Sept. 20, 1932. D. G. LITTLE 1,877,918

AMPLIFIER

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Fig. 1.

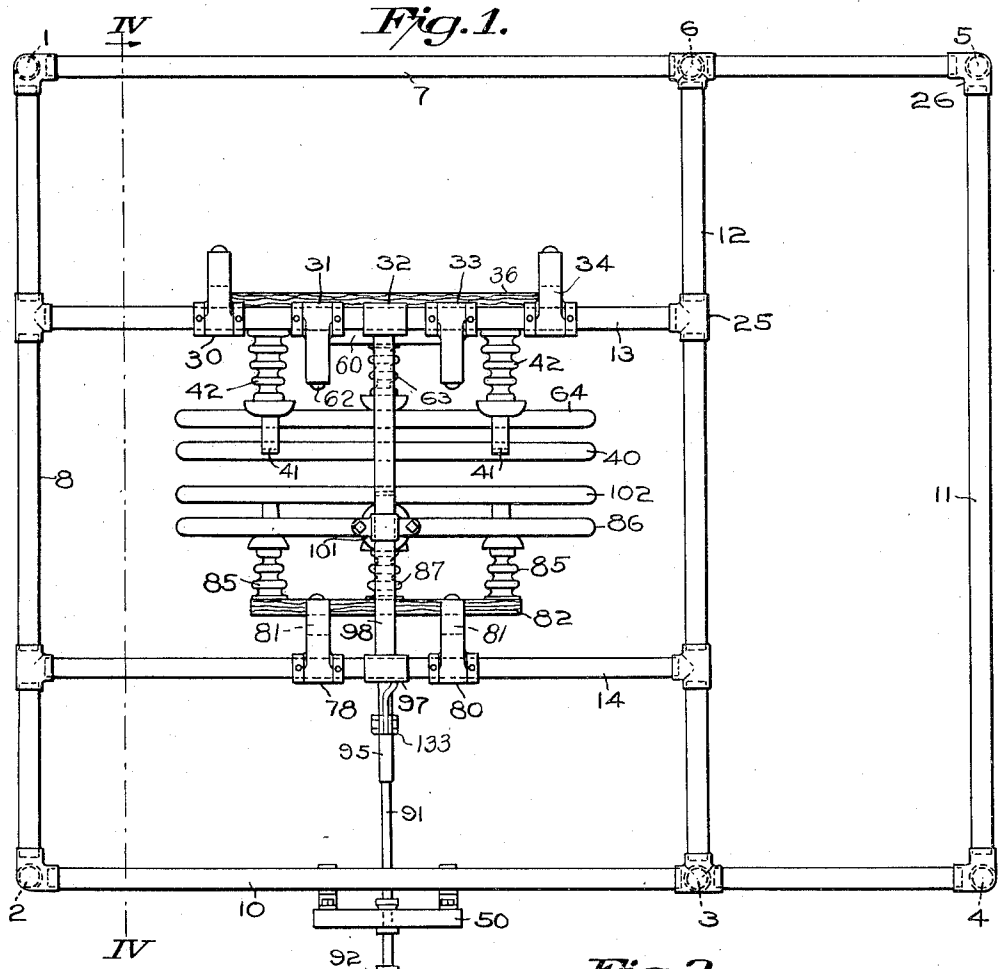


Fig. 2.

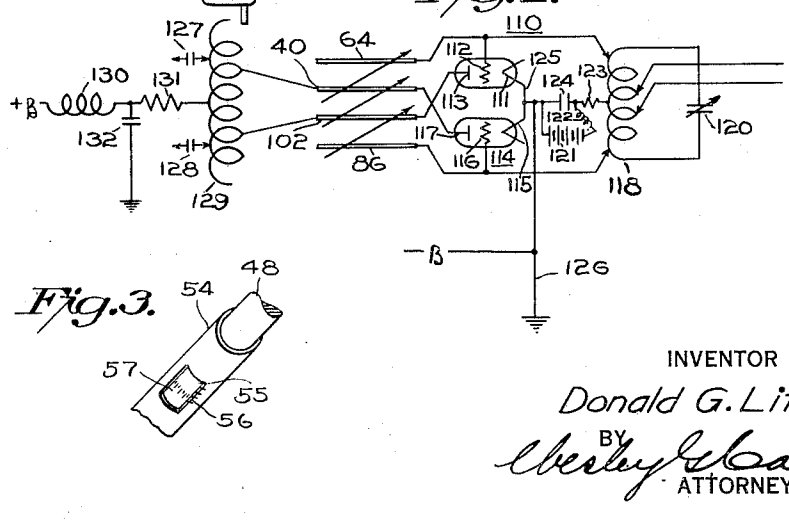


Fig. 3.

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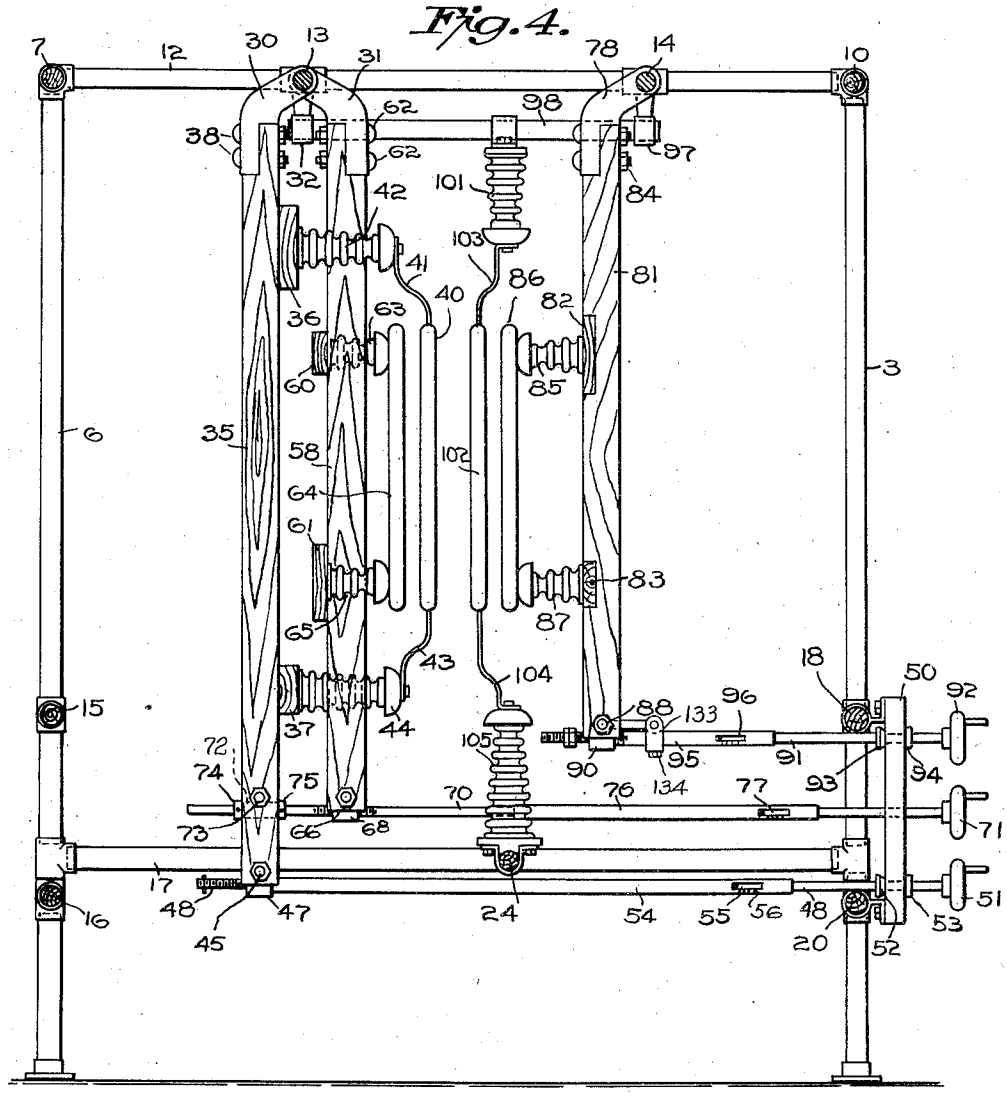
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AMPLIFIER

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Fig. 4.



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AMPLIFIER

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Fig. 5.

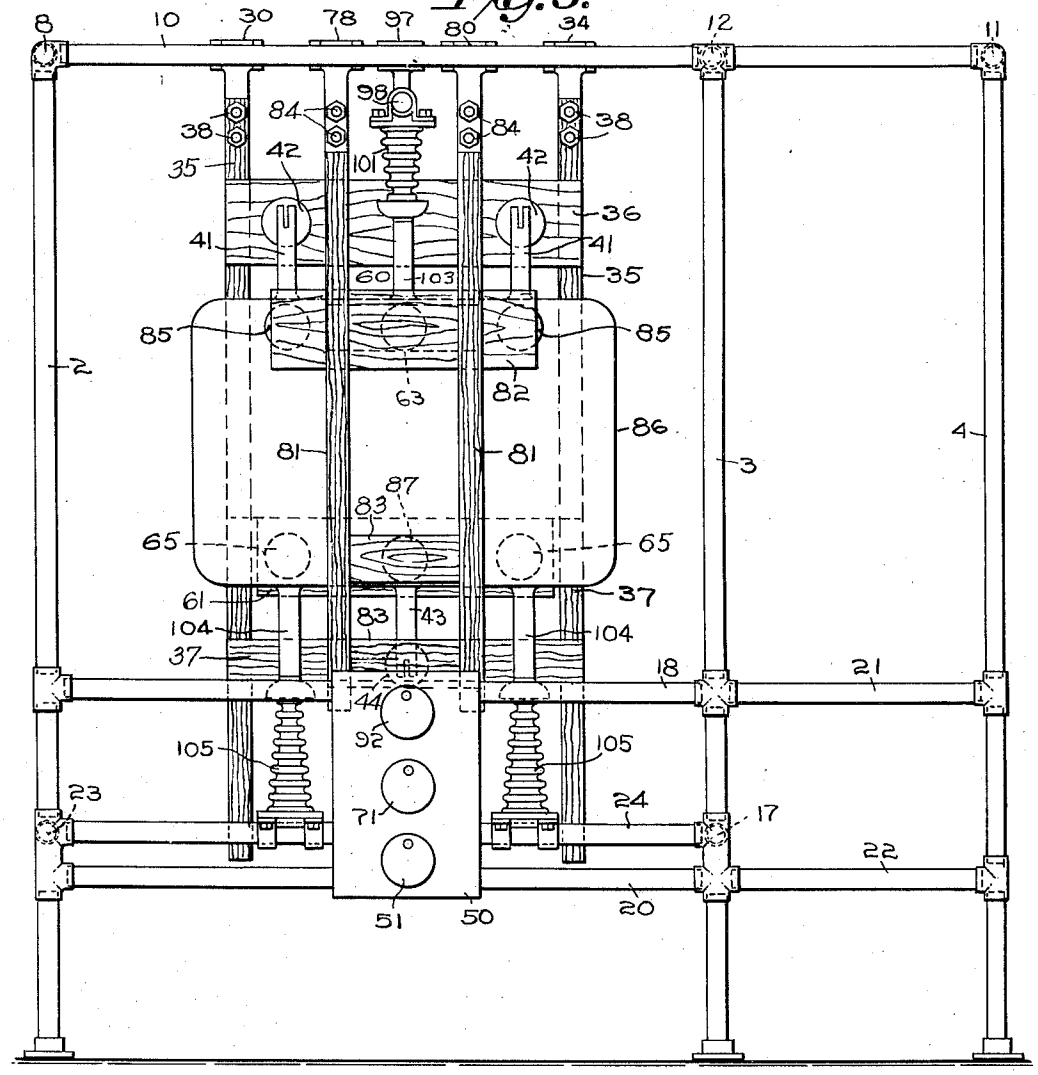
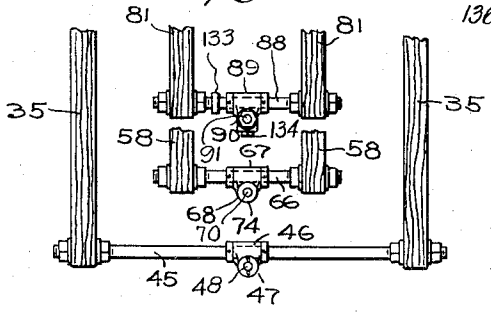


Fig. 6.



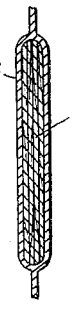


Fig. 7

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Patented Sept. 20, 1932

1,877,918

UNITED STATES PATENT OFFICE

DONALD G. LITTLE, OF SPRINGFIELD, MASSACHUSETTS, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

AMPLIFIER

Application filed January 16, 1928. Serial No. 247,033.

My invention relates broadly to amplifiers, and it has particular relation to the construction and arrangement of the constituent parts of amplifiers designed and intended to handle relatively large amounts of power at high frequencies.

The apparatus constituting an amplifying stage of a modern high-power radio-transmitter is generally weighty and cumbersome, necessitating the provision of a steel framework for its support. The framework must carry, in addition to a plurality of high-power, water-cooled thermionic devices, a plurality of inductors, one or more variable tuning condensers and a plurality of fixed coupling condensers. These units must be carefully insulated from the frame, and yet they must be so positioned that interconnections between them may be made as short as possible.

Inasmuch as the elements of the high-power thermionic tubes have a large capacity to ground, the problem of satisfactorily neutralizing an amplifier stage of the type referred to, against parasitic oscillations, is difficult of solution, particularly if the amplifier is of the balanced type in which a plurality of groups of large tubes are arranged in push-pull relation. The plates of the neutralizing condensers required, as well as the condenser associated with the tuned output circuit of the amplifier, must necessarily be of massive construction to reduce losses, and they also give rise to ground-capacity effects that interfere with proper neutralizing.

It is, accordingly, an object of my invention to provide an improved construction and arrangement of the various elements constituting an amplifier-stage arranged to handle large amounts of power at high frequencies.

Another object of my invention is to so improve the construction and arrangement of an amplifier-stage of the aforementioned type that the neutralization thereof against parasitic oscillations may be positively accomplished with the minimum of adjustments.

Another object of my invention is to provide a combined tuning and neutralizing condenser particularly adaptable for use in high-power amplifiers.

Another object of my invention is to provide, in a combined tuning and neutralizing condenser of the aforementioned type, means whereby the capacities of the several condensers may be separately and independently adjusted.

Another object of my invention is to provide mechanism for simultaneously adjusting the relative position of several sets of condenser plates.

Another object of my invention is to provide, in condensers of the aforementioned type, means for indicating the adjustment of the individual plates thereof.

Another object of my invention is to provide a condenser of the aforementioned type that has a minimum capacity to ground, and one that, accordingly, is particularly suitable for use in a balanced high-power amplifying stage.

Another object of my invention is to provide a condenser of the aforementioned type that shall have minimum power losses.

In a preferred commercial embodiment of my invention, the supporting frame for an amplifying-unit is composed partially of steel tubing and partially of wood, the wooden sections being interposed wherever the steel tubing, if continuous, would constitute a closed circuit in which high-frequency oscillatory currents could circulate.

Undesirable ground-capacity effects from the tuning and neutralizing condenser-plates are minimized by mounting them vertically, and by symmetrically arranging them with reference to a point that is maintained at ground-potential, insofar as currents at radio-frequency are concerned, the process of neutralizing the unit against parasitic oscillations is simplified.

By giving to each condenser-plate an area of approximately four to six square feet, I am enabled to provide the requisite tuning and neutralizing capacities with the minimum number of such plates, namely, four.

The individual plates are preferably made of copper sheathing laid over a foundation

of laminated wood and are provided with rounded edges to minimize corona losses.

The tuning and neutralizing condensers are provided with adjusting devices extending therefrom to an instrument panel located well outside of the electrostatic field, and the plates thereof are so mounted with reference to one another that the capacities constituted thereby may be independently adjusted.

Among the novel features of my invention are those particularly set forth in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with further objects and advantages thereof, will best be understood from a consideration of the following description of a specific embodiment, taken in connection with the accompanying drawings, in which

Figure 1 is a top plan view of an amplifying-unit embodying a preferred modification of my invention, certain incidental apparatus, such as thermionic tubes, fixed coupling-condensers, cooling-water coils, inductors, rheostats and the like, being omitted for the sake of clarity.

Fig. 2 is a diagrammatic view of the apparatus comprised in an amplifying-unit, and the circuits involved therein,

Fig. 3 is an enlarged fragmentary view of one of the indicating scales carried by the condenser-adjusting devices,

Fig. 4 is a vertical sectional view taken along a line corresponding to the line IV—IV of Fig. 1,

Fig. 5 is a front elevational view of the amplifying-unit,

Fig. 6 is a detail view illustrating the manner in which the adjusting devices are operatively connected to the condenser-plate supporting frames, and

Fig. 7 is a view in cross section of a condenser plate according to applicant's invention as shown in connection with rod 91.

The apparatus illustrated in Figs. 1, 4 and 5 comprises a rectangular supporting framework consisting of a plurality of upright tubular members 1, 2, 3, 4, 5 and 6, joined at their upper ends by tubular cross-members 7, 8, 10 and 11. An upper cross-member 12 is connected between the members 7 and 10, and the member 12, is in turn, connected to the cross-member 8 by two spaced cross-members 13 and 14. The upright members are connected, near their lower ends, by a plurality of cross-members 15, 16, 17, 18, 20, 21, 22, and a member 23 (not shown in the drawings) that connects the members 1 and 2 and is parallel to the member 17. An additional cross-member 24 is connected between the members 17 and 23, intermediate the uprights 3 and 6. The junctions between the various uprights and cross-members may be made in a convenient manner by utilizing pipe-fittings of the usual type, such as the fittings 25 and 26 shown in Fig. 1.

Although not specifically so shown in the drawings, certain of the main uprights and certain of the horizontal connecting members are tubular steel and certain others are wood, the wooden elements being inserted wherever the steel tubing, if continuous, would constitute a closed circuit. By interposing non-conducting portions in otherwise closed metallic circuits, oscillatory currents at high frequencies are prevented from circulating in the framework, and the efficiency of the amplifying unit is increased. The interposition of wooden members in the framework forms no part of the present invention, being fully disclosed in the copending application of Howard Fansler, Serial No. 58,821, filed September 26, 1925.

A plurality of suspension devices 30, 31, 32, 33 and 34 are mounted on, and depend from, the upper horizontal connecting member 13, the devices 30, 31, 33 and 34 being rotatable and the device 32 being fixed. A heavy wooden framework, comprising vertical members 35 and horizontal connecting members 36 and 37, is carried by the rotatable suspension devices 30 and 34, the upper ends of the members 35 being affixed to the depending portions of the said suspension devices and being affixed thereto by a plurality of bolts 38.

A relatively large condenser-plate 40 is supported parallel to the vertical members 35 by conducting straps 41 which connect its upper edge to two insulators 42 carried at the extremities of the cross member 36, and by a strap 43 which connects its lower edge to a single insulator 44 that extends horizontally from the center of the cross-member 37.

The vertical members 35 of the framework are connected, at their lower ends, by a tie-rod 45 (shown in detail in Fig. 6), on which is rotatably mounted a collar 46 having an interiorly threaded depending portion 47. An adjusting rod is threadedly connected to the depending portion of the collar and extends therefrom to the front of the amplifying unit where it passes through an opening in an instrument panel 50 carried by the cross members 18 and 20, and terminates in an adjustment knob 51. Thrust collars 52 and 53 surround, and are affixed to, the rod 48, where it extends through the instrument panel, and prevent axial movement between the rod and the panel.

A tube 54 surrounds the rod 48 for the major portion of its length, one end of the tube being affixed to the threaded portion 47 and the collar 46.

At the end of the tube 54 nearest the instrument panel, the wall thereof is provided with an opening 55 through which the rod may be viewed. One edge of the opening

carries a series of markings 56, and the rod, at this point, is provided with a circular series of graduations 57 which cooperate with the markings carried by the edge of the opening in the tube to constitute an adjustment-indicator. The specific manner in which the index carried by the opening and the markings carried by the rod cooperate is clearly shown in Fig. 3.

A heavy wooden frame, comprising vertical members 58 and horizontal bracing members 60 and 61, is carried by the rotatable suspension devices 31 and 33, the upper ends of the members 58 being affixed to the depending portions of the suspension devices by a plurality of bolts 62. The suspended members 58 hang between the insulators 42 that support the upper edge of the plate 40, and the insulator 44, that supports the lower edge of the same plate, passes between the suspended members.

An insulator 63 is mounted on, and extends horizontally from, the cross-member 60 intermediate the suspended members 58 and supports the upper edge of a condenser plate 64 having an area equal to the plate 40. Two insulators 65 are mounted on, and extend horizontally from, the lower cross-member 61, exteriorly of the suspended members 58, and support the lower edge of the condenser plate 64, in substantial parallelism with the plate 40.

The lower ends of the wooden members 58 are connected by a tie-rod 66, as shown in Fig. 6, and a collar 67, having a depending, interiorly threaded portion 68, is rotatably mounted thereon. An adjusting rod 70 is threadedly connected to the depending portion 68 of the collar 67 and extends therefrom toward the front of the amplifying unit where it passes through the instrument panel 50 and terminates in an operating knob 71. The opposite end of the rod 70 passes through a bearing device at 72 rotatably mounted on a tie-rod 73 extending between the members 35 and is prevented from moving axially with reference thereto by a plurality of thrust collars 74 and 75. The rod 70 is provided with an enclosing tube 76 having an adjustment-indicating window 77 formed in a wall thereof, the tube being restrained from axial movement by means of a mounting device, such as a bracket 133 or the like, having a set screw 134 or other clamping means for preventing undesirable movement of the tube.

Two suspension devices 78 and 80 are rotatably mounted on the top horizontal cross-member 14, and carry a substantial wooden framework comprising vertical members 81 and horizontal bracing members 82 and 83. The upper ends of the vertical members 81 are affixed to the depending portions of the suspension devices 78 and 80, respectively, by means of a plurality of bolts 84.

Two insulators 85 are mounted on, and extend horizontally from, the outside ends of the bracing member 82 and support the upper edge of a large vertical condenser-plate 86, the lower edge of the plate being supported by an insulator 87 that is mounted on, and extends horizontally from, the bracing member 83 intermediate the members 81.

A tie-rod 88 extends between the lower ends of the depending members 81 and has rotatably mounted thereon a collar device 89 provided with an interiorly threaded depending portion 90. An adjusting rod 91 is threadedly connected to the depending portion 90 of the collar member and extends therefrom toward the front of the framework where it passes through the instrument panel 50 and terminates in a knob 92. The rod is prevented from axial movement with reference to the panel by a plurality of collars 93 and 94 which are affixed to it, one on each side of the panel. The rod is encircled by a tube 95, one end of which is affixed to, and moves with, the collar device 89. The tube 95 has an observation window 96 provided with indicia, the same as the tubes described in connection with the other adjustment rods.

In addition to the aforementioned bearing members carried by the cross pieces 13 and 14, the cross piece 14 is provided with a suspension device 97 between which and the device 32 mounted on the member 13 extends a horizontal bar 98. An insulator 101 depends from the bar 98, and a condenser plate 102 is suspended from the lower end of the insulator by means of a heavy strap 103, and is supported from below by similar straps 104 carried by two insulators 105 mounted on the cross-member 24 which extends between the frame members 17 and 23.

The condenser plates 40 and 102 constitute the tuning condenser for the output, or tank, circuit of the unit. The condenser plate 64 and the condenser plate 40 constitute one of the neutralizing condensers, the other neutralizing condenser comprising the fixed plate 102 and the movable plate 86.

The capacity of the output-circuit condenser, constituted by the plates 40 and 102, may be adjusted by rotating the rod 48 by means of the knob 51 to cause the lower ends of the members 35 which carry the plate 40 to approach or recede from the instrument panel 50. The capacity of the neutralizing condenser constituted by the plates 64 and 40 is not altered by the movement of the members 35, inasmuch as the frame members 58, which carry the plate 64, are constrained to move with the said members 35 by reason of the fact that the adjusting rod 70 is threadedly connected to the collar 67 carried by the members 58, and cannot move axially with reference to the members 35 on account of the collars 74 and 75.

Similarly, the capacities of the two neu-

tralizing condensers, constituted by the plates 64 and 40 and the plates 86 and 102, may be altered by rotating the adjusting rods 70 and 91, respectively, without interfering with the adjustment of the output-circuit condenser.

It will be noted that the adjusting knobs 51, 71 and 92 are located at a considerable distance from the condenser plates and that they are purposely positioned outside of the electric field existing between the said plates. The adjustment of the various tuning and neutralizing capacities, accordingly, may be made by the attendant without disturbing capacity effects being caused by the presence of any portion of his anatomy in the electric field.

The observation windows and the several series of index marks carried by the tubes and the adjustment rods may be so arranged as to permit the setting of the condenser plates to a predetermined capacity, to a predetermined spacing apart, or to a predetermined wave length, the latter setting, of course, being controlled by the size of the output inductor associated therewith.

One extremely valuable feature of my invention resides in the fact that the condenser plates depart very slightly from parallelism during adjustment. This is advantageous in that it prevents the electric field between the plates from becoming unduly concentrated at any one position, with the consequent likelihood of corona and brush discharges occurring.

The space bounded by the upright members 3, 4, 5 and 6, and the horizontal members 11, 12 and 17 is, in a commercial embodiment of my invention, occupied by eight high-power water-cooled tubes and the mounting devices therefor. In addition, a portion of this space may be utilized for the positioning of the input inductor.

Although not specifically so shown in the drawing, the top cross-members 13 and 14 may be provided with additional insulating supports from which depend the inductors going to make up the output or tank circuit, these inductors being positioned relatively close to the upper edges of the condenser plates.

In order to more fully appreciate the advantages accruing from the positioning of the condenser plates in vertical planes, attention should be directed to Fig. 2. The apparatus shown diagrammatically in Fig. 2 comprises two groups of high-power thermionic devices, the corresponding elements of the devices in each group being connected in parallel and the several groups being connected in push-pull relationship with respect to an input and an output circuit.

In the drawings, one group is represented by a thermionic device 110 having a filament 111, a grid 112 and an anode 113 and the second group is represented by a similar thermionic device 114, having a filament 115, a grid 116 and an anode 117. The source of filament power is not illustrated.

The grid 112 of the device 110 is connected to one end of an input inductor 118 which is shunted by a tuning condenser 120, and the grid of the device 114 is connected to the opposite end of the inductor 118. Negative biasing potential is supplied from any convenient source 121 over a circuit including a radio-frequency choke coil 122 and a resistor 123 which is connected to a mid-point on the input inductor 118. In order that this mid tap shall be maintained at ground potential, a blocking condenser 124 is inserted between the resistor and a conductor 125 common to the filaments, which conductor is provided with a ground connection 126.

The output circuit of the thermionic devices comprises an inductor 129 having the condenser plates 40 and 102 connected in shunt thereto, and the inductor 129 may be connected to a later amplication stage by a plurality of coupling condensers 127 and 128.

Plate potential is supplied from any convenient source over a circuit which includes a radio-frequency choke coil 130 and a resistor 131 connected to a mid-point on the inductor 129. The resistor 131 is grounded through a large stopping condenser 132 which serves to maintain the mid-point on the inductor 129 at ground potential with respect to radio frequencies.

The grid 112 of the thermionic device 110 is cross-coupled to the anode 117 of the thermionic device 114 through the capacity existing between the plate 64 and the plate 40 of the tank circuit condenser. The grid 116 of the thermionic device 114 is cross-coupled to the anode 113 of the thermionic device 110 through the capacity which exists between the plate 102 of the tank circuit condenser and the plate 86 which is conductively connected to the grid 116.

By reason of the fact that the four condenser plates are, at all times, substantially vertical and have horizontal projections which are substantially equal, the capacity-to-ground of the plate 40 is substantially the same as that of the plate 102. The capacity-to-ground of the plate 64 is practically the same as that of the plate 86, provided the spacing between these plates and the tank-condenser plates is approximately the same. The approximate equivalency of the capacity-to-ground of the several condenser plates renders the process of neutralizing the circuit against parasitic oscillations vastly more simple than is the case when each condenser comprises a plurality of plates either horizontally or vertically positioned. The circuit, considered as a whole, oscillates about the grounded mid portions of the input and output inductors, the several tuning-condenser plates receiving alternatively potentials

which are equal in magnitude and opposite in sign.

When the neutralizing condenser capacities are altered to effect neutralization of the circuit, the capacity-to-ground of the two sides of the system is not sufficiently changed to interfere materially with the tuning of the output circuit.

In addition to the fact that the capacities to ground remain fairly constant, another important advantage is present, namely, the neutralizing-condenser plates are effectively shielded, one from the other, by the interposition of the plates constituting the tank circuit condenser.

Although perhaps not readily apparent from an inspection of the drawings, it has been found in practice that the vertical arrangement of the condenser plates permits the assembly of an amplifying unit in which the leads interconnecting the plates, the input and output inductors, and the thermionic device, are of minimum length. Inasmuch as even the smallest portion of a conductor offers an appreciable impedance to oscillatory currents at ultra-high frequencies, the shortening of interconnections permitted by my invention results in a marked increase in efficiency.

Each of the individual condenser plates preferably comprises a foundation 135 made of seasoned wood, either laminated or plain, completely covered by copper sheathing 136. The foundation element should have thickness of approximately 1 or 2 inches, or more, in order that the edges of the plates may be sufficiently rounded-off to prevent corona discharges between them.

Each plate is preferably supported from three insulators since this method of support is less likely to introduce unbalanced stresses which might tend to warp the plates.

I have, accordingly, provided, by my invention, an amplifier-unit assembly that is particularly adapted for use in connection with radio transmitting installations handling currents at extremely high frequencies. The losses in my improved tuning and neutralizing condenser are negligible, and the adjustment of the various capacities may be expeditiously made.

By reason of the fact that the various component parts of the amplifying unit, including the condenser plates, the thermionic device, the coupling condensers, etc., may be physically so arranged that they are balanced at radio frequency with respect to grounded points, it is much easier to tune and neutralize the unit than amplifying units with which I have been previously acquainted.

Although I have shown and described only one specific embodiment of my invention, many modifications and alternative forms thereof will be apparent to those skilled in the art of radio transmission. My invention, therefore, is not to be limited except by the prior art or by the spirit of the appended claims.

I claim as my invention:

1. In combination, a framework adapted to support radio apparatus constituting a power-amplifying stage, and a condenser having substantially vertical plates, said framework hingedly supporting certain of said plates, the adjustable movement of said hingedly supported plates being substantially normal to others of said plates.

2. In combination, a framework adapted to support radio apparatus constituting a power-amplifying stage, and a combined neutralizing and tuning condenser, the plates of said condenser being substantially vertical, said framework hingedly supporting certain of said plates, the adjustable movement of said hingedly supported plates being substantially normal to others of said plates.

3. In combination, a framework adapted to support radio apparatus constituting a power-amplifying stage, and a combined tuning and neutralizing condenser comprising a plurality of substantially vertical plates mounted thereon, said plates being angularly adjustable with respect to each other, the adjustable movement of said hingedly supported plates being normal to others of said plates.

4. In combination, a framework adapted to support radio apparatus constituting a power-amplifying stage, a combined tuning and neutralizing condenser comprising a plurality of substantially vertical plates mounted thereon, means for varying the angular relation of said plates to each other in a direction normal to the plane of at least one of said plates, and means for indicating the adjustment thereof.

5. A combined tuning and neutralizing condenser comprising supporting means, a condenser element fixedly supported from said means, a plurality of condenser elements pivotally supported from said means, means for adjusting the space relations of said plurality of condenser elements to said fixed element, and means for adjusting the space relation among said plurality of elements.

6. A combined tuning and neutralizing condenser comprising supporting means, a condenser element relatively fixedly supported from said means, a condenser element pivotally supported from said means in capacitive relation to said fixed element, a plurality of condenser elements pivotally supported from said means and arranged for simultaneous angular movement with respect thereto and to said fixed element, and means for varying the angular relation to each other of said plurality of pivotally supported elements.

7. In a radio-frequency power structure, means for varying the capacity between parts thereof and retaining substantially constant capacity between the structure and the

ground including condenser elements disposed in planes substantially normal to a major reference ground base and means for adjusting said elements in a direction substantially normal to the planes thereof.

8. In a radio-frequency power structure, means for varying the capacity between parts thereof and retaining substantially constant capacity between the structure and ground including a plurality of condenser elements, comprising a movable group, disposed in planes substantially normal to a major reference ground base, means for simultaneously moving said movable group thereof relative to another thereof in a direction substantially normal to the planes thereof and means for relatively moving elements of the movable group in said direction.

In testimony whereof, I have hereunto subscribed my name this ninth day of January, 1928.

DONALD G. LITTLE.