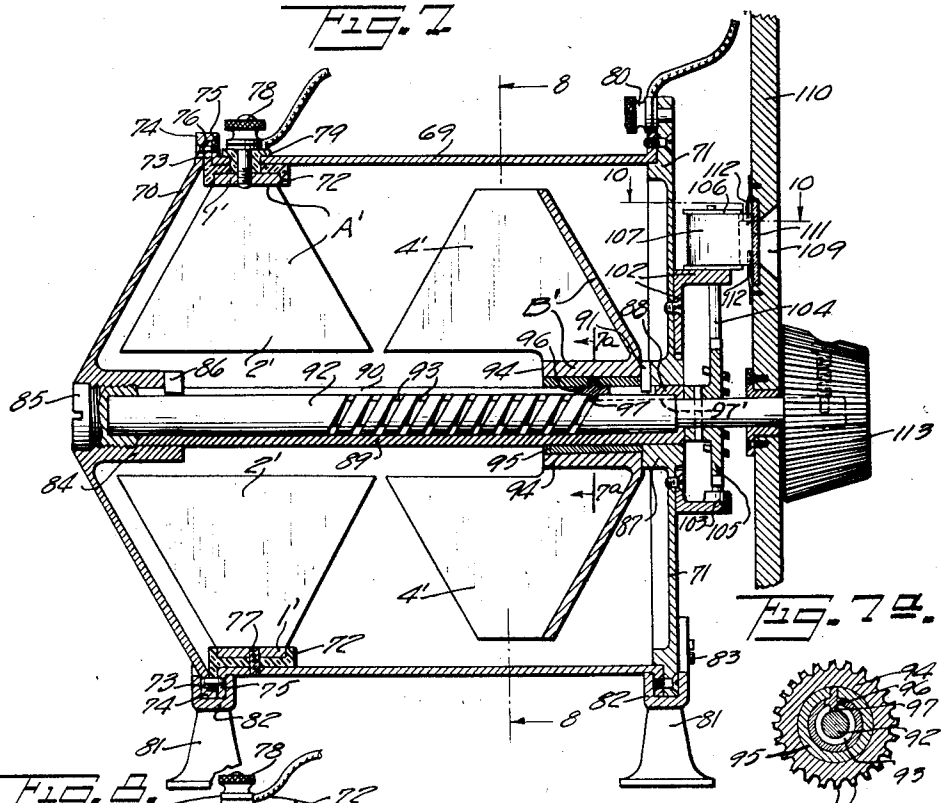


Fig. 7a.

Fig. 8.

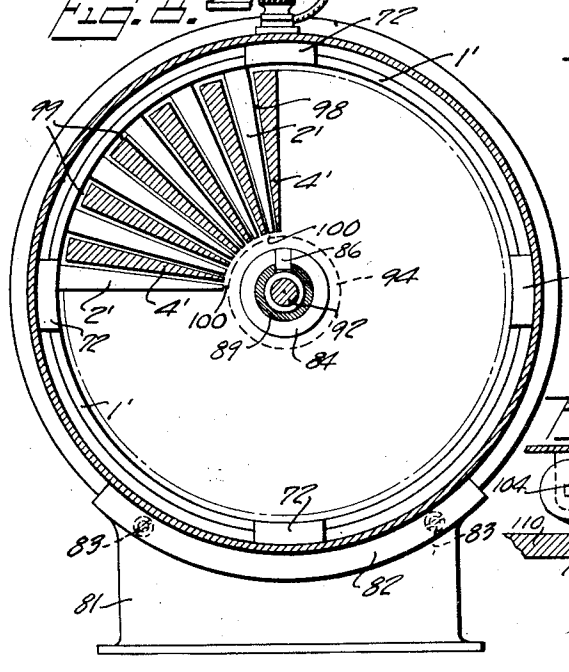


Fig. 9.

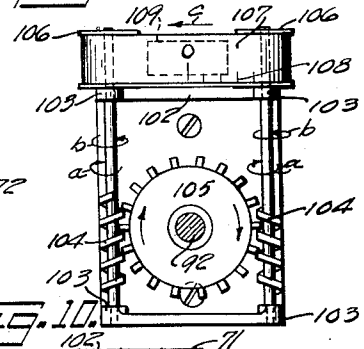
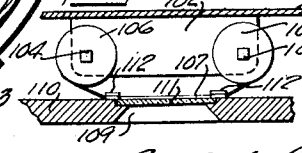


Fig. 10.



INVENTOR

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Dec. 3, 1929. A. A. THOMAS 1,737,741

ELECTRIC CONDENSER

Filed Aug. 24, 1925 4 Sheets-Sheet 4

FIG. 11.

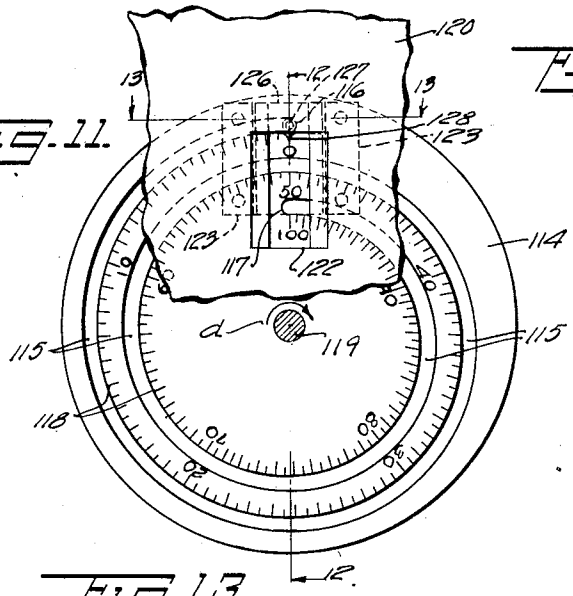


FIG. 12.

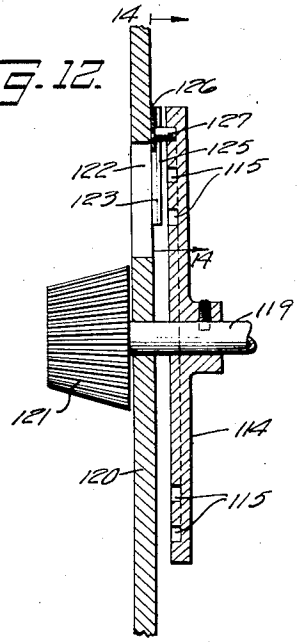


FIG. 13.

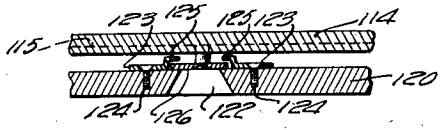


FIG. 14.

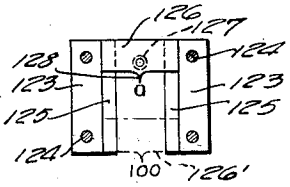
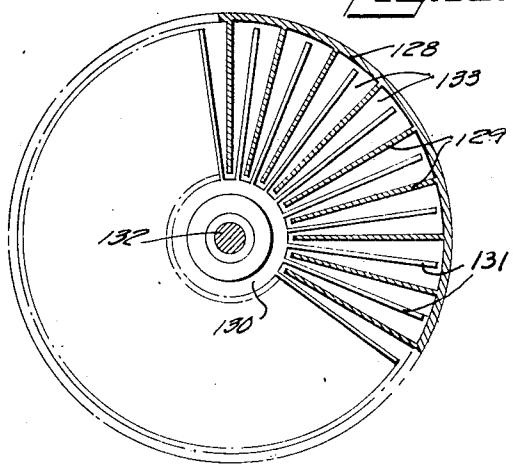


FIG. 15.



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Patented Dec. 3, 1929 1,737,741

UNITED STATES PATENT OFFICE

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ELECTRIC CONDENSER

Application filed August 24, 1925. Serial No. 51,915.

My invention relates to electric condensers, and its object is to provide various features of novelty in variable condensers for improving the construction and operation of such devices. As will appear later, my invention is particularly useful for tuning condensers in radio circuits, although not limited to that field.

In variable condensers heretofore constructed for use in radio sets, the fixed and movable plates are separate parts and have to be individually mounted and spaced in parallel relation on a shaft or other supporting member. Such construction requires time and care in the assembling and spacing of the plates, involving the use of many spacing washers of precise thickness. From the standpoint of operation, a construction like that is objectionable on account of the unavoidable contact resistance between the individual plates and the spacing washers. Then, too, in prior condensers having rotary plates, it is necessary to suspend these plates on one side of the shaft, thereby producing an unbalanced rotor. This unbalanced condition of the rotor requires considerable friction in the bearings in order to make it stay put, so that even slight wear in the bearings may cause the unbalanced weight of the plates to move the rotor shaft out of adjusted position. In some condensers it has been necessary to attach a counterbalancing weight to the rotor.

Another serious trouble experienced with tuning condensers of prior design is the difficulty of separating stations that operate on short wave-lengths and therefore high frequencies. Such stations are crowded at the low end of the dial reading, where they are sometimes so close together that it is impossible to tune out undesired stations. This difficulty is increasing as more transmitting stations are assigned on short wave-lengths. On an ordinary condenser dial, there are 100 divisions over an arc of 180 degrees. That is to say, a half turn of the knob varies the capacity between minimum and maximum. In straight capacity condensers, this requires crowding many wave-lengths (at the present time about fifty or more) into the first fifteen points of the dial, which means several stations to a point. In the so-called "straight-line wave-length" condensers, this crowding of stations at the lower end of the dial is not quite so bad, but still troublesome enough. With more and more stations being assigned on lower wave-lengths, the problem of tuning in on low dial settings grows more acute. Even in those condensers where the dial markings are set over a complete circle, the slightly wider spacing between division lines does not appreciably help at the crowded end of the dial. In an effort to remedy this condition, manufacturers have recently begun to put out condensers in which the plates are so shaped that the dial readings are calibrated in frequencies. While this type of "straight-line frequency" condenser has a dial over which allotted wave lengths are distributed more or less uniformly, it is still necessary to crowd all the frequencies over an arc of 180 degrees. As more stations come into operation, this short dial range increases the difficulty of separating the various frequencies.

Further, in prior constructions of tuning condensers, where the capacity range is covered by a half turn or a whole turn of the rotor shaft, it is necessary to have a vernier attachment for the final delicate adjustment of the plates.

It is the purpose of my invention to overcome the foregoing and other objections and disadvantages in prior condensers by means of an improved construction in which, among other novel features, the plates are cast integral with a base or support, and the scale or dial readings cover more than one complete turn of the indicator shaft. In my new condenser the fixed as well as the movable plates project radially from a base member in an axial direction. The base member and plates are cast in one piece, thereby obviating the necessity of spacing washers and the individual assembling of plates as heretofore. This radial arrangement of the plates in a single casting produces a simple compact structure, rigid and balanced, with the plates accurately and permanently spaced. When the plates are interleaved, the two parts of the condenser are separated by a plurality of

radial air-gaps, which may be made of substantially uniform width.

The basic idea of a condenser with radial plates may be mechanically embodied in various ways. For instance, these plates may radiate inwardly from a supporting outer ring, or they may extend outwardly from a small inner ring. In another form of structure, which I shall describe later in detail, the radial plates project axially from a disk-like support. In these and other modifications of my invention, the ring and plates are preferably cast in one piece. One of the plate-carrying parts is the stator, and the other part is slidable toward and from the stator, or both parts may be slidably mounted. The radial plates on the two parts are so arranged that they are closely interleaved without touching when the parts are brought together. The two sets of plates are insulated from each other with a minimum amount of dielectric material, so as to reduce losses to the lowest point.

Another novel feature of my invention consists in an improved indicator mechanism in which the readings cover more than one revolution of the indicating member or the rotor shaft. In prior condenser dials or scales, the reading cannot possibly cover more than one full turn of the indicator knob, irrespective of whether the dial itself revolves or whether a pointer moves over a fixed scale. Consequently, in those devices, the maximum scale length available is confined to a fixed limit, within which the dial markings must be placed, and this necessitates narrow division spaces, with the difficulties already explained. Now, in my new indicator mechanism, the scale length may be extended to any practical limit, requiring several turns of the indicator member to encompass the entire scale. This enables me to calibrate the scale with more and wider divisions than heretofore possible, so that stations on short wave-lengths are separated farther on the scale and are therefore more easily tuned in and out than is possible in prior condensers.

The indicating device of my invention may be embodied in a number of practical forms. For example, I may use a compound dial consisting of two or more dials having readings which are automatically brought into successive operation as the indicator knob is turned. Or, there may be a single dial provided with a scale extending more than 360 degrees around the dial, combined with an automatically adjustable member for visually indicating the correct reading in any position of the dial. In another embodiment of my invention, I provide a scale on a shifting band which is operated from the shaft that controls the position of the movable plates. I mention these various forms here as merely illustrative of the principle of my invention, and not in a restrictive sense.

A further advantage of my invention lies in the fact that no separate vernier attachment is necessary to secure a delicate adjustment of the movable plates, as in radio tuning. The connections between the tuning knob at the panel and the shaft which controls the movable plates are such that several turns of the knob are required to bring the plates into or out of full mesh with each other. This means slow steady movement and therefore correspondingly delicate adjustments of the movable plates. The tuning knob also controls the indicating mechanism, which is properly calibrated in reference to variations of capacity.

The foregoing and other advantages of my invention will become clear from a detailed description of several embodiments shown in the accompanying drawings by way of example. In these drawings,

Fig. 1 is a longitudinal cross-section through a variable condenser constructed in accordance with my invention, the two sets of plates being shown in separated position and certain parts being broken away for lack of space;

Fig. 2 is a view similar to Fig. 1, showing the condenser plates in full interleaved position and also showing the operative connections between the dial shaft and the condenser shaft;

Fig. 3 represents a transverse cross-section on line 3—3 of Fig. 1, showing the radial arrangement of the condenser plates;

Fig. 4 is a face view of the indicating mechanism attached to the condenser shown in Figs. 1 and 2;

Fig. 5 is a view similar to Fig. 4, except that the outer dial is removed to show the operative connection for the inner dial, and a section of the inner dial is broken away to show certain details;

Fig. 6 is a cross-section on line 6—6 of Fig. 4;

Fig. 7 shows a longitudinal cross-section through another form of condenser embodying my invention;

Fig. 7^a is a fragmentary detail view in section on line 7^a—7^a of Fig. 7;

Fig. 8 is a transverse cross-section of line 8—8 of Fig. 7;

Fig. 9 is a face view of the indicating mechanism attached to the condenser of Fig. 7;

Fig. 10 shows a top view of the indicating mechanism as taken approximately on the broken line 10—10 of Fig. 7;

Fig. 11 illustrates a modified form of dial mechanism that rotates through 720 degrees to indicate the full range of movement of the condenser plates, the supporting panel in this view being broken away for clearness;

Fig. 12 is a cross-section on line 12—12 of Fig. 11;

Fig. 13 is a cross-section on line 13—13 of Fig. 11;

Fig. 14 shows a face view of the shutter plate used in the construction of Figs. 11—13, this detached view being taken approximately on line 14—14 of Fig. 12; and

Fig. 15 illustrates more or less diagrammatically a condenser in which the radial plates are of substantially uniform thickness, as distinguished from the constructions in Figs. 3 and 8, where the plates are wedge-shaped to provide radial air-gaps of uniform width.

I will first describe the construction illustrated in Figs. 1 to 6. These figures, as in fact all the figures in the drawings, are not intended for shop drawings, and I have purposely shown the parts of heavier construction and more spread out than would be necessary in actual practice. I have done this to make the drawings as clear as possible.

Referring to Figs. 1 and 2, the parts indicated as a whole by A and B represent the two sets of conducting plates by which the capacity of the condenser is regulated as required. The part A consists of a base member 1 from which extend a plurality of radial plates 2. Similarly, the part B consists of a base member 3, provided with a series of radial plates 4 arranged to mesh or be interleaved with the radial plates 2 on part A. The base members 1 and 3 are here shown in the form of concave conical disks, from the inner faces of which project the radial plates in axial planes that, theoretically at least, pass through the center of the disks. The parts A and B with their respective plates are preferably cast each in a single piece of suitable metal, such as aluminum, alloys of aluminum, white metal, brass, and the like.

The radial arrangement of the plates 2 and 4 is clearly shown in Fig. 3, where the plates 2 of part A are shown in white outline, while the plates 4 of part B are shown in cross-section. In the preferred embodiment of my invention, the plates 2 and 4 are wedge-shaped in thickness, so that the intermeshing plates are separated by a plurality of radial air-gaps 5 of substantially uniform width, which provides a more uniform distribution of the electrostatic field in and between the condenser plates. Also, as seen in Fig. 2, when the plates are fully interleaved, the free edges of one set of plates are separated from the base member of the other set of plates by marginal air-gaps 5′. This increases the capacity of the condenser.

The parts A and B are relatively adjustable either by making one set of plates fixed and the other movable, or by so mounting them that both sets are slidable toward and from each other. In Figs 1 and 2, I have shown the latter construction by way of illustration. The parts A and B are slidably mounted on a rotary shaft 6, which has two screw-threaded sections 7 and 8. The base member 1 of part A is formed with a hub 9 on which is fixed a screw-threaded bushing 10 for engaging the screw-threads 7 of the operating shaft 6. The bushing 10 is fully insulated from the metallic part A by a flanged insulating sleeve 11, which may be constructed of any hard insulating material suitable for the purpose. The base member 3 of part B is formed with a hub 12 in which is fixed a screw-threaded bushing 13 arranged to engage the screw-threads 8 of shaft 6. The bushings 10 and 13 are made of hard bearing material capable of maintaining a firm, yet easily adjustable, engagement with the operating shaft. The screw-threads 7 and 8 run in opposite directions, so that when the shaft 6 is rotated the parts A and B are simultaneously shifted toward or from each other, depending upon the direction in which the shaft is turned.

The shaft 6 is mounted for rotary movement in end plates 14 and 15, which are preferably in the form of thin metal disks provided with suitable bearings 16 for receiving the ends of the shaft. The disks 14 and 15, which may be provided with radial strengthening ribs 17, are rigidly connected and held spaced apart in proper relation by a plurality of rods 18, 19, 20 and 21. For illustration I have shown four of these rods arranged diametrically opposite, but it is obvious that any suitable number and arrangement of rods may be employed. The rods 18 and 19 are of good conducting material or are otherwise insulated. As shown in Figs. 1 and 2, the metal rod 18 is completely insulated from the metallic body of the condenser by insulating bushings 22, but the metal rod 19 is grounded. The base member 1 of the condenser part A is provided with a pair of perforated lugs or ears 23 and 24, and the part B has similar lugs 25 and 26. In assembling the condenser, the insulated conducting rod 18 passes through the lugs 23 and 26, and the grounded rod 19 passes through the lugs 24 and 25. The lug 24 of part A has an insulating bushing 27, and the lug 26 of part B also has an insulating bushing 28. It will be seen from this that the plates 2 of part A are thoroughly insulated from the metallic body of the condenser by means of a very small amount of insulating material, whereby dielectric losses are reduced. The plates 4 are electrically connected to the condenser mass, and thus constitute the grounded part of the condenser.

The insulated rod 18, from which the grounded part B is insulated and to which the part A is electrically connected, is provided at its outer end with a suitable binding post or terminal 29 for connecting the lead 30. To insure a firm electrical contact between the rod 18 and the movable part A, a

suitable contact spring or collector brush 31 may be attached to the lug 23 as by a screw 32, or otherwise. The free end of spring 31 may be curved to conform to the shape of rod 18, so as to provide increased contact area. In like manner, the lug 25 of the grounded part B may have a spring contact 33 engaging the grounded rod 19. The outer end of rod 19 is provided with a binding post or terminal 34 for receiving the other lead 30′ of the circuit in which the condenser is supposed to be connected. In place of contact springs 31 and 33, I may use pigtail connections 31′ and 33′, which are flexible and avoid all frictional contacts between the fixed conducting rods 18 and 19 and the movable parts A and B, respectively. The spacing rods 20 and 21 may either be used as additional guides for the slidable plates, or they may simply be used as connecting rods for the end plates 14 and 15. If the rods 20 and 21 pass through guide lugs 23′ and 24′ in the parts A and B, as shown in Fig. 3, they should be insulated similarly to the rods 18 and 19; or, they could be made of insulating material, as indicated. On the other hand, if the rods 20 and 21 do not engage the parts A and B, no insulation for them is necessary.

To the end plates 14 and 15 is attached a cylindrical cover or casing 35, as by screws 36 or otherwise, to form a dust-proof housing for the condenser plates. The cover 35 may be of thin light metal, or of suitable insulating material.

The rotary shaft 6 has fixed thereon a sleeve 37 by means of a pin 38 or otherwise. This sleeve acts as a stop for the slidable parts A and B when the plates 2 and 4 are in full mesh, as shown in Fig. 2. That is to say, when the bushing 10 of part A and the bushing 13 of part B strike the sleeve 37, as in Fig. 2, further rotation of the shaft in the same direction is positively prevented, so that there is no danger of either set of plates striking the base member of the other set. When the plates 2 and 4 are completely separated as shown in Fig. 1, the hub 12 of part B strikes the flange 16′ of bearing 16, and this locks the shaft against further movement to separate the two sets of plates.

In the position of the parts A and B as illustrated in Fig. 1, the capacity of the condenser is a minimum. When the shaft 6 is turned, let us say, for example, clock-wise, the parts A and B with their radial plates 2 and 4 gradually come together, until the plates are fully interleaved or in mesh, as shown in Fig. 2. The capacity of the condenser is now at its maximum. Reverse rotation of the shaft causes the condenser plates to separate. During the rotation of shaft 6 the parts A and B are guided in their sliding movements back and forth by the guide rods 18 and 19, or by all four rods shown in Fig. 3, if desired. The connections between parts A and B and the guide rods are such that the condenser plates slide easily into and out of mesh and yet are positively held against any radial or turning movement.

The construction and positioning of parts A and B on shaft 6 are such that the two sets of plates, when interleaved, are separated by a plurality of radial air-gaps which are made as narrow and as uniform as mechanical conditions permit. When the plates overlap in full, they present large surface areas in close electrostatic relation. As a result, we have a maximum condenser capacity in a construction of minimum cubic space. This is readily seen from Fig. 3, which shows forty-eight plates in the most compact arrangement possible. In Figs. 1 and 2, the plates 2 and 4 are so shaped as to increase in width from the outer to the inner end. The side edges of the plates are curved to provide the desired rate of variation of capacity as the plates are moved into and out of mesh with each other. Of course, the number, size and shape of the plates may be varied in accordance with the particular design of condenser under construction or to meet special requirements that may arise in any given instance.

In the broad aspect of my invention, any suitable connections may be used for operating the controlling shaft 6. I prefer, however, at least at the present time, to operate the shaft by means of a knob or similar member that requires more than one complete revolution to move the condenser plates fully into and out of mesh. This permits delicate variations of capacity without the need of a separate vernier attachment.

In the illustrative embodiment of Figs. 1 and 2, the shaft 6 has an extension 39 on which is fixed a pinion 40. On the panel 41, on which the instrument is rigidly supported by any suitable means, as by screws 41ª passing through lugs 41ᵇ on end disk 15, is journaled a stub-shaft 42 carrying a gear wheel 43 arranged to mesh with pinion 40. The gear wheel 43 is rigidly mounted on the shaft 42 and always rotates therewith. On the outer end 44 of stub-shaft 42 is fixed a knob 45. In Fig. 6, the end of shaft 42 is shown square, so that the knob 45 is readily locked to the shaft when inserted thereon, and a set screw 46 prevents withdrawal of the knob from the shaft. Any other suitable means may be used for operatively connecting the knob 45 with the gear shaft 42. The knob 45, which may be moulded from suitable insulating material, such as bakelite, hard rubber, glass, and the like, is provided with a beveled annular extension or flange 46, on which is marked a suitable indicating scale 47. On the bushing 48, which forms the bearing for the gear shaft 42, is mounted a disk 49. The outer annular section of disk 49 is beveled, as indicated at 50, and is provided with a scale 51 which forms a continuation of the scale 47 on disk

46. For the sake of brevity and distinction, I will refer to the members 46 and 49 as the inner and the outer dial respectively.

The outer dial 49 is not connected with the stub-shaft 42, but is free to turn thereon when actuated by the inner dial 46, as I am about to explain in detail. The mounting of disk 49 is such that it is frictionally held in operated position until positively actuated by the disk 46. In Fig. 6, this frictional holding means for the disk 49 is shown in the form of a spring washer 52, which is held against the outer face of the disk by a nut 53 adjustably mounted on the screw-threads 54 of shaft 42. The disk 49 is provided with a hub 55, which bears frictionally against a thin metal plate 56 suitably secured in the recess 57 of the supporting panel 41, as by means of screws 56′, or otherwise.

As best shown in Fig. 5, the outer face 58 of the outer dial 49 is provided with a spiral groove 59 which terminates in a recess 60. The inner dial 46 has on its outer face a recess 61, in which is mounted a lug or pin 62 arranged to extend into the spiral groove 59. The pin 62 is formed with an extension 63 around which is coiled a spring 64 that normally tends to push the pin 62 against the bottom of groove 59. When the disks 46 and 49 are in normal position, as shown in Figs. 4 and 5, the pin 62 is at the beginning of the spiral groove 59. The outer dial 49 is provided at the back with a rearwardly extending lug 65 arranged to engage a fixed stop 66 on the plate 56 when the dial is in normal position. The stop 66 may be formed by simply upsetting the metal of plate 56.

The operation of the dial mechanism above described is as follows:

When the dials 46 and 49 are in normal or zero position, as shown in Fig. 4, the condenser plates 2 and 4 are in the position illustrated in Fig. 1. When it is desired to increase the capacity of the condenser by moving the plates toward each other, the knob 45 is turned clockwise. This rotates the inner or smaller dial 46 in the same direction and the inner scale 47 moves clockwise in reference to a fixed indicating mark 67 placed on the outer face 58 of the disk 49. As the knob 45 is being turned to the right, the pin 62 follows in the spiral groove 59 of the outer dial 49, which remains in normal position due to the frictional washer 52. When the knob completes one revolution from normal position, the pin 62 snaps into the recess 60 of the spiral groove 59, as indicated by the dotted circle 62′ in Fig. 5. It will be seen from this figure that the initial and final positions of the pin 62 are exactly 360 degrees apart. Now, if we continue to rotate the knob 45 clockwise, after making one full turn thereof (that is, after the pin 62 has snapped into the recess 60 of spiral groove 59), the pin 62 locks the outer and inner dials together and the outer dial is carried around with the inner dial. In other words, after the inner dial has made one complete revolution, any further movement thereof in the same direction is accompanied by a like movement of the outer dial 49, the two dials rotating as a single member.

By referring to Fig. 4, it will be seen that the outer scale 51 begins where the inner scale leaves off after the inner dial 46 makes one full turn. I have arbitrarily divided the readings on the two dials into a scale of 100, with 50 divisions on each dial. In doing this I have followed the conventional practice in dividing readings on condenser dials into a scale of 100. However, while the scale in prior condensers is distributed over an arc of 180 degrees and sometimes over 360 degrees, the 100 divisions in the scale of my new indicating mechanism are spread over two complete circles. This allows for greater separation of the indicating marks and thereby produces a scale of corresponding greater fineness than is possible in prior condenser readings.

The outer scale 51 does not come into operation until the knob 45 has been given a full turn, when the condenser plates 2 and 4 will be in a position midway of the two extreme positions shown in Figs. 1 and 2. When a dial reading beyond the 50 mark is required and the knob 45 is turned beyond one revolution, then the outer scale 51 automatically comes into play and rotates with respect to a fixed indicating mark 68. This mark may simply be a colored arrow on the panel in the position indicated in Fig. 4. After the outer dial 49 has been turned one complete revolution in a clockwise direction from its normal position, the lug 65 strikes the fixed stop 66 and further forward movement of the dials is arrested. This occurs when the condenser plates 2 and 4 are in full mesh, as shown in Fig. 2.

In the foregoing description of the automatic coupling of the two dials 46 and 49 and their forward movement as a single member after the knob 45 has made one complete turn, we have not taken into account the possibility of the knob being reversed after the two dials have become coupled. For instance, let us say that the operator has turned the knob until the scale reading "70" is below the fixed pointer 68, and he now finds that he must decrease the capacity of the condenser by turning the knob counterclockwise. The backward turning of knob 45 has no effect on the coupling of the two disks, as long as the pin 62 is seated in recess 60. The two latter parts are so designed that, when the knob 45 is turned counterclockwise, the pin 62 remains in recess 60 and holds the two disks locked together for backward movement as a single member. Now, assuming that the knob 45 has been

turned backward until the outer dial 49 is again in normal position, the outer dial is held positively locked by the stops 65 and 66, but continued backward rotation of the inner dial 46 to normal position is permitted by the pin 62 being forced out of the recess 60. It must be understood that after the outer dial 49 is held locked in normal position against rearward movement, a slight pressure applied to the knob 45 for backward turning forces the pin 62 out of the recess 60. This pressure need not be much more than that required for the normal rotation of the knob and is easily regulated by the depth and shape of recess 60 and by the shape of pin 62. The deeper this pin projects into the recess, the more pressure will be required to force it out of the recess, and vice versa. The pressure of spring 64 on the pin 62 need play only a small part in determining the degree of resistance offered by the pin 62 in being forced out of recess 60, because the primary purpose of this small spring is to push the pin into the recess. This might be done by gravity alone, but it is safer to rely on a positive actuating means like a small spring.

Although I have included only two dials in the indicating mechanism above described, it is obvious that the basic idea of this part of my invention may be mechanically embodied by the use of more than two dials arranged to be automatically and successively brought into and out of operative connection. For practical purposes, however, at least in the operation of radio sets used at the present time, two dials will be found sufficient. This means that by giving the knob 45 two complete turns, the capacity of the condenser is varied from a minimum to a maximum, and vice versa. The ratio between the gear 43 and the pinion 40 is such that two revolutions of the stub-shaft 42 (or two full turns of knob 45) rotate the operating shaft 6 sufficiently to slide the condenser plates from one extreme position to the other. While this may seem like a reversal of the operation of the so-called vernier attachments heretofore employed, in that the knob 45 is given two turns to produce a greater number of turns of shaft 6, it must be remembered that the screw connections between the main shaft 6 and the condenser plates 2 and 4 do more than compensate for the increased gear rate between the shafts 42 and 6. As the shaft 6 is rotated, the screws 7 and 8 produce a very delicate adjustment of the slidable parts A and B, and this adjustment may be made as fine as a micrometer movement, if desired. Hence, in the connections between the indicator shaft 42 and the main driving shaft 6, I secure a vernier adjustment of the condenser plates without any separate vernier attachment. It is hardly necessary to add that the particular connections between the knob 45 and the parts A and B above described are to be considered as one of many constructions adapted to carry out the basic idea of my invention.

In the indicating mechanism of Figs. 1–6, it is evident that the arrangement of movable scales and fixed pointers can be reversed by substituting movable pointers and fixed scales. For instance, the inner scale 47 can be placed on the annular space 58 of disk 49, and the outer scale 51 would then be placed on the panel around the disk 49, while the disks 46 and 49 would simply have each a suitable indicating mark or pointer. Such an arrangement of movable scales and fixed pointers is within the scope of my invention.

Another embodiment of my invention is illustrated in Figs. 7 to 10, which I will now describe in detail. In this construction, there is a fixed part A′ and a slidable part B′. The part A′ consists of an outer ring or base member 1′ from which project inwardly a series of radial plates 2′. The slidable part B′ consists of a base member 3′ in the form of a cone-shaped disk from which extend radial plates 4′. Since the relative arrangement of the radial plates 2′ and 4′ is the same as that of the plates 2 and 4 of Figs. 1, 2 and 3, I need not repeat the detailed description of Fig. 3 in so far as it is applicable to Fig. 8. In order to avoid unnecessary repetition in the drawings, I have shown only a quarter segment of the radial plates 2′ and 4′ in Fig. 8, it being understood that the remaining plates are arranged as shown in Fig. 3. The parts A′ and B′, like the parts A and B of Figs. 1 and 2, are preferably each cast as a single piece, so that the plates 2′ and 4′ are accurately spaced and rigidly supported without the use of separate devices. The condenser plates are enclosed in a dust-proof housing formed by a cylindrical casing 69 and a pair of end plates 70 and 71. The housing parts may be made of thin light metal or of suitable insulating material as desired.

The fixed part A′ is rigidly secured to the inner wall of casing 69 by clips or channel pieces 72 made of suitable insulating material. These clips, of which four are shown in Fig. 8 by way of example, not only support the fixed part A′, but at the same time they insulate it from the metal body of the condenser structure. As seen in Fig. 7, the clips 72 fit firmly over the ring 1′ and thereby hold the same in rigid position. The clips 72 are each provided with an extension 73, and these extensions are arranged to be clamped between the flange 74 of end plate 70 and the annular shoulder 75 on casing 69. Screws 76 connect the flanges 73 and 75, and insulated screws 77 may be used for fastening the clips 72 directly to the casing. It

should be noticed that the part A′ is insulated from the metal casing 69 by a ring of air, except for the clips 72. In air condensers, it is desirable to have as little solid dielectric as possible.

A suitable binding post 78 is electrically connected with the ring 1′ of part A′ and is insulated from the metal casing 69 by an insulating bushing 79. If the casing 69 is made of insulating material, the binding post 78 may be directly mounted on the casing without the use of separate insulation. The other binding post 80 is grounded and may conveniently be mounted on the end plate 71, as shown in Fig. 7. The binding post 80 is thus electrically connected with the movable part B′, which is grounded to the condenser mass.

The housing formed by the parts 69, 70 and 71 is supported on a pair of cradles 81, which are provided with arc-shaped channels 82. The annular end flanges of the housing structure rest in the channels 82, and suitable fastening devices (such as screws 83) secure the housing to the cradles. If the condenser is to be directly supported from a vertical panel, the cradles 81 are not necessary.

The end plate 70 is formed with a hub 84 in which is mounted an adjustable bearing 85. In the inner end of hub 84 is fixed a key 86, which may be a flat piece of metal inserted in a slot in the hub. The end plate 71 is formed with a hub 87, in which is fitted a bearing 88. In the present instance, the bearing 88 forms one end of a sleeve 89, the other end of which is fixed into hub 84. The sleeve 89 is formed with a longitudinal slot 90 arranged to receive the key 86 in hub 84, so as to lock the sleeve positively against rotary movement. If desired, the hub 87 may be provided with a lug or key 91 arranged to fit tight into the slot 90 of the sleeve 89 as an additional means to prevent turning of the sleeve.

A rotary shaft 92 extends through the sleeve 89 and is journaled in the bearings 85 and 88. The shaft 92, which is so fitted in the sleeve that it turns easily therein, is provided with a spiral groove or worm 93. The part B′ is formed with a hub 94 in which is fixed a bushing 95 adapted to fit slidably on the fixed sleeve 89. The bushing 95 is provided with a key 96 which terminates in a pin 97. The key 96 is arranged to fit snugly but slidably into the longitudinal slot 90 of sleeve 89. The pin 97 extends into the spiral groove 93 of the operating shaft 92. An axial slot 97′ in shaft 92 permits insertion of the pin 97 into the operating groove 93.

It will be seen from the foregoing that when the shaft 92 is rotated in a clockwise direction (as viewed at the front end of the shaft), the plates 4′ slide along the sleeve 89 toward the fixed plates 2′. The key 96 in slot 90 of the sleeve allows the part B′ to slide back and forth on the sleeve and yet positively locks this part against any rotary movement, so that the condenser plates 2′ and 4′ are always maintained in correct radial relation to each other. The rate of travel of plates 4′ on sleeve 89 for any given turning movement of shaft 92 depends upon the pitch of the worm 93. This movement may be made so delicate as to permit a micrometer adjustment of the condenser plates.

In the particular example illustrated in Fig. 7, it takes about eleven turns of shaft 92 to move the plates 4′ into and out of full mesh with the fixed plates 2′. When the plates 2′ and 4′ are fully interleaved, the parts A′ and B′ are separated not only by the radial air-gaps 98 between the adjacent sides of the plates (see Fig. 8), but also by circumferential air-gaps 99 and 100, which are formed between the free edges of the plates and the adjacent surface of the supporting ring or base member of parts A and B. This may be clearly seen from Fig. 8, where the outer circumferential air-gaps 99 are formed between the outer ends of plates 4′ and the inner surface of ring 1′, while the inner circumferential air-gaps 100 are formed between the inner ends of plates 2′ and the adjacent surface of the hub 94 on part B′. In other words, when the two sets of radial plates fully overlap, the insulated part A′ and the grounded part B′ are separated by a thin and substantially uniform air-gap of zigzag shape. This provides a maximum amount of condenser surface between the opposed metal parts A′ and B′ on which electrostatic charges are impressed.

On the front face of disk 71 is mounted a bracket 102, which is provided with bearings 103 for supporting a pair of rotary worm shafts or screw rods 104. On shaft 92 is fixed a worm gear 105 arranged to engage the worm shafts 104 for simultaneously rotating them in the same direction. That is to say, referring to Fig. 9, when the gear wheel 105 is turned clockwise the shafts 104 are simultaneously turned toward the left, as indicated by arrows *a*. When the gear wheel 105 is rotated in the reverse direction, the shafts 104 are both turned in the direction indicated by arrow *b* in Fig. 9. The rate of rotation of the shafts 104 in relation to the turning movement of the gear wheel 105 depends upon the pitch of the worms on those shafts.

On the upper ends of shafts 104 are fixed two small drums or spools 106 which carry a tape or ribbon 107 provided with a suitable scale 108. A simple way of mounting the spools 106 on the shafts 104 so that they will also turn with the shafts, is to make the ends of the shafts of square or other non-circular shape. Since the spools 106 always turn together at the same speed in one direction or the other, the scale ribbon 107 will unwind from one spool and simultaneously wind up the same amount on the other spool,

so that there is always a taut stretch of tape between the two spools. The scale tape 107 is seen through an opening 109 in the panel 110. At the inner end of the sight opening 109 may be fixed a piece of glass or other transparent member 111. In order to keep the ribbon 107 close to the glass 111, I provide a suitable guide 112 through which the ribbon passes.

On the outer end of the operating shaft 92 is fixed a knob 113 for rotating the shaft and simultaneously operating the indicating mechanism. When the knob 113 is turned clockwise, the plates 4′ are moved toward the fixed plates 2′, and at the same time the indicating ribbon 107 is shifted from right to left, as indicated by arrow *c* in Fig. 9. The markings on the scale are so arranged as to indicate in some appropriate manner the extent to which the condenser plates overlap. As previously stated, it has been the custom of manufacturers to divide condenser scales arbitrarily into 100 divisions, and the same practice may be followed in marking the scale 108. Since it requires several turns of the tuning knob 113 to vary the capacity of the condenser from minimum to maximum and vice versa, the scale 108 is spread out over a considerably greater length than is possible in prior constructions where the scales cannot extend beyond a maximum of 360 degrees on the tuning dial. Consequently, the lengthened scale 108 avoids crowding of short-wave stations at the low readings and enables the operator to note thereon such delicate adjustments of the condenser plates that undesired stations are easily tuned out.

In Figs. 11 to 14, I have illustrated a third form of indicating mechanism, in which the scale is arranged on a single dial over a length represented by 720 degrees, or two full turns of the knob. This is accomplished as follows:

A disk or dial 114 is formed on its front face with a spiral groove 115, which begins at 116 and ends at 117, these two points being 720 degrees of rotation apart. Along the spiral groove 115 is marked a spiral scale 118, which is arbitrarily divided into 100 points. The disk 114 is fixed on a shaft 119, which may be considered the equivalent of shaft 42 in Fig. 2, or shaft 92 in Fig. 7, or any other suitable operating shaft. The shaft 119 extends through a panel 120 and is operated by means of a knob 121. The panel 120 has a window or sight opening 122. Back of this window are mounted two oppositely arranged guides 123, which are secured in properly spaced relation on the back of the panel by screws 124, or otherwise. The guide pieces 123 are formed with parallel offset flanges 125 between which slides a shutter 126 carrying a pin 127. This pin projects rearwardly into the spiral groove 115. The shutter 126 is at its lower edge formed with a pointed projection 128, which is arranged centrally of the scale window 122. The projection 128 acts as an indicating pointer and may be appropriately colored for an easy reading of the scale.

When the dial 114 is in normal or zero position, as indicated in Fig. 11, the slidable shutter 126 is in its uppermost position and the pointer 128 indicates the zero mark on the scale. If we now imagine the knob 121 turned clockwise, as indicated by arrow *d* in Fig. 11, the shutter 126 will be automatically adjusted into a position where the pointer 128 always stands over the proper mark on the spiral scale 118. In other words, as the spiral edge of scale 118 turns in toward the center of the disk, the spiral groove 115 gradually moves the shutter 126 down and maintains it in proper alignment with the changing periphery of the scale. The lowermost position of shutter 126 is indicated at 126′ in Fig. 14, and that position is reached when the dial has received two complete turns in a forward direction. When the dial 114 is turned backward, the indicating shutter 126 is pushed up into the correct indicating position. It is obvious that the scale 118 can be extended over a greater length than two turns of the dial, and the construction of Fig. 11 is to be considered merely as an example of how this feature of my invention may be embodied in practical form.

Fig. 15 indicates diagrammatically a condenser construction in which the radial plates are of uniform thickness instead of being wedge-shaped as in Figs. 3 and 8. We have here a ring 128 provided with a plurality of radially arranged plates 129, which are preferably integral with the ring. The other cooperating condenser part consists of an annular member 130 having a plurality of outwardly extending radial plates 131 arranged to intermesh with the plates 129. The plates 131 may be cast integral with the supporting member 130, which is slidably mounted on a shaft 132. This slidable mounting of the plates 131 on shaft 132 may be in accordance with Fig. 1 or Fig. 7, or may follow any other practical construction. Since the plates 129 and 131 are of uniform thickness the radial air-gaps 133 are necessarily of non-uniform width, being widest at the outer end and narrowest at the inner end. Personally I prefer at this time a construction like that shown in Fig. 3 or Fig. 8, where the two sets of plates are separated by radial air-gaps of practically uniform width, so as to provide a more uniform distribution of the electrostatic field between the plates.

It will be clear from the foregoing detailed description of several illustrative embodiments of my invention that I have provided an electric condenser of compact construction and yet having a large surface area between the overlapping plates. The movable set of

radial plates being mechanically balanced, there is no undue strain on the operating shaft, as in prior condensers. By casting the condenser plates in one piece with the base from which they project, I not only insure a rigid mounting and uniform spacing of the plates, but greatly simplify the cost of manufacture and assembling of the condenser parts. In fact, the parts A and B in Figs. 1 and 2 may be cast from the same mould or substantially identical moulds, since the only difference between them is that the hub opening in part A is enlarged to accommodate the insulating sleeve 11. This opening may be enlarged after the part is cast. The arrangement of the individual plates is such that the space between them is easily accessible for machining or smoothing of the sides, cleaning, etc. Being cast in one piece, the plates have a low resistance, since they eliminate the contact resistance of spacing washers used in prior constructions. Also, in the condenser of my invention, the plates project in planes at right angles to the planes of the end disks between which the plates are mounted, and there is thus practically no electrostatic reaction between the charged plates and the end disks of the surrounding framework. This is of practical advantage in that it eliminates certain losses or leakage that would otherwise occur.

The precise shape and number of radial plates will naturally vary in different types and sizes of instruments constructed under my invention. In Fig. 1, the plates are curved at their edges, while in Fig. 7 they are shown with straight edges. It is not intended that the geometric forms of these plates as shown are mathematically correct for any given rate of capacity variation. The precise shape or outline of the plates for any particular instrument forms no part of my present invention and is left to the builder or designer. Certain mathematical formulæ have been developed for calculating the shape of condenser plates to produce a given rate of variation in capacity for a given movement of the plates into and out of mesh with each other. The rate of capacity variation, and therefore the shape of the condenser plates, depends upon whether the instrument is an ordinary straight capacity condenser, or a straight-line wave-length condenser, or of the straight-line frequency type.

Attention is called to the fact that in my new condenser I require a very small amount of insulating material and that is placed at points away from the surface of the plates where the electrostatic field exists. This reduces such condenser losses and disturbances as are due to the presence of a solid dielectric.

In the various forms of indicating mechanism herein set forth, the scales have been arbitrarily marked off into 100 divisions without taking into account the particular type of condenser or the rate of capacity variation produced by turning the dial through a given angle. The scales may be provided with any appropriate marks, such as the call letters of stations, the wave lengths or frequencies at which the stations operate, or any other desired notations.

By making the housing for the plates fluid-tight, it is possible to use other dielectric fluids than air, if such are found necessary for any special design of instrument.

It will be understood that all the various features of my invention need not be embodied in a single instrument, for it is possible to use some of these features without others. Also, in the broad aspect of my invention, certain features may be used in condensers of fixed capacity. The particular constructions herein described are not to be considered limitations or restrictions, but merely as examples of practical embodiments containing the principles of my invention. Changes and modifications will doubtless occur to those skilled in the art without departing from the scope of the invention as defined in the appended claims.

What I claim as my invention is:

1. A condenser comprising two parts, each part consisting of an annular base member provided with a set of radial plates cast integral with said member, and means for mounting said annular members coaxially so that the two sets of plates may be interleaved by axial movement.

2. A variable condenser comprising two parts, each part consisting of a base member provided with a set of radial plates, means for mounting said members coaxially so that the two sets of plates may be interleaved, and means for axially sliding one part with respect to the other.

3. In a variable condenser, two sets of radial plates coaxially mounted, a rotary shaft passing through the axial center of said plates, a connection between said shaft and one set of plates for axially shifting these plates with respect to the other set of plates, and means for turning said shaft in either direction.

4. In a variable condenser, two sets of radial plates coaxially mounted and arranged to overlap, a rotary shaft passing through the axial center of said plates, a connection between said shaft and each set of plates for simultaneously moving both sets of plates along said shaft in opposite directions, and means for turning said shaft in either direction to control the overlapping area of said plates.

5. In a variable condenser, two sets of radial plates coaxially mounted and arranged to overlap, a rotary shaft passing through the axial center of said plates and having a spiral groove, a member connected to one set of plates and extending into said groove, where-

by rotation of said shaft in either direction causes said last-named set of plates to slide along the shaft toward or away from the other set of plates, and means for holding said slidable set of plates against rotary movement.

6. In a variable condenser, two sets of radial plates coaxially mounted and arranged to overlap, a rotary shaft passing through the axial center of said plates and having two spiral grooves oppositely arranged, a member connected to each set of plates, said members extending into said spiral grooves, whereby rotation of said shaft in either direction causes said sets of plates to slide simultaneously along said shaft in opposite directions, and means for holding both sets of plates against rotary movement without interfering with their sliding movement along said shaft.

7. A condenser comprising two parts, each part consisting of a base member provided with a set of radial plates, the thickness of said plates decreasing toward the center from which the plates radiate, so that the two sets of plates when interleaved are separated by radial airgaps of substantially uniform width, and means for axially sliding one set of plates with respect to the other.

8. As a new article of manufacture, a one-piece condenser part consisting of a circular base having a plurality of integral radial plates extending in an axial direction from one side of said base.

9. A condenser comprising a pair of coaxially mounted annular members provided each with a plurality of integral radial plates, the plates of one member being arranged to overlap the plates of the other member, a rotary shaft passing centrally through said members, and means whereby the rotary movement of said shaft causes slidable axial movement of one of said members to vary the overlapping area of the plates.

10. A condenser comprising a pair of coaxially mounted annnular members provided each with a plurality of integral radial plates, the plates of one member being arranged to overlap the plates of the other member, a rotary shaft passing centrally through said members, and means whereby the rotary movement of said shaft causes said members to slide simultaneously along said shaft in opposite directions into and out of overlapping engagement.

11. In a variable condenser, two substantially identical parts comprising each an annular member provided with integral radial plates, a rotary shaft passing centrally through said annular members, which are so arranged on said shaft that their plates may be interleaved, and means for imparting axial sliding movement to one of said members by turning said shaft.

12. In a variable condenser, two substantially identical parts comprising each an annular member provided with integral radial plates, a rotary shaft passing centrally throuhg said annular members, which are so arranged on said shaft that their plates may be interleaved, and cooperating means on said shaft and said members for simultaneously sliding said members axially toward or from each other by rotary movement of said shaft in either direction.

13. In a condenser, two substantially identical metal parts cast from the same mould and consisting each of a single integral member provided with a plurality of radial plates, the plates of one casting being arranged to mesh with the plates of the other.

14. In a variable condenser, the combination of a metal framework comprising a pair of end members and a plurality of parallel rods for rigidly connecting said members, one of said rods being insulated from said members and a second rod being grounded to said members, said pair of rods also constituting guide rods and having each an end projecting beyond one of said end members, a binding post on the projecting end of each rod of said pair, a rotary shaft supported between said end members and being parallel with said rods, two sets of plates slidably mounted in said framework between said end members and having means for slidably engaging said pair of guide rods, said shaft passing centrally through both sets of plates, one set of plates being insulated from said shaft and said grounded rod but being electrically connected with said insulated rod, the other set of plates being insulated from said insulated rod and grounded to said end members, screw-threaded connections between said shaft and said sets of plates for simultaneously sliding said plates into and out of mesh, and means for operating said shaft.

15. A condenser having two substantially identical metal parts comprising each a one-piece casting provided with a plurality of integral radial plates, the plates of one casting being arranged to mesh with the plates of the other.

16. A condenser of substantially cylindrical shape comprising two parts practically identical, each part being cast in a single piece consisting of a circular base provided with a series of radial plates or ribs projecting axially from one side of said base, the two series of radial plates or ribs being interleaved by axial overlapping.

17. A condenser comprising two castings arranged in substantially axial alignment, each casting consisting of a base member provided with a series of integral radial plates or ribs, the two series of said radial plates or ribs being interleaved by axial overlapping.

18. As a new article of manufacture, a one-piece condenser casting consisting of a circular base provided with tapering plates circu-

larly arranged, said base having an opening at the center.

19. As a new article of manufacture, a condenser part consisting of a single casting composed of a circular base having integral plates, said base also having an opening at the center and a plurality of perforated lugs at the periphery.

20. A condenser comprising two castings arranged in substantially axial alignment, each casting consisting of a base provided with a series of integral tapering plates or ribs circularly arranged, the plates of one casting being adapted to mesh with the plates of the other.

21. A variable condenser comprising two castings arranged in substantially axial alignment, each casting consisting of a base provided with a series of integral tapering plates or ribs circularly arranged, a rotary shaft passing centrally through the bases of said castings, and means whereby rotation of said shaft causes one of said castings to slide relatively to the other for meshing said plates.

22. A variable condenser comprising a pair of similar parts composed each of a base having integral tapering plates, a rotary shaft passing centrally through said condenser parts, an insulating bushing carried by one of said condenser parts to insulate it from said shaft, the other part being grounded to the shaft, and operative connections whereby rotation of said shaft slides one of said condenser parts relatively to the other.

23. A variable condenser comprising a cylindrical casing having an end piece provided with a bearing and with means for mounting said piece on a panel, a pair of similar condenser parts composed each of a base having integral plates, a rotary shaft passing through said end bearing and through said condenser parts, an insulting bushing carried by one of said condenser parts to insulate it from said shaft, the other part being grounded to the shaft, and operative connections whereby rotation of said shaft slides one of said condenser parts relatively to the other.

24. In a variable condenser, the combination of a cylindrical casing closed by a pair of end pieces, a plurality of rods connecting said end pieces, means on one of said end pieces for securing the entire condenser to a supporting panel independently of said rods, two insulated condenser parts composed each of a base having integral plates, the base of one of said parts having projections through which said rods extend, a rotary shaft mounted in said end pieces and extending centrally through said condenser parts, and operative connections whereby rotation of said shaft causes one of said condenser parts to slide relatively to the other part.

25. In a variable condenser, the combination of a cylindrical casing closed by a pair of end pieces, a plurality of rods connecting said end pieces, two condenser parts composed each of a base having integral plates, the base of one of said parts having projections through which said rods extend, a rotary shaft mounted in said end pieces and extending centrally through said condenser parts, said shaft having a spiral groove, means carried by the other condenser part for engaging said spiral groove, means for holding said last-mentioned condenser part against rotation, whereby rotation of said shaft causes said movable condenser part to slide along the shaft relatively to the other part, and an insulating bushing carried by the slidable condenser part to insulate it from said shaft, the other condenser part being grounded to the shaft.

26. In a variable condenser, the combination of a cylindrical casing closed by a pair of end pieces, a plurality of rods connecting said end pieces, one of which has means for securing the entire condenser to a supporting panel, two insulated condenser parts composed each of a base having integral plates, the base of one of said parts having projections through which said rods extend, a rotary shaft mounted in said end pieces and extending centrally through said condenser parts, said shaft having a spiral groove, means carried by the other condenser part for engaging said spiral groove, and means for holding said last-mentioned condenser part against rotation, whereby rotation of said shaft causes said movable condenser part to slide along the shaft relatively to the other part.

27. In a variable condenser, the combination of a cylindrical casing closed by a pair of end pieces, a plurality of rods connecting said end pieces, one of which has one or more screw-threaded integral lugs for securing the entire condenser to a supporting panel, two condenser parts composed each of a base having integral plates, the base of one of said parts having projections through which said rods extend, a rotary shaft mounted in said end pieces and extending centrally through said condenser parts, said shaft having a spiral groove, means carried by the other condenser part for engaging said spiral groove, means for holding said last-mentioned condenser part against rotation, whereby rotation of said shaft causes said movable condenser part to slide along the shaft relatively to the other part, and an insulating bushing carried by one of the condenser parts to insulate it from said shaft, the other condenser part being grounded to the shaft.

28. An electric condenser construction comprising a panel, framework mounted on said panel and extending rearwardly therefrom, a condenser unit mounted on said framework and comprising a pair of elements arranged one in front of the other, one of said elements being a stator secured to said framework, the

other element being slidable transversely of the panel toward and from said stator element, said stator and slider elements comprising a pair of castings provided with integral members projecting axially and arranged to intermesh, a rotatable threaded shaft extending through said stator element and having a threaded engagement with said slidable element, and a rotatable device on the outside of said panel for operating said shaft in either direction.

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