March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 1

Fig. 1

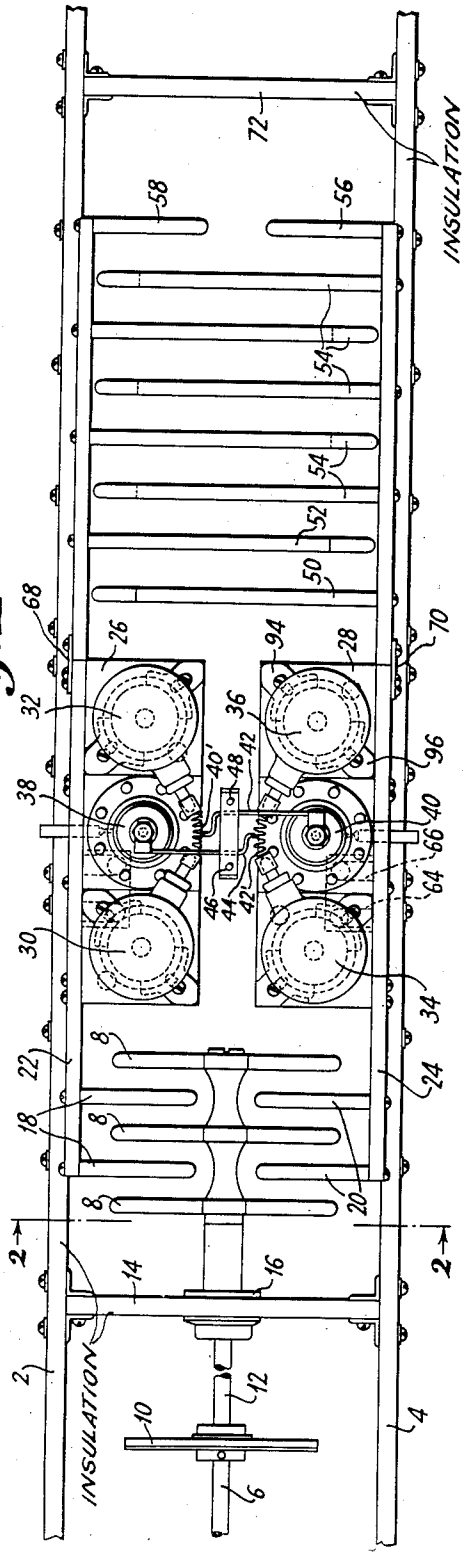
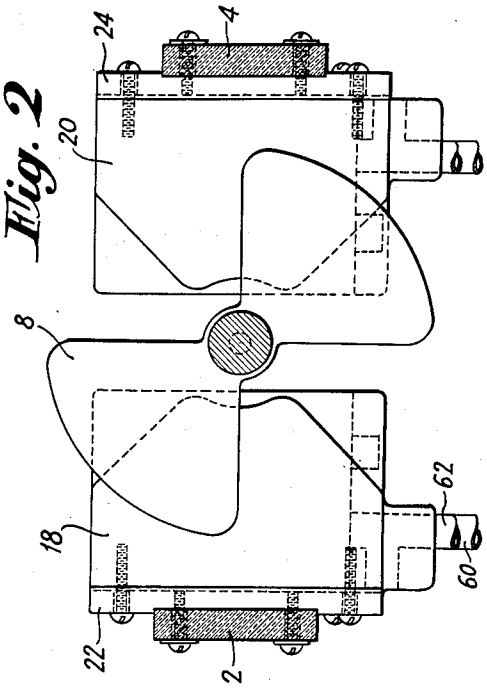


Fig. 2



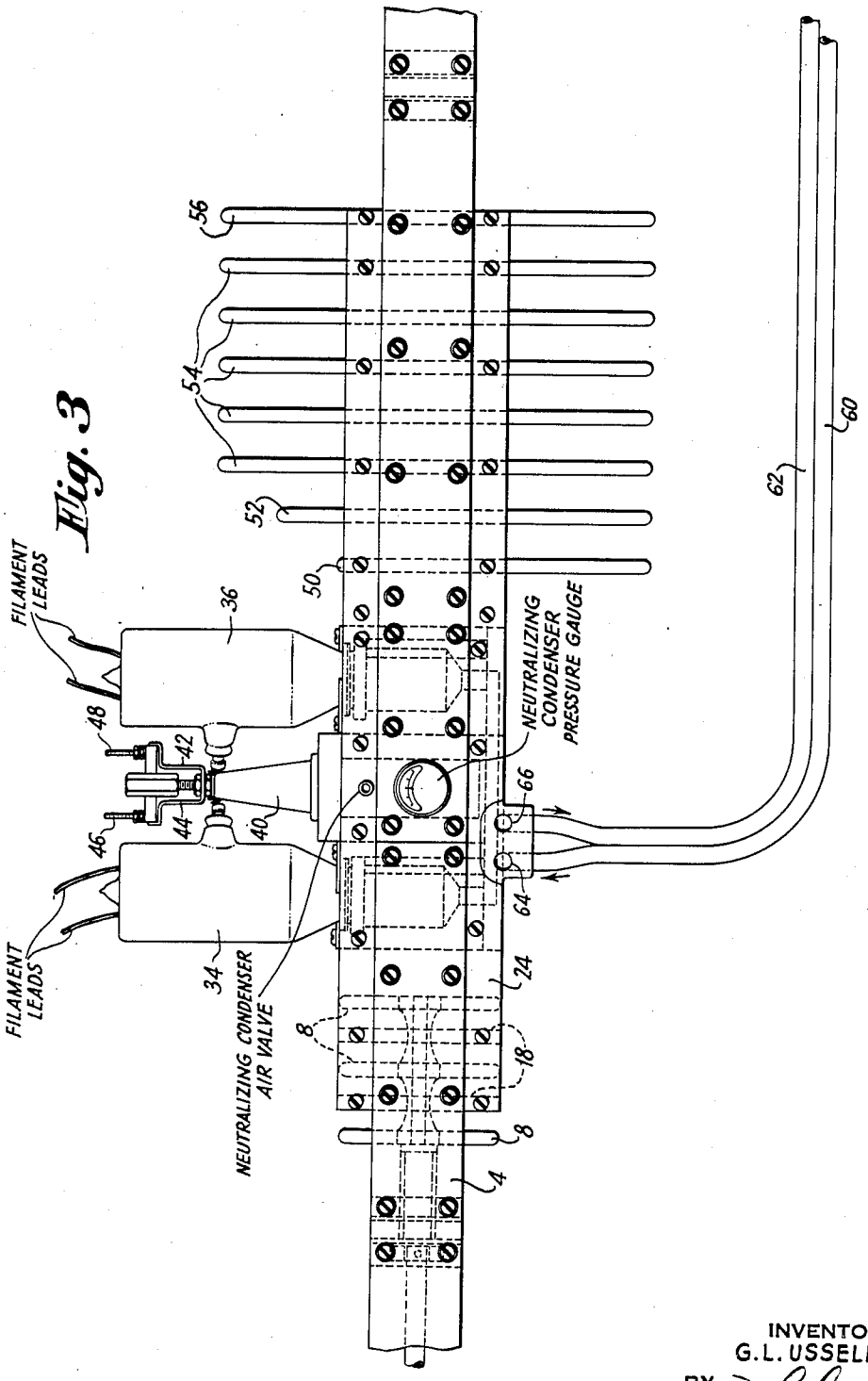
INVENTOR
G. L. USSELMAN
BY H. B. Swope
ATTORNEY

March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 2

Fig. 3



INVENTOR
G. L. USSELMAN
BY
ATTORNEY

March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 3

Fig. 4

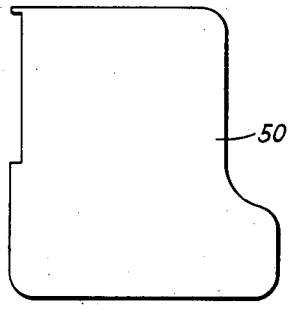


Fig. 5

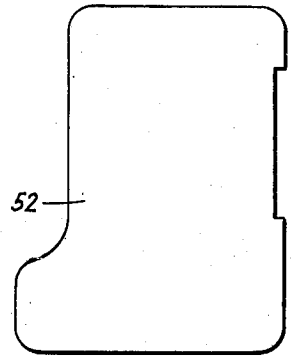


Fig. 6

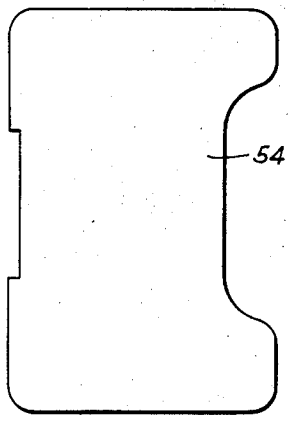


Fig. 7

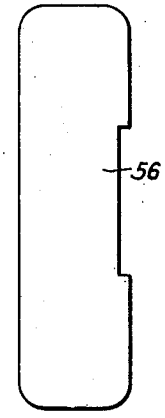
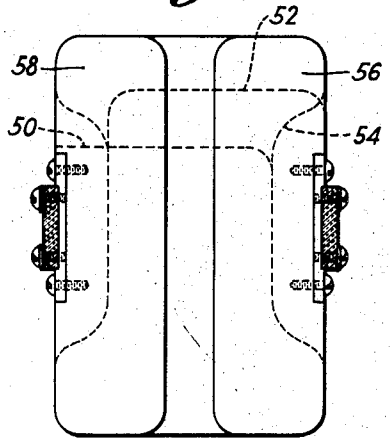


Fig. 8



INVENTOR
G. L. USSELMAN
BY H. L. Grover
ATTORNEY

March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 4

Fig. 9

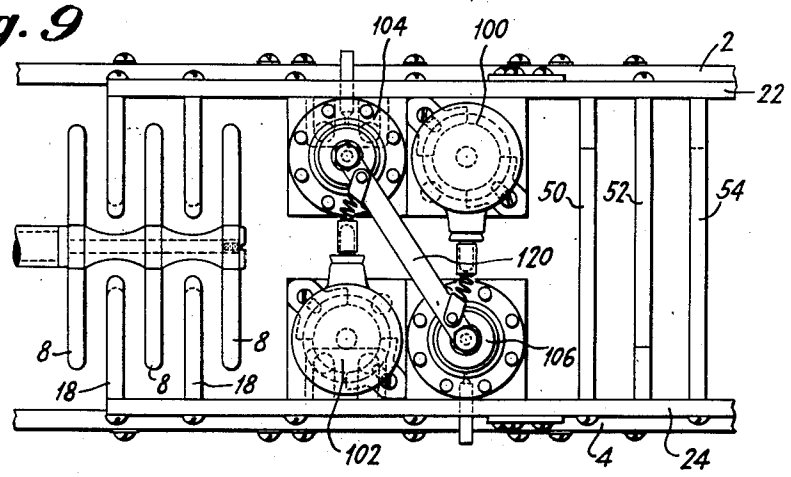
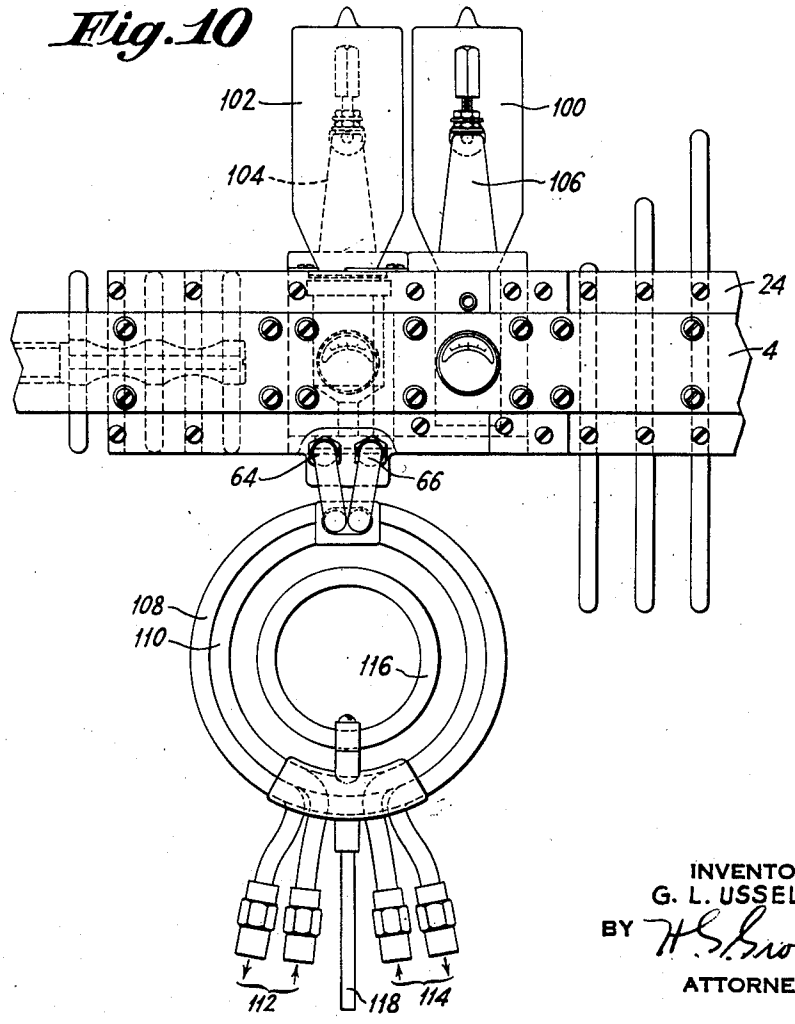


Fig. 10



INVENTOR
G. L. USSELMAN
BY H. S. Grover
ATTORNEY

March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 5

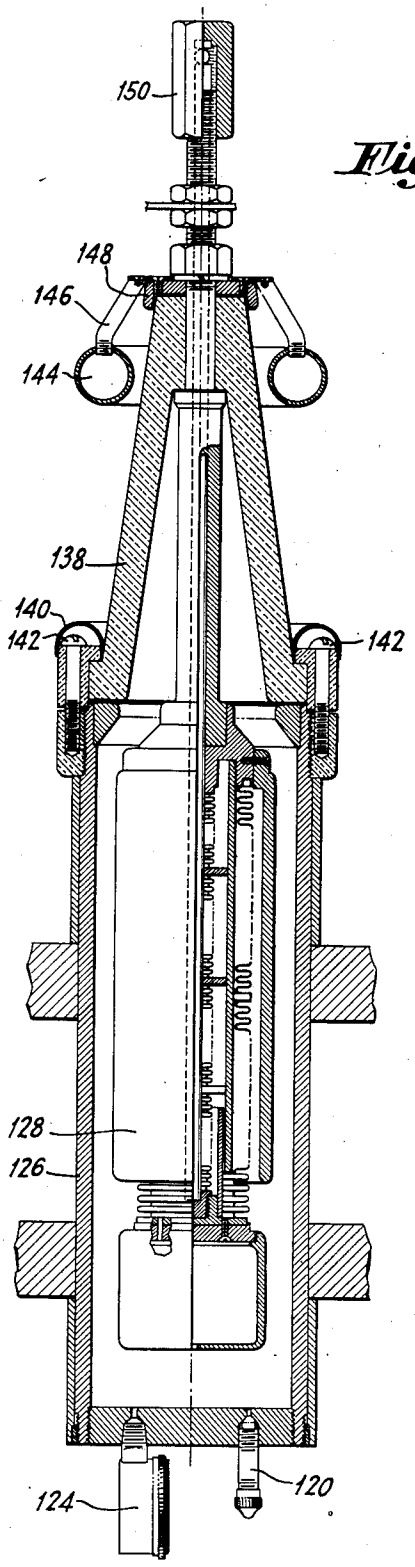


Fig. 11

INVENTOR
G. L. USSELMAN
BY
ATTORNEY

March 12, 1940. G. L. USSELMAN 2,193,500

HIGH FREQUENCY APPARATUS

Filed Aug. 14, 1936 6 Sheets-Sheet 6

Fig. 12

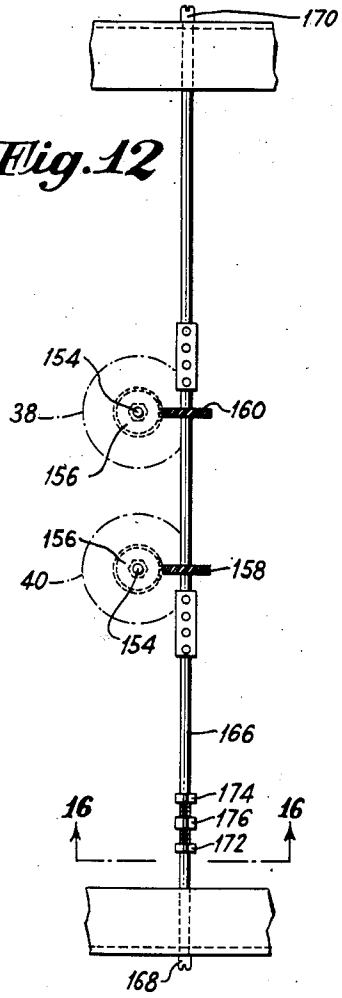
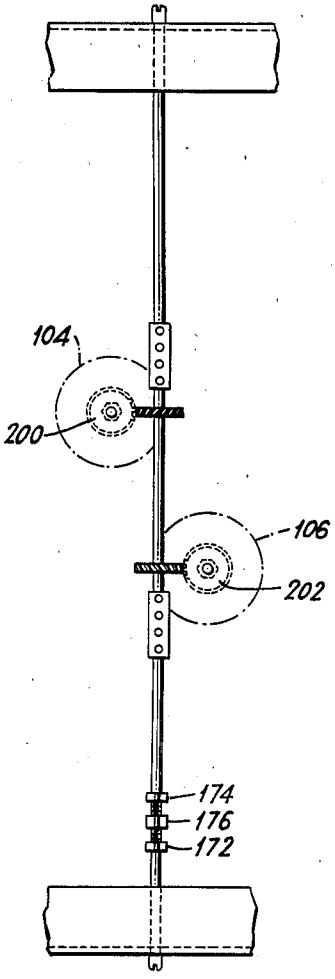


Fig. 14



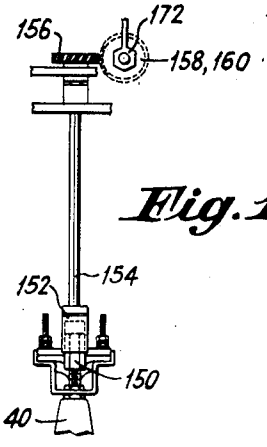


Fig. 13

INVENTOR
G. L. USSELMAN
BY H. S. Glover
ATTORNEY

Patented Mar. 12, 1940

2,193,500

UNITED STATES PATENT OFFICE

2,193,500

HIGH FREQUENCY APPARATUS

George Lindley Usselman, Port Jefferson, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application August 14, 1936, Serial No. 96,046

6 Claims. (Cl. 250—27)

My present invention relates generally to the improvement of high frequency apparatus particularly suited for use in short wave radio transmitters.

Among the objects of my present invention are;

To provide an improved condenser for high frequency use;

To provide an improved cooling system for vacuum tubes generally;

To provide an improved push-pull arrangement of tubes, tuning and neutralizing condensers, and;

To provide an improved push-pull vacuum tube arrangement employing condensers and vacuum tubes, the arrangement being such as to be perfectly symmetrical reactively with respect to tubes and with respect to ground.

A further object of my present invention is to provide a neutralized stage for a radio transmitter employing neutralizing leads of minimum length. Such leads are desirable for various reasons and in order to effect this object I employ condensers of the compressed air or fluid type. These condensers not only enable me to minimize the length of the neutralizing leads but they also permit optimum utilization of space with increased safety factor.

Further objects, advantages, and features of my present invention will be apparent as the more detailed description thereof proceeds.

Referring to the drawings which are illustrative only of my present invention;

Figure 1 is a top view of a push-pull stage employing a variable tuning condenser, parallel vacuum tubes, compressed air neutralizing condensers, and a fixed auxiliary tuning condenser;

Figure 2 is a view of Figure 1 taken along the line 2, 2 of Figure 1;

Figure 3 is a side view of the system shown in Figure 1 and shows, among other things, the inductance for the push-pull stage which is made up of a pair of pipes or fluid conducting tubes, Figure 3 also showing an air valve for injecting air of desired pressure into one of the neutralizing condensers and also showing the air gage for indicating the air pressure and in turn, the effective capacity of the neutralizing condenser. Generally, the higher the pressure, the higher the voltage the condenser will stand. Other factors for increasing the break-down voltage of the condenser are described and explained hereinafter;

Figures 4, 5, 6, and 7 are side views of condenser plates used in the system shown in Figures 1 and 3;

Figure 8 is a rear end view looking from right to left of the system shown in Figures 1 and 3;

Figures 9 and 10 are views similar to Figures 1 and 3 of a modified push-pull system employing single tubes rather than parallelled tubes;

Figure 11 is a sectional view through an improved neutralizing condenser which may be used in connection with Figures 1 and 3 or Figures 9 and 10;

Figures 12, 13, and 14 are views of apparatus for uni-controlling or simultaneously adjusting a pair of neutralizing condensers in a push-pull circuit.

Turning to Figure 1, the transmitter assembly is set up to include a variable condenser portion to the left, the neutralizing condenser and tube structure at the center, and a removable fixed condenser portion at the right. The entire structure is generally supported by two insulating strips 2, 4, in turn supported by legs, not shown, or to any suitable metallic or insulating supporting means.

The variable condenser section is provided with a shaft 6 which rotates the variable condenser plates 8 through the medium of a flexible coupling 10 and shaft 12. The flexible coupling 10 is preferably made of the insulating type whereby shaft 6 may be grounded and whereby shaft 12 is permitted to float. In this way, the tendency for parasitic oscillation generation is reduced. The rotatable plates 8 are generally supported together with a shaft 12 by means of an insulating strip 14 containing the bearing 16. The general shape of the plates 8 is shown in Figure 2 as is also the shape of the fixed plates 18, 20, the latter being supported upon the metal strips 22, 24, in turn, mounted upon the insulating strips 2, 4 respectively.

The central section consists of two metallic blocks 26, 28 supported upon the metal strips 22, 24. The metal blocks 26, 28 generally house and otherwise support vaccum tubes 30, 32, 34, and 36, it being noted that tubes 30 and 32 are connected in parallel as are also tubes 34 and 36. These pairs of tubes are connected to the stator plates 18 and 20, in turn connected to the opposite sides of a push-pull circuit. The neutralizing condensers 38, 40 are also connected respectively to the blocks 26, 28 but are cross-connected to the pairs of tubes 30, 32 and 34, 36 for neutralization purposes as is known in the art.

The grids of tubes 30, 32 are connected together by flat metallic ribbon 40' and through

lead 42 to the central electrode of neutralizing condenser 40. Similarly, the grids of tubes 34, 36 are connected together by metal ribbon 42' and through lead 44 to the central electrode of neutralizing condenser 38. As shown in Figure 3, the side view of the arrangement, the grids are also connected to the input leads 46, 48 through the conductors 44, 42.

For the longer wavelengths, a fixed condenser section is provided which, as shown in Figures 1 and 3, include condenser plates 50, 52, 54, and 56. Condenser plate 50, with alternate condenser plates 54 and condenser plate 56 are connected to the metal strip 24, in turn connected to the anodes of tubes 34, 36 through the metal block 28. Similarly, condenser plate 52, the other alternate plate 54, and condenser plate 58 are supported by and electrically connected to a metal strip 22. The number of condenser plates may be varied so as to give the desired capacity. The end plates 50, 52 as shown in Figure 3 and as shown in greater detail in Figures 4 and 5 respectively, are so shaped as to minimize unbalanced capacity to tubes 26 and 28. By way of explanation, due to differences in separation between the tube grids and the condenser plates, the plate 50 offers a greater capacitive reactance to the grid of tube 32 per unit area, than does plate 52 with respect to the grid of tube 36. Accordingly, if condenser plate 50 were made the same size as condenser plate 54 then its capacity to the grid of tube 32 would be such as to unbalance the push-pull arrangement of tubes, neutralizing condensers, and tuning condensers. Similarly, condenser plate 52 should be made of some intermediate size but may be made larger than condenser plate 50 or otherwise, if made too large condenser plate 52 would tend to unbalance the system by its effect on the grid of tube 36.

For a somewhat similar reason two end plates 56, 58 are provided which eliminates unbalance to ground.

The shape of the intermediate plates 54 is shown in Figure 6 and the shape of the end plates 50, 56 is shown in Figure 7.

A rear end view of the condenser assembly is shown in Figure 8.

The inductance in shunt with the condenser system which includes the variable and fixed sections as shown in Figure 1, consists of the tubular piping 60, 62 (Figure 3). Only a section of the pipe 60, 62 is shown but it is to be understood that it extends between and is electrically connected to a pair of inlet and outlet orifices such as 64, 66 for block 28. In Figure 3, the inlet and outlet orifices 64, 66 are drawn with broken lines. The pipes 60, 62 are connected at their midpoints to an inlet rubber water pipe, not shown, and an outlet rubber water pipe, not shown, it being understood that there is a short-circuiting connection of low impedance across the pipes 60, 62 where the rubber pipes are connected. This short-circuiting strap is slidable along the pipes 60, 62 which extend parallel. That is to say, the pipes 60, 62 for block 26 and similar pipes 60, 62 for block 28 extend parallel to one another and the short-circuiting strap forms the connection across both pairs of pipes 60, 62, forming effectively a U-shaped inductance loop. If desired, the inductance system may be coiled as shown in the patent to H. E. Hallborg, No. 1,963,131, dated June 19, 1934.

As before explained, the fixed section of the condenser consisting of the plates 50 to 58 may be removed by disconnecting the straps 68, 70 by which it is attached to the frame members 22, 24.

A further insulating spacer 72, similar to 14 is provided as shown in Figures 1 and 3.

It should be noted in connection with Figure 2 that the rotor plates are cut out of a single piece of metal. This form of rotor plate with two sectors mechanically and electrically connected together and as associated with the stator plates as shown in Figure 1, eliminates objectionable sliding contacts. Sliding contact is objectionable not only when tuning but also when a tuned condition has been reached and the condenser arrangement shown eliminates these objections.

Figures 9 and 10 are respectively, top and side views of a modified push-pull system which is generally similar to Figures 1 and 3. However, in Figures 9 and 10 only a single tube is mounted on each side of the push-pull system. As shown in Figures 9 and 10, the tubes 100, 102 and the neutralizing condensers 104, 106 are alternately arranged at the corners of a rectangle or a square. The arrangement shown in Figures 9 and 10 offers the advantage that the length of the circuit connection between the grid of a tube and its neutralizing condenser is reduced to a minimum. It is to be understood, of course, that the tubes and condensers may be arranged otherwise. For example, the neutralizing condensers and tubes might be placed opposite one another but this would require crossing of the neutralizing leads. Also, in this case, the tubes or the neutralizing condensers may be placed next to the fixed section of the condenser. In general, the rest of the structure shown in Figures 9 and 10 as regards the variable and fixed condenser sections follows the principles of design as set forth above in explaining Figs. 1 and 3. It will be understood, however, that the areas of the respective plates 50, 52 and the plate 54 adjacent 52 may be differently proportioned from those shown in Figs. 1 and 3, due to the fact that the tubes 100 and 102 respectively are not necessarily directly opposed to one another. The cooling water openings 64, 66 of Figure 10 are shown connected to the doubly wound copper coils 108, 110. Rubber hose inlet and outlet pipes 112, 114 are also provided for each half of the coil, it being understood that each half of the coil of Figure 10 goes to either block 26 or block 28. That is to say, the water circling through the hose 112 would go to either block 26 or block 28 and the water circling through the rubber hose connection 114 and the other half of the coil system 108, 110 would also circle to the other block, such as, 28 and 26 respectively. Also, as shown in Figure 10, a metal disc or inductance tuner 116 is provided which is rotated by means of shaft 118 for additional tuning adjustment.

Returning to Figure 9, an insulating strip 120 is suitably mounted on the neutralizing condensers 104, 106. This insulating strip 120 supports the grid excitation and neutralizing connections.

The neutralizing condensers referred to hereinabove are described more fully in the copending application of C. W. Hansell, G. L. Usselman, and C. W. Latimer, Serial No. 27,678, filed June 21, 1935. That is to say, for high voltage operation I prefer to use the condensers as shown in this copending patent application. For operation at still higher voltages modifications such as shown in Figure 11 are found desirable. In Figure 11 I have shown a neutralizing condenser which has general application, it being provided with an air inlet 120, a pressure gage 124, and

an outer electrode or wall 126 which in Figures 1, 3, 9, and 10 is replaced by the metallic blocks 26, 28. The inner electrode structure 128 is adjustable and constructed as described in the copending application referred to. However, to prevent corona creepage along the conical insulator 138 an annular corona shield 140 at the base of the insulating cone 138 is provided in order to shield the screw heads 142 for fastening the cone 133 to the base 126. Also, a circular doughnut-shaped corona shield 144 is provided at the upper end or apex of the insulating cone 138 which ring-shaped corona shield is supported by means of metal arms 146. It has been found that by the provision of the shields 144 and 140 the condenser may be subjected to voltages twice as great as compared to the voltages at which, without the shields, flash-over or arcing takes place between points 142 and 148.

A further feature of my present invention resides in the uni-control of the neutralizing condensers shown in Figures 1 and 3 and Figures 9 and 10.

Figures 12 and 13 are top and side views of uni-control mechanism for simultaneously adjusting the neutralizing condensers 104, 106 which correspond with condensers 38, 40 shown in Figures 1 and 3. Referring to Figure 11 when hexagonal nut 150 is rotated the capacity of the neutralizing condenser is altered, as explained more fully in the copending application of Hansell, Usselman, and Latimer referred to hereinabove. The neutralizing condensers 38, 40 of Figures 1, 3, 12, and 13 are provided with these hexagonal adjusting nuts 150 as shown more clearly in Figure 13. A hexagonal cup, or socket, 152 fits over each nut 150 and each socket is pinned to a shaft 154. Shafts 154 are preferably made of insulating material. At the upper end of each shaft, as shown in Figures 12 and 13, there is a 90° worm gear 156 engaging the separated worm driving gears 158 and 160. Gears 158, 160, 164 are pinned or otherwise fastened to the metal drive shaft 166 which is rotated by inserting a screw driver in either of its slotted ends 168, 170. A pair of stops 172, 174 are provided which engage a further stop 176. Stop 176 is in the form of a nut threaded to shaft 166 and limits the movement of the shaft so as to prevent undesired extreme movements of the inner electrode of the neutralizing condensers shown in greater detail in Figure 11. In order to effect this result the nut 176 is keyed so that it may move axially along the shaft 166 but is prevented by the keying means, not shown, from rotating with the shaft. Also in order to effect this result, it should be clear that the socket 152 is so dimensioned as to permit the nut 150 to move up and down within the socket 152 but not rotate within the socket. In other words, the socket 150 and nut 152 rotate together although they are relatively slidable along the axis of rotation.

Figure 14 is a top plan view of a system for simultaneously adjusting the neutralizing condensers of the arrangement such as shown, for example, in Figures 9 and 10. Because the condensers are staggered or lie on opposite sides of the shaft the gearing 200, 202 is similarly staggered because of corresponding changes in the condenser structure. For this reason, too, the pitch on the sets of gears 200, 202 is reversed. The mechanism is otherwise similar to that described in connection with Figures 12 and 13 and consequently, further detailed description is believed to be unnecessary in view of what has been said in connection with Figures 15 and 16. If desired, the block, tube and neutralizing condenser structure may be of the type shown in the copending application of C. W. Hansell, G. L. Usselman, and C. W. Latimer, Serial No. 27,678, filed June 21, 1935.

I claim:

1. In apparatus of the character described, a pair of co-planar stator plates, a rotor condenser plate system, means providing electrical insulation of said rotor plate system from all other portions of said apparatus, means for adjusting said rotor plate system with respect to said stator plates, a pair of electron discharge tubes, each tube having its anode connected substantially directly through connections of low direct current and alternating current resistance and impedance to one of said stator plates respectively, and a fixed condenser system connected in shunt to said anodes, said fixed condenser system comprising end plates unequally spaced from said anodes, said end plates being of different size in order to maintain capacitive symmetry of said tubes with respect to each other.

2. A push-pull system comprising a variable condenser having complementary stator plates disposed in co-planar pairs and a cooperating adjustable rotor system comprising plates interleaved with said stator plates, a push-pull electron discharge tube system the tubes of which have their anodes substantially directly connected each to a particular group of said stator plates, a fixed condenser connected in shunt with said variable condenser and comprising a plurality of interleaved stator plates whereof each plate is of an effective area which is a function of its distance away from the electrical center of said discharge tube system, said function being suitably determined for balancing the electrical characteristics of said tubes, a pair of neutralizing condensers each having one of its electrodes substantially directly connected to a particular group of said stator plates, and means for simultaneously varying the capacities of said neutralizing condensers.

3. Apparatus of the character described comprising in combination a pair of electron discharge tubes having their anodes disposed in a push-pull arrangement, a tuning condenser system connected across said anodes and including two groups of stator plates and a group of rotor plates, certain of the stator plates of one group being co-planar with respect to corresponding stator plates of the other group, means including an insulation member for supporting said rotor plates in interleaved relation to the co-planar stator plates, means including conductive supports each for electrically interconnecting the stator plates of a particular group, and for maintaining certain of the same in interleaved relation to certain of the stator plates of the other group, and means providing insulation of all the stator plates of one group from those of the other group, said apparatus being further characterized in that a stator plate of one group is disposed adjacent the anodes of said discharge tubes, said stator plate being of reduced size relative to the stator plate of the other group which is nearest thereto.

4. Apparatus according to claim 3 and further characterized in that two of the stator plates, one in each group are of progressively diminished areas relative to others of the interleaved plates, the plate of smallest area being disposed nearest the anodes of said discharge tubes.

5. Apparatus according to claim 3 and having two substantially identical stator plates, one in each group, disposed in a common plane and furthest removed of all the plates from said discharge tubes.

6. A resonant circuit arrangement for a push-pull system comprising a capacitor having a plurality of pairs of co-planar stator plates, and movable plates interleaved therewith, a set of additional plates electrically connected to those of the co-planar stator plates which are disposed on one side of a plane separating complementary stator plates of each pair, a second set of additional plates electrically connected with those of the co-planar stator plates which are disposed on the opposite side of said plane, the plates of said first and second sets being interleaved, and a pair of discharge tubes disposed in push-pull relationship and in unsymmetric proximity to opposing ones of said additional plates, certain of said additional plates being of sufficiently reduced area with respect to others thereof so that electrostatic compensation for said unsymmetric proximity is provided.

GEORGE LINDLEY USSELMAN.