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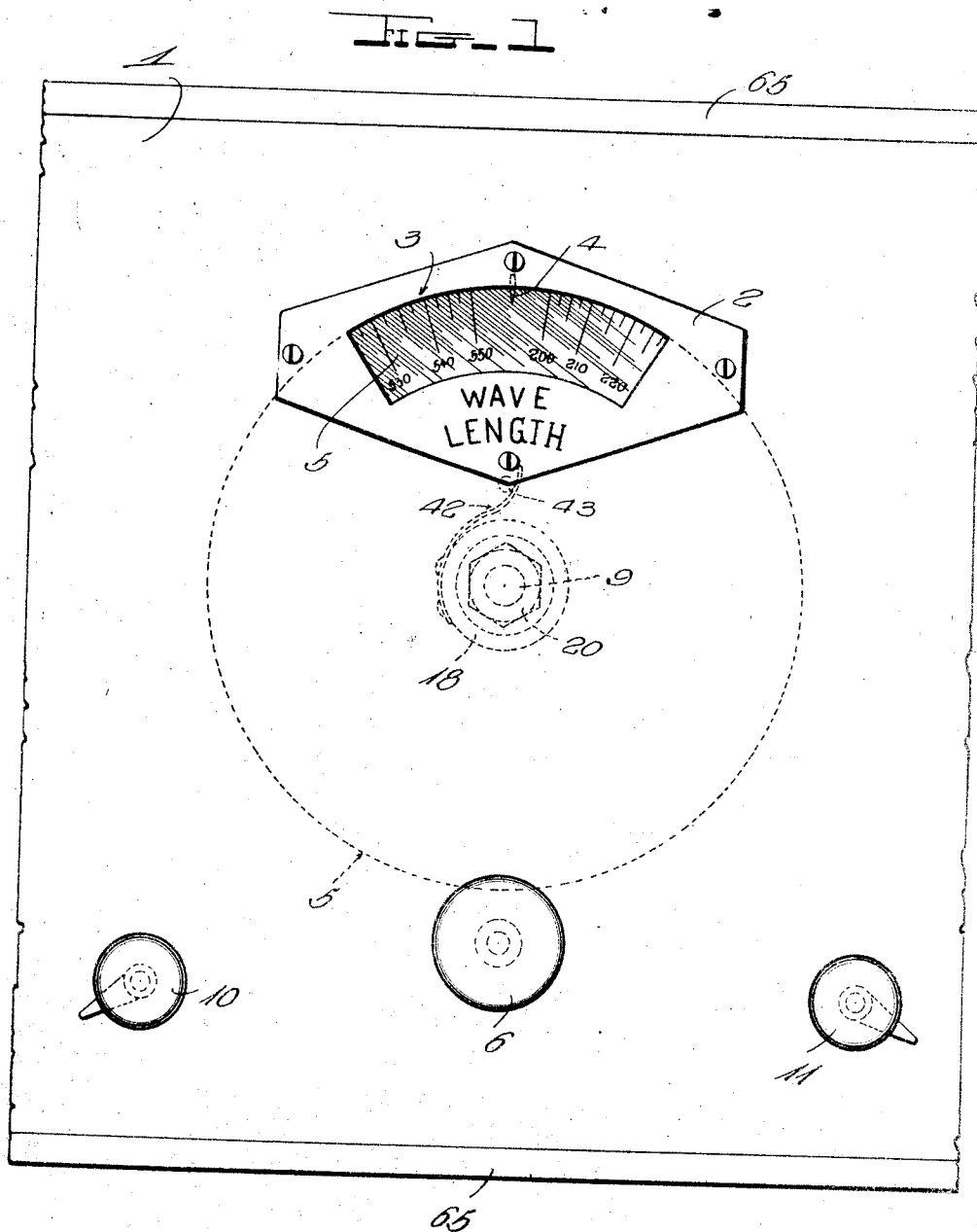
F. O. HARTMAN

1,614,428

VARIABLE CONDENSER

Filed Nov. 5, 1925

6 Sheets-Sheet 1



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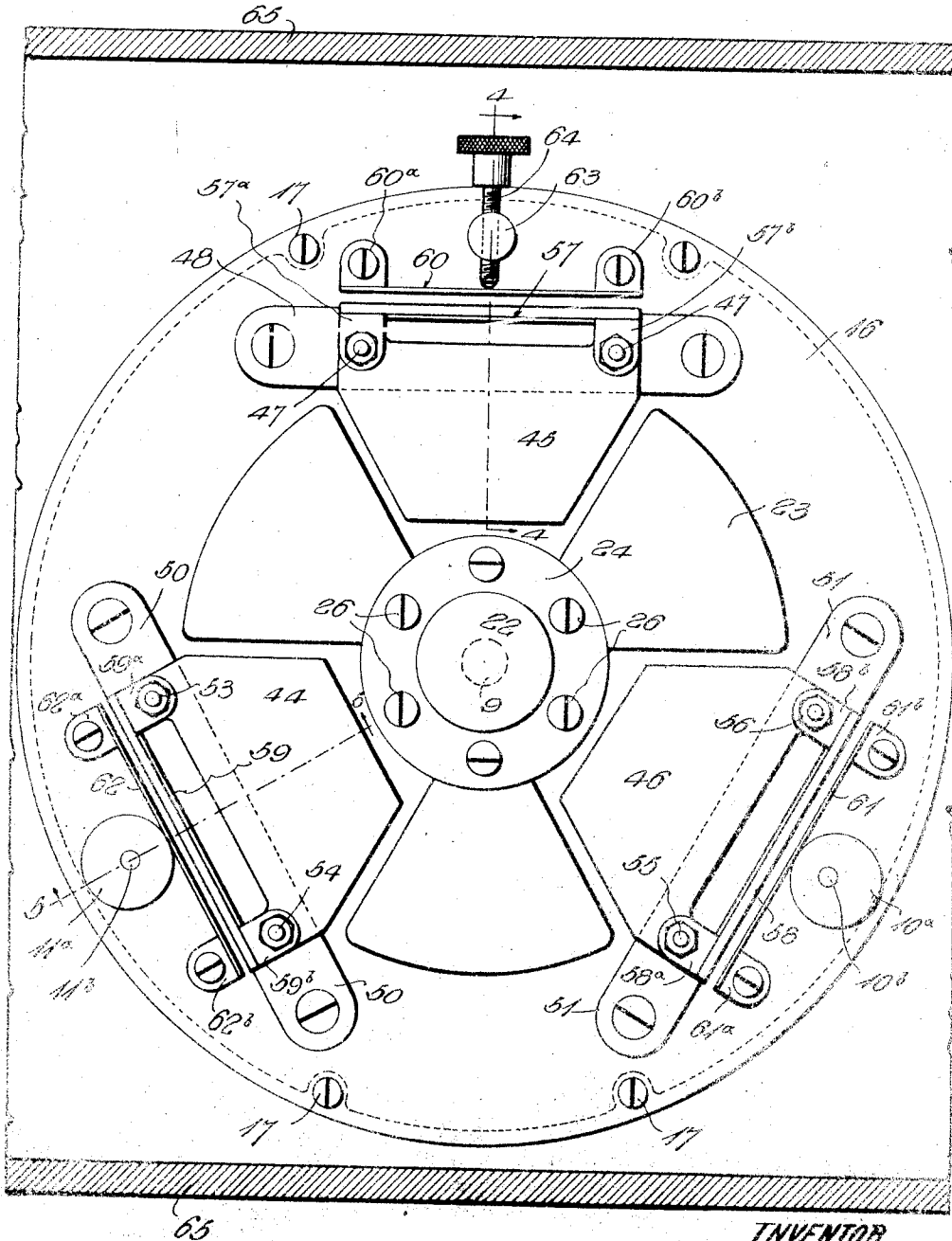
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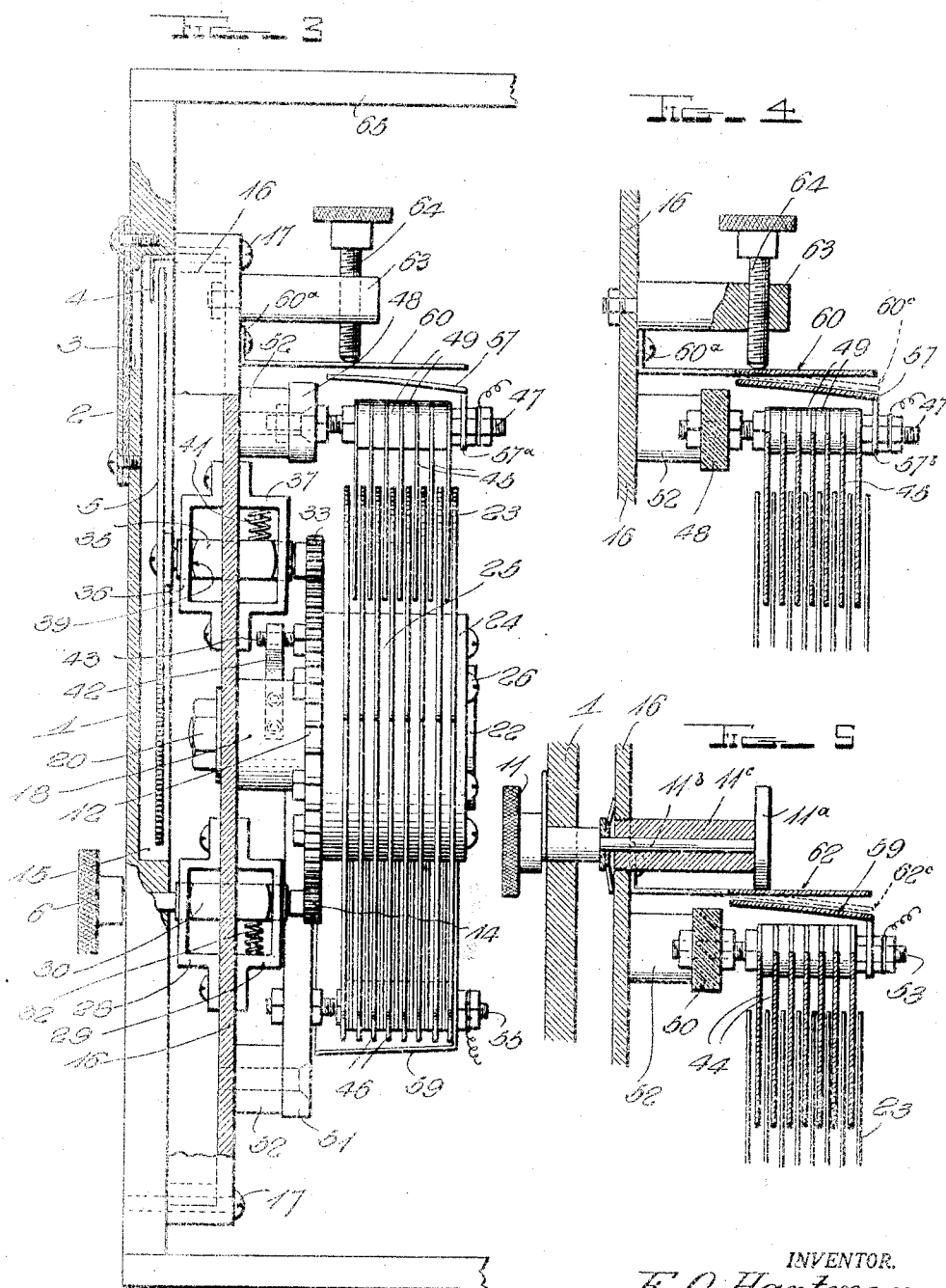
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6 Sheets-Sheet 5



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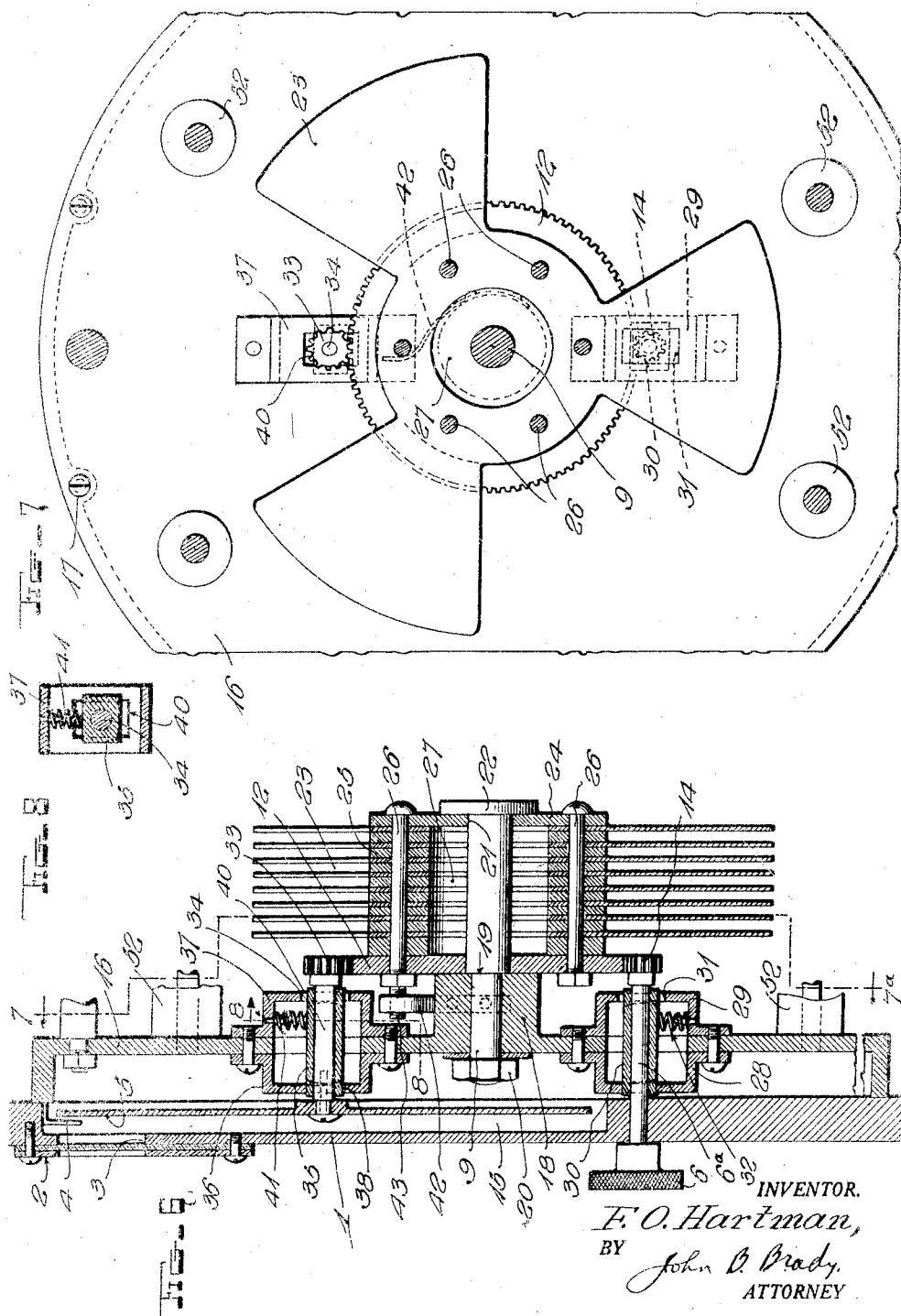
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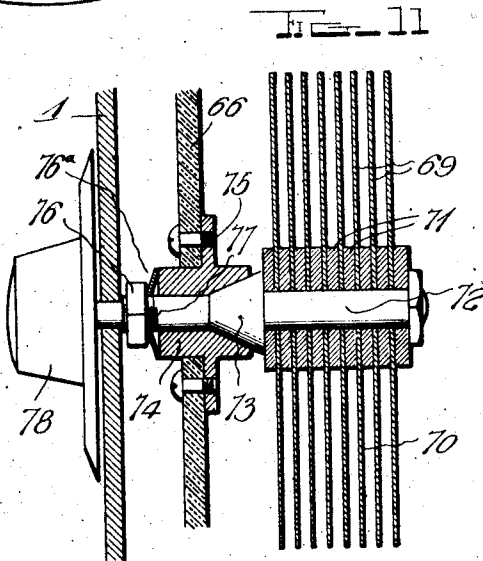
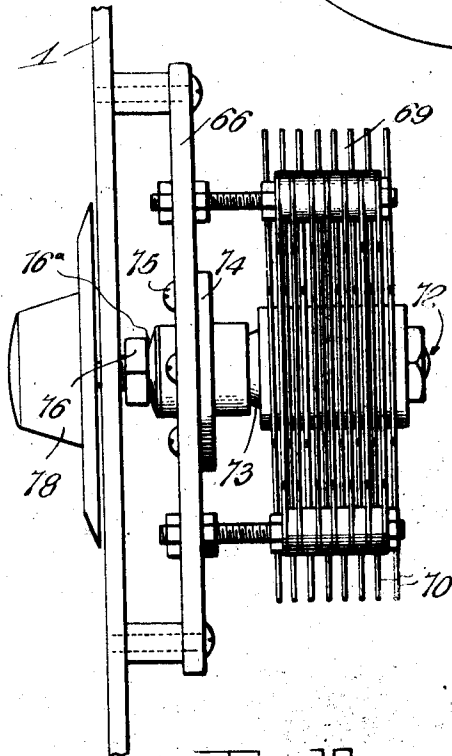
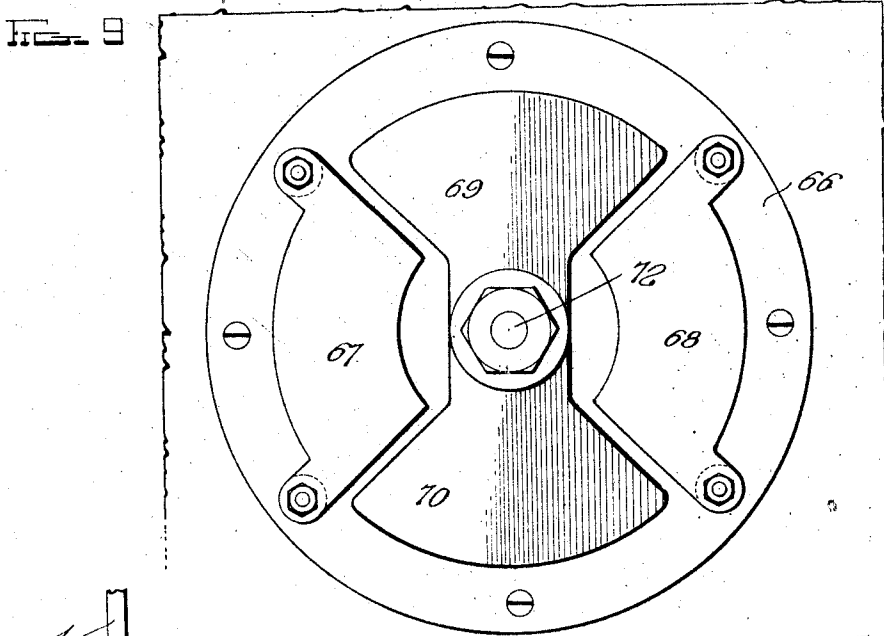
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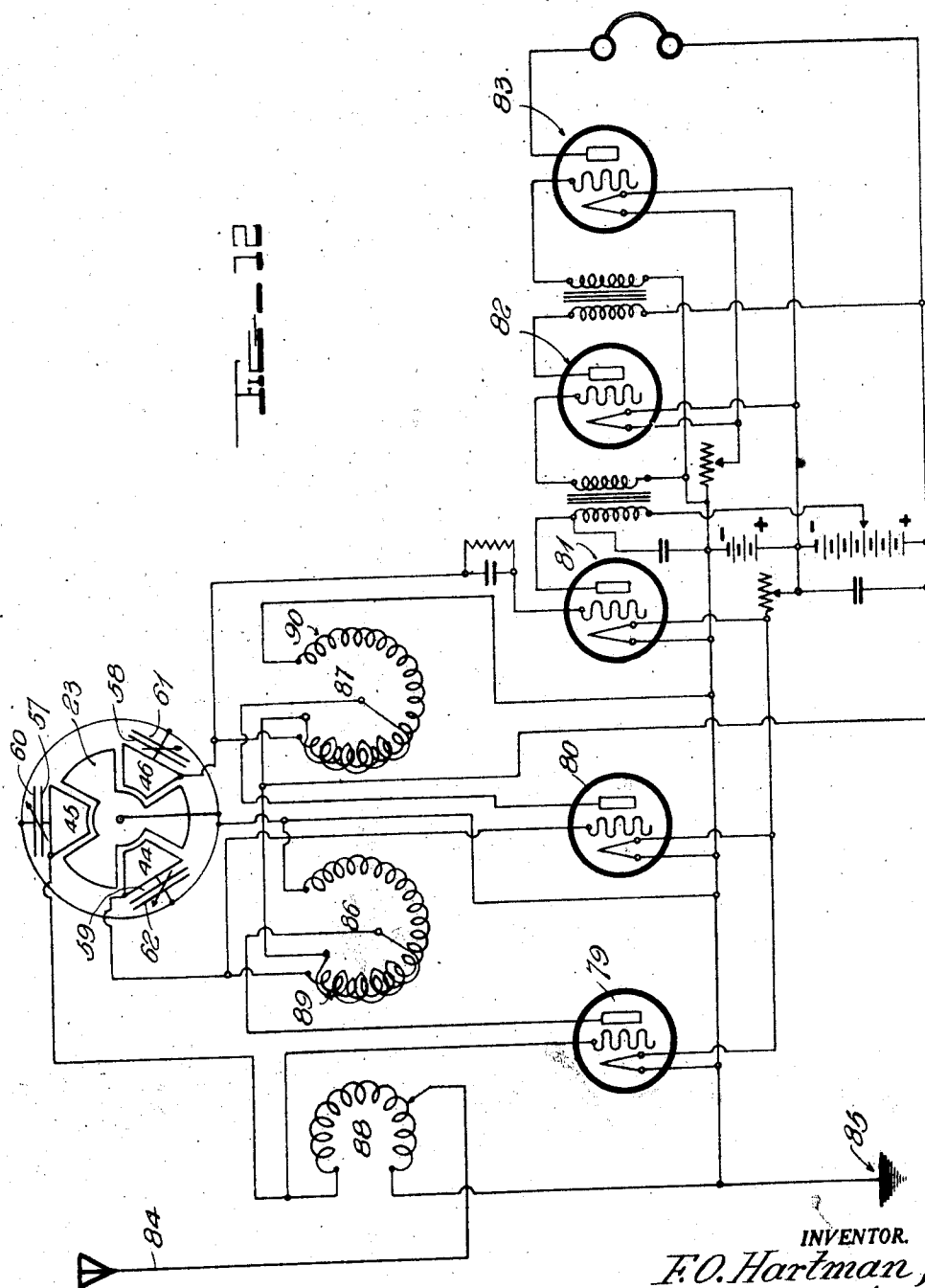
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6 Sheets-Sheet 6

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UNITED STATES PATENT OFFICE.

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VARIABLE CONDENSER.

Application filed November 5, 1925. Serial No. 67,132.

My invention relates broadly to electrical tuning systems and more particularly to a construction of tuning apparatus for use in radio broadcast reception.

One of the objects of my invention is to provide a construction of tuning apparatus for radio reception by which a number of electrical circuits may be simultaneously controlled by a central adjustable unit.

Another object of my invention is to provide a construction of variable tuning device for the simultaneous control of electrical circuits, wherein provision is made for accurately balancing the several electrical circuits for the correction of differences in the capacity characteristics which may exist therein.

Another object of my invention is to provide a construction of variable condenser in which a multi-bladed rotor is provided working into a like number of stators with independently adjustable means associated with each of the sets of stator plates and arranged to be spacially regulated with respect to independent cooperating adjustable plates, connected to the several circuits under control for accurately compensating for differences in the capacity characteristics thereof.

Still another object of my invention is to provide a construction of variable condenser in which a rotor having a multiple number of rotor plates thereon, may be accurately interleaved with a like number of independent sets of stator plates for simultaneously varying the tuning of a plurality of independent circuits.

My invention finds particular application in the simultaneous control of a plurality of electron tube circuits of a radio frequency amplifier in a radio receiving apparatus for radio broadcast reception. In apparatus of this kind it is customary to provide a number of tuning dials which control variable condensers which are arranged to tune the input circuits of a plurality of electron tubes in succession. It is generally impractical to connect all of these condensers directly on the same shaft for simultaneous operation by reason of the differences in the characteristics of the various circuits. I provide means for simultaneously tuning the several electron tube circuits, and independent adjustable means for compensating for the differences in the several circuits. I have accomplished these results by a particular con-

struction which will be described in detail in the specification hereinafter following. I desire that it be understood however that I do not intend my invention to be limited to the particular construction illustrated, but that my invention is entitled to the full scope of mechanical equivalents.

I provide a rotor having a plurality of rotor plates projecting from a central shaft in a number of sets corresponding to the number of circuits which are to be controlled. The central shaft of the rotor plates is journaled for rotation in such manner that the sets of rotor plates may be interleaved between corresponding sets of stator plates which project inwardly toward the central shaft, but are substantially insulated therefrom. On the rear of each of the sets of stator plates I provide a plate extending substantially at right angles to the plane of the stator plates in such position that an independently mounted resilient plate may be moved in variable spacial relation with respect to the aforementioned plates. This independent variation in the spacial relation between plates extending substantially at right angles with the plates constituting the stator and rotor of the variable condenser permits the circuits to be so arranged that accurate compensation of the several circuits may be made corresponding to differences in the electrical characteristics of the several tubes and condensers and inductances in the circuits and then the circuits simultaneously tuned by rotation of the central shaft. The details of construction of the several parts of the condenser comprising my invention will be more fully described hereinafter, by reference to the following specification and the accompanying drawings, in which:

Figure 1 is a front elevation of a tuning apparatus which includes the principles of my invention; Fig. 2 is a back view of the tuning apparatus showing the arrangement of the several sets of stator and rotor plates; Fig. 3 is a side elevation showing the operating parts of the variable condenser in the tuning system of my invention; Fig. 4 is a detailed cross-sectional view taken on line 4-4 of Fig. 2 and illustrating one of the compensating capacity units employed in the tuning apparatus; Fig. 5 is a fragmentary cross-sectional view illustrating the construction of the compensating capacity unit arranged to control from the front of the

tuning panel of the tuning apparatus taken on line 5-5 of Fig. 2; Fig. 6 is a central vertical section through the condenser showing the rotor mounting; Fig. 7 is a vertical section taken on line 7-7 of Fig. 6; Fig. 8 is a detail vertical sectional view taken on line 8-8 of Fig. 6 showing the construction of the gearing intermediate the rotor and the indicator dial of the apparatus; Fig. 9 is a rear plan view of a modified construction of tuning condenser; Fig. 10 is a side elevation of the condenser construction illustrated in Fig. 9; Fig. 11 is a central vertical section taken through the rotor of the variable condenser construction illustrated in Fig. 9; and Fig. 12 is a wiring diagram showing the arrangement of the tuning apparatus of my invention in a radio receiving circuit.

Referring to the drawings in detail, the apparatus panel is designated by reference character 1 having a sight opening 3 therein which is covered by a plate 2. The panel has a centrally positioned sight mark 4, with reference to which the calibrations on a rotary dial 5 may be read through the sight opening 3 from the front of the apparatus. A control knob 6 projects through the front of the panel for controlling the movement of the stub shaft 9 through the intermediary of a major gear 12 with which a pinion 14 is meshed. Control knobs 10 and 11 also project through the apparatus panel 1 and are controlled from the front thereof. The apparatus panel 1 is cut out or counter-sunk, as represented at 15 to permit the dial 5 to be freely rotated therein. The variable condenser is mounted upon a panel 16 which is suitably secured to the rear of the apparatus panel 1. I have illustrated a plurality of screws 17 which serve to position the supporting plate 16 to the rear of the panel 1. A hub 18 is centrally positioned upon the plate 16 providing a central support for the stub shaft 9. The shaft 9 has an annular shoulder 19 which abuts against the face of the projecting hub 18 and is secured rigidly thereagainst, by means of a nut 20 which is screw threaded upon the end of the shaft 9 bearing against the front face of the panel 16. The stub shaft 9 is substantially larger in diameter throughout one portion of its length forming a bearing portion 21 with a head 22 at the end thereof. The rotor plates 23 are built up between the end gear 12 and an end plate 24 with separators 25 between the plates 23 and bolts 26 passing through the complete set of plates and separators. The end gear 12 and the end plate 24 extend inwardly and form annular bearing faces cooperating with the bearing portion 21 of the stub shaft 9. The interior space 27 between the inside walls of the separators 25 and the plates 23 is filled with a suitable lubricant whereby accurate movement of the

rotor plates 23 may be secured with minimum friction of parts. That is to say, the space 27 may be filled with a lubricating grease well packed so that it is effective over a relatively long period of time. The method by which the rotor plates are varied in angular position will be more clearly understood by reference to the details shown in Figs. 6 and 8. A pair of U shaped plates 28 and 29 are secured on opposite sides of plate 16 forming a housing for a bearing 30. The bearing 30 consists of a substantially rectangular block having a bore therethrough in which is journaled the operating shaft. In Fig. 6 the control knob 6 is shown having its shaft 6^a passing through the bore in the block 30. The block 30 is substantially reduced at its opposite ends and fits snugly in an aperture in the U shaped plate 28, but in a position for vertical displacement in U shaped plate 29; by reason of the elongated aperture 31 in the U shaped plate 29 and the relative pivotal mounting of the opposite end of the bearing block in the U shaped plate 28. The bearing block 30 is spring-pressed by the resilient means indicated at 32 in a direction toward the major gear 12 whereby pinion 14 is constantly urged into engagement with the gear 12. The indicator 5 is geared to be rotated with the angular displacement of the rotor plates 23 through the intermediary of pinion 33 of shaft 34. The shaft 34 is journaled in a bearing block 35 which is positioned between U shaped bracket members 36 and 37. The bearing block 35 is substantially rectangular and fits snugly into a correspondingly shaped aperture 38 in bracket 36. The ends of the bearing block are substantially reduced in width, enabling the block to be snugly fitted between the bracket members 36 and 37. The end of the bearing block 35 which projects into the bracket 36 is provided with rounded edge faces 39 enabling the bearing block to rock in the bracket 36 in the manner of a pivotal mounting. The bracket 37 has a rectangular aperture 40 which is elongated in a vertical direction. The bearing block 35 is normally spring pressed by means of spring 41 which throws the bearing block 35 to one side in the direction of the stub shaft 9. This tendency results in maintaining the major gear 12 and pinion 33 in mesh and under uniform tension throughout all positions of angular displacement of the rotor plate 23. I may provide a suitable stop member 42 mounted in fixed relation with respect to the plate 16 and arranged to cooperate with the projecting end 43 of one of the bolt members 26 to preclude the rotation of the rotor plates through any greater angle than 360 degrees in one direction. It may be desirable to have the rotor operate in either direction through more than 360 degrees in which event I omit the stop con-

struction. It will be observed that I have shaped the rotor plates to provide a plurality of sets of plates projecting outwardly from the stub shaft 9. I do not wish to be limited to any particular number of these sets of plates, as I have illustrated in Figs. 2, 3, 6 and 7, a triple set of plates while in Figs. 9 and 10 I have shown two sets of plates. The number of sets of plates is directly dependent upon the number of individual circuits which are to be adjusted. In Figs. 12, I have shown a radio receiving apparatus including three stages of radio frequency amplification and accordingly I have illustrated three sets of plates.

Referring more particularly to Fig. 2 of the drawings, I have illustrated three independent sets of stator plates 44, 45 and 46 which project inwardly toward the stub shaft 9 and having their edges tapered substantially parallel with the edges of the rotor plates 23, when the rotor is in minimum capacity position with respect to the stator plates. The stator plates 45, are shown built up on extended bolts 47 which extend at substantially right angles to the insulated strips 48 and upon which are alternately positioned the stator plates 45 and spacing members 49. The sets of stator plates are each insulated from the supporting plate 16 in a manner as described with reference to the stator plates 45, that is, the set of stator plates 44 is insulatingly mounted with respect to the supporting plate 16 by means of the insulated strip 50, while the insulated strip 51 supports the stator plates 46. The insulated strips 48, 50 and 51 are suitably spaced from the supporting plate 16 by members 52 which form supporting feet beneath opposite ends of the strips. The stator plates 44 are built up on the vertically extending bolt members 53 and 54, while the stator plates 46 are built up on the projecting bolt members 55 and 56. In order to compensate for differences in the electrical circuits with which the condenser is connected independent of the tuning obtained by the angular displacement of the rotor plates 23 with respect to the stator plates 44, 45, and 46, I provide fixed plates 57, 58 and 59 which extend substantially at right angles to the sets of stator plates 44, 45 and 46 along the rear thereof and are supported with respect thereto by tongue extensions which engage the ends of the bolt members which support the stator plates. That is to say, plate 57 is provided with extended tongues 57^a and 57^b which are secured over the ends of the supporting bolt members 47 and 48. Plate 58 is provided with extended tongues 58^a and 58^b in the upper corners of the plate and extending substantially at right angles to the surface of the plate in such manner that the tongues may be secured upon the supporting screws 55 and 56. The plate 59 has extended tongues 59^a and 59^b in opposite corners of one edge thereof and extending substantially at right angles to the surface of the plate and in engagement with the extended supporting bolts 53 and 54. It will therefore be seen that the rear sides of each of the sets of stator plates 44, 45 and 46 are substantially closed by means of plates 57, 58 and 59. Cooperating plates 60, 61 and 62 are mounted adjacent each of the plates 57, 58 and 59 are supported from the base 16 by means of tongues which are bent at right angles to each of the plates. That is to say, plate 60 is provided with tongues 60^a and 60^b which support the plate substantially at right angles with respect to the base 16. Similarly, plate 61 is provided with tongues 61^a and 61^b extending at right angles to the plate and securing the plate on the supporting base 16 substantially at right angles to the rear edges of the stator plates 46. Likewise, plate 62 is provided with tongues 62^a and 62^b enabling the plate to be supported in spaced relation to the plate 59 which closes the rear edges of stator plates 44. There is sufficient material cut away from each of the lower portions of plates 60, 61 and 62 to give the plates sufficient resiliency to enable the plates to be mechanically flexed or varied in special relation with respect to the plates 57, 58 and 59. The mechanical flexing of these plates may be secured in a number of different ways. In Fig. 2 I have shown a standard 63 through which an adjustable screw 64 is threaded engaging one side of the plate 60 in such manner that the plate 60 may be moved from its full line position in Fig. 4 to its dotted line position 60^c which is a position of maximum capacity. In this manner differences in the characteristics of the electrical circuits with which the condensers are connected may be compensated. The adjustment of spacial relation of the plate 60 and 57 is shown as being obtained wholly within the cabinet 65 which houses the tuning apparatus. In order to adjust the capacity values between the other sets of plates operating means 10 and 11 are actuated. I provide cam members 11^a and 10^a on the shafts 11^b and 10^b which extend through the bearings 11^c and 10^c supported from the base plate 16, and which operate to vary the spacial relation of the plates. By varying the angular displacement of the operating means 10 and 11, the spacial relation between plates 61 and 68 and 62 and 59 may be suitably varied to secure the desired compensation to enable simultaneous control of all of the circuits. In Fig. 5 I have illustrated the limits of the compensating adjustments as lying between the full line position of plate 62 and the dotted line position 62^c of the plate 62.

In the modified construction of the tuning condenser illustrated in Figs. 9, 10, and 11, a sub-panel 66 of insulating material may be supported in spaced relation to the instrument panel 1 carrying the independent sets of stator plates 67 and 68. The rotor plates are shown as comprising two sets 69 and 70 extending in diametrically opposite directions and supported in spaced relation by spacing members 71 carried on shaft 72. The shaft 72 may be provided with a conical bearing member 74 which is secured by suitable means 75 to the sub-panel 66. The desired position of the extensions 69 and 70 of the rotor plates may be secured by adjusting nut 76 on the threaded portion 77 of the shaft 72 against the spring washer 76^a. In this manner the rotor plates may be set to a position exactly intermediate the stator plates 67 and 68. The shaft 72 may be suitably controlled by knob 78 from the front of the panel 1. In the operation of my invention the variable condenser when employed as a uni-control for the circuits of a radio receiving apparatus has the connections arranged as illustrated in Fig. 12 where electron tubes 79 and 80 are arranged to function as radio frequency amplifiers, while tube 81 operates as a detector and tubes 82 and 83 function as audio frequency amplifiers. The receiving apparatus is shown connected to an antenna system 84 and ground 85. The radio frequency amplifier is shown constructed according to the principles set forth in my co-pending application Serial No. 42,556, filed July 9, 1925, and entitled Radio receiving system. The input and output circuits of each of the electron tubes are shown coupled through toroidal transformers 86 and 87, while the antenna connection to the receiving set is coupled through a toroidal winding 88 all of which are described in detail in the above referred to co-pending application. The toroidal winding 88 and the secondary windings 89 and 90 of toroidal transformers 86 and 87 are all tuned simultaneously. The rotor plates 23 of the condenser are all connected to one end of each of the windings 88, 89 and 90. The stator plates 44, 45 and 46 are each connected to the opposite ends of the windings 88, 89 and 90. The plates 57, 58 and 59 are illustrated as electrically connected with each of the sets of stator plates 44, 45 and 46 as hereinbefore described, while plates 60, 61 and 62 are variably related to the aforementioned plates and each connected to the ends of windings 88, 89 and 90 which are common in the rotor plates 23. It will be seen that for different characteristics of the electron tubes 79, 80 and 81 that the capacity values between plates 60—57, 58—61 and 59—62 may be so adjusted as to compensate for differences in the electrical characteristics of the tubes so

that simultaneous and equal adjustment of the several tuning circuits may be secured by angular displacement of the rotor plates 23 with respect to the stator plates.

The auxiliary or individual tuning condensers do more than take care of the variation in the internal capacity between elements of the respective tubes. They make up for the variation in distributed capacity of the tuning condensers which comprise the simultaneous control feature. Condensers cannot be practically made which are identical in capacity and with the positioning of the toroid coils there is also an unequal distribution of leads. The different length of leads together with the difference in condenser capacity values add to the variation in capacity of the tube elements and it is this total variation that my condenser construction compensates by means of the individual condensers.

While I have shown my invention as particularly adapted for the control of multiple tuned radio frequency electron tube amplifier circuits, it will be understood that the variable condenser construction of my invention may be employed for the simultaneous adjustment of various electrical circuits and that I intend no limitation upon the application of my invention. While I have described the variable condenser construction in certain specific details, it will be understood that modifications may be made and that no limitations upon the invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A variable electrical condenser comprising in combination a central rotatable member, a plurality of rotor plates projecting radially from said rotatable member, a plurality of stator plates arranged adjacent said member and insulatively supported with respect thereto, said stator plates being disposed in the same plane with said rotor plates, and auxiliary condensers connected across said cooperating sets of stator and rotor plates and disposed substantially at right angles with respect to the plane of said plates, whereby the mutual capacity between said cooperating sets of rotor and stator plates may be simultaneously varied by angular movement of said rotor plates with respect to said stator plates, and differences in electrical capacity compensated for by independently actuating said auxiliary condensers.

2. A variable electrical condenser comprising in combination a plurality of sets of rotor plates arranged to interleave with a plurality of sets of cooperating stator plates disposed substantially in the same plane therewith for simultaneously varying the

mutual capacity relation between said cooperating sets of stator and rotor plates and auxiliary variable capacity means disposed substantially at right angles with respect to the plane of said rotor and stator plates and electrically connected between each of said cooperating sets of rotor and stator plates; and arranged to be independently actuated for compensating for differences in the capacity relation between said cooperating sets of plates.

3. A variable condenser construction comprising in combination a rotatable member, a set of rotor plates carried by said member, a cooperating set of stator plates with which said rotor plates are arranged to be interleaved, said rotatable member having a pair of inwardly extending end plates forming bearing surfaces, and a journal comprising a stub member extending outwardly from a panel for engaging said bearing surfaces whereby said rotatable member may be moved about said journal as a center for adjusting the mutual capacity relation between said rotor and stator plates.

4. A variable condenser construction comprising in combination a rotatable member, a set of rotor plates carried by said member, a cooperating set of stator plates with which said rotor plates are arranged to be interleaved, and a journal for said rotatable member consisting of a stub member projecting outwardly from a panel, said rotatable member having a pair of inwardly extending bearing surfaces at opposite ends thereof arranged to engage said stub member and forming a housing for lubricant therebetween, whereby said rotatable member may be readily revolved for interleaving said rotor plates with said stator plates in varying degrees.

5. A variable condenser construction comprising in combination a panel, a stub member projecting outwardly from said panel, a rotatable member arranged to be journaled on said stub member, a plurality of rotor plates carried by said rotatable member and adapted to be interleaved with a plurality of stator plates, said rotatable member having a housing formed between a pair of end plates, said end plates projecting inwardly to form bearing surfaces for engaging said stub member for enclosing within said rotatable member a lubricating chamber whereby said rotor plates may be angularly moved with respect to said stator plates with minimum friction.

6. A variable condenser construction comprising in combination with a panel, a stub member projecting from said panel, a rotatable member journaled upon said stub member and carrying a plurality of rotor plates thereon, a plurality of stator plates with which said rotor plates are arranged to interleave, a gear formed on one end of said

rotatable member, an actuating shaft journaled in said panel, a pinion on one end of said actuating shaft arranged to mesh with said gear, and means interposed between said actuating shaft and said panel whereby said actuating shaft is free to move within given limits in a plane passing through said stub member.

7. A variable condenser construction, the combination of a panel, a stub member projecting from said panel, a rotatable member journaled upon said stub member, a plurality of rotor plates carried by said rotatable member and arranged to be interleaved with a plurality of cooperating stator plates, a gear carried by said rotatable member, and a rotary actuator passing through said panel and having a pinion adjacent one end thereof meshing with said gear, said rotary actuator having means whereby said pinion is normally spring pressed into engagement with said gear and arranged to be angularly moved with respect thereto in the plane of said stub member for compensating for irregularities in movement of said rotor plates.

8. In a variable condenser construction the combination of a supporting panel, a rotatable member mounted adjacent said panel, a plurality of rotor plates carried by said rotatable member, a plurality of stator plates insulatively supported with respect to said rotor plates in such manner that said rotor plates may be interleaved with said stator plates, a plate member substantially closing the rear of said stator plates and an auxiliary plate member mounted upon said supporting panel adjacent said first mentioned plate, and means for varying the spacial relation between said plates, members for independently compensating for differences in capacity variation between said stator and rotor plates.

9. A variable condenser construction comprising in combination a plurality of sets of stator and rotor plates arranged in the same plane and adapted to be interleaved with each other for varying the mutual capacity, a substantially flat condenser plate secured to said stator plates and bending substantially at right angles to the plane of said plates on one side of said plates away from that side at which said rotor plates enter said stator plates and a resilient auxiliary condenser plate arranged adjacent said aforementioned plate and adapted to be varied in spacial relation with respect thereto.

10. A variable condenser construction comprising in combination a rotatable member, a plurality of rotor plates carried by said rotatable member, a plurality of stator plates into which said rotor plates are arranged to be interleaved, a gear carried by said rotatable member, a panel, a stub mem-

ber projecting from said panel upon which said rotatable member is journaled, a rotary shaft actuator passing through said panel and carrying a pinion meshing with said gear, and a driven shaft passing through said panel said driven shaft carrying a rotary indicator and a pinion meshing with said gear, said shafts having means for constantly urging said pinions into meshing with said gear, while allowing said pinions to move in a plane passing through the axis of said rotatable member and compensating for any irregularities in movement of said gears. 10

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