Jan. 6, 1942. J. R. REID 2,268,619

RADIO RECEIVING APPARATUS

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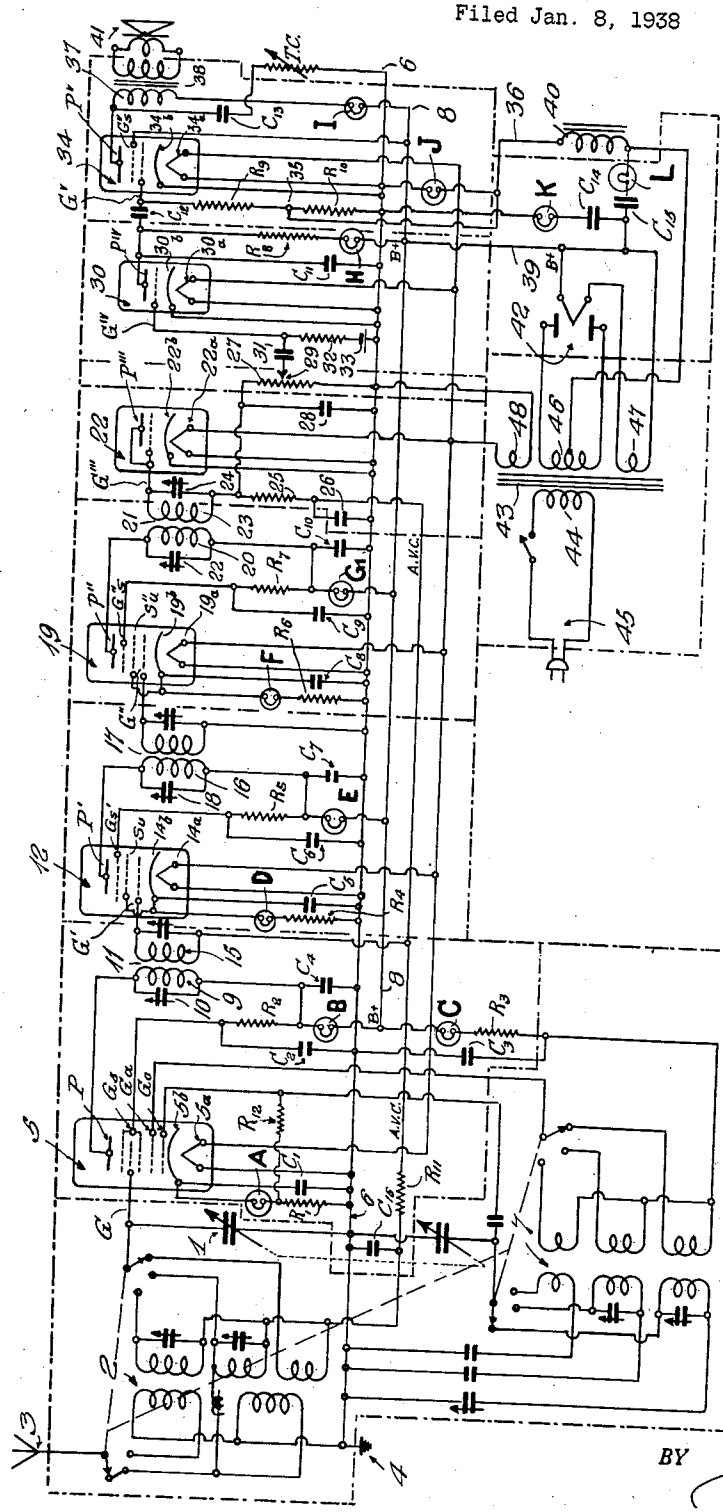

INVENTOR.
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BY John B. Brady
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Jan. 6, 1942. J. R. REID 2,268,619

RADIO RECEIVING APPARATUS

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FIG. 2

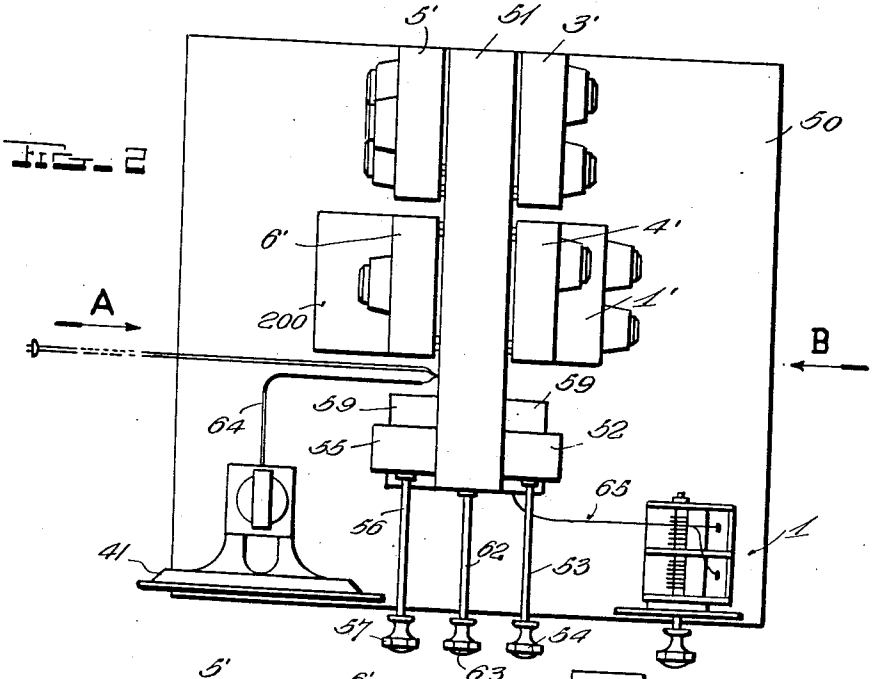


FIG. 3

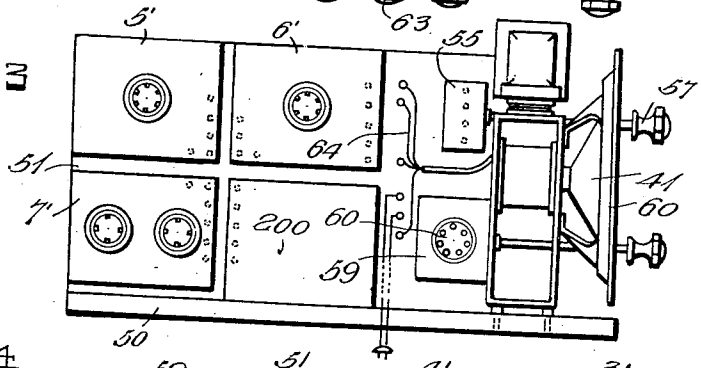
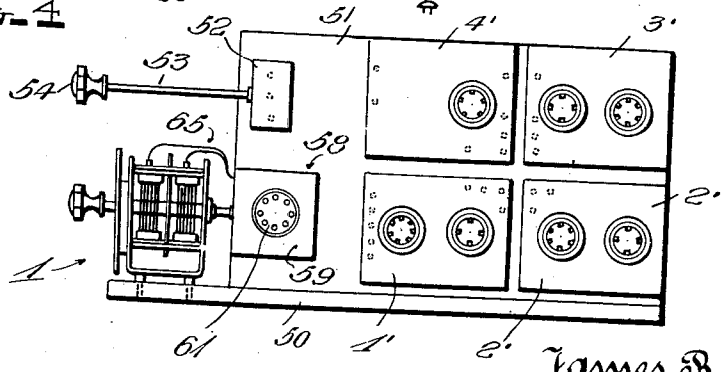


FIG. 4



INVENTOR.
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RADIO RECEIVING APPARATUS

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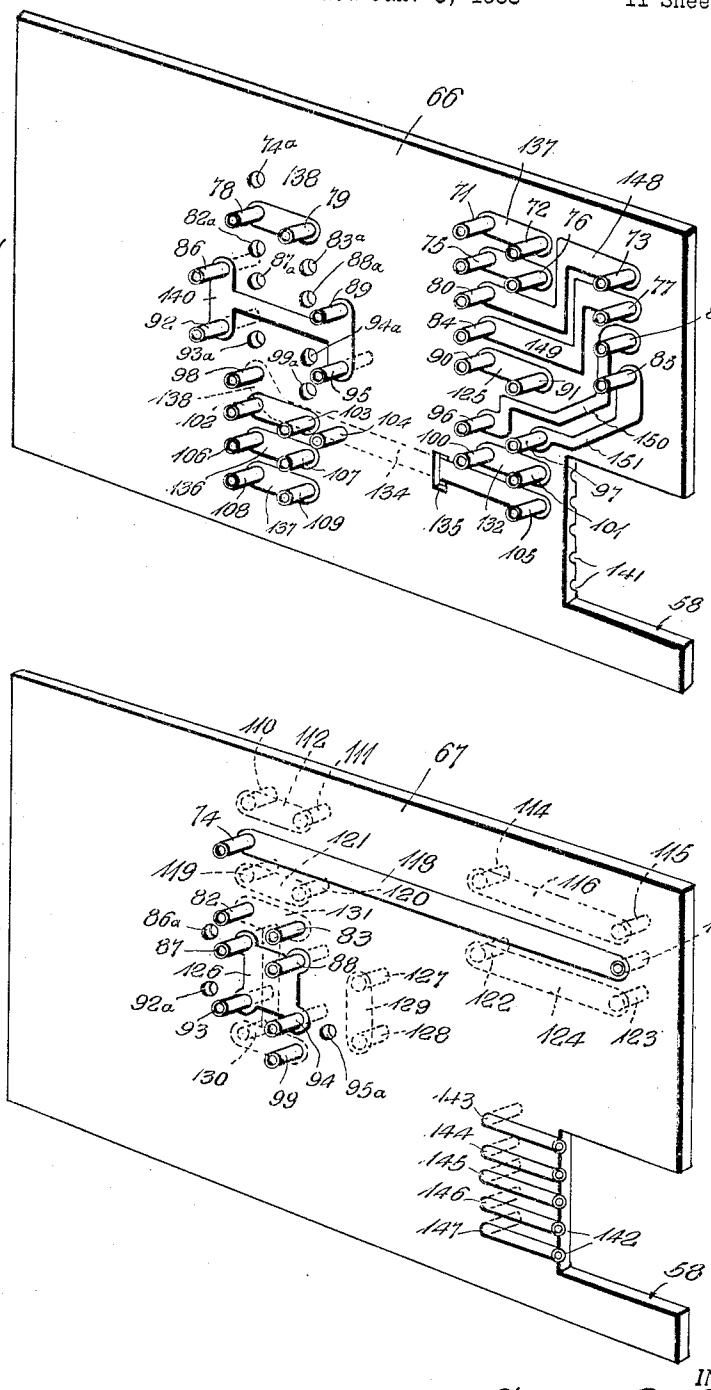
FIG. 5



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RADIO RECEIVING APPARATUS

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FIG. 6.

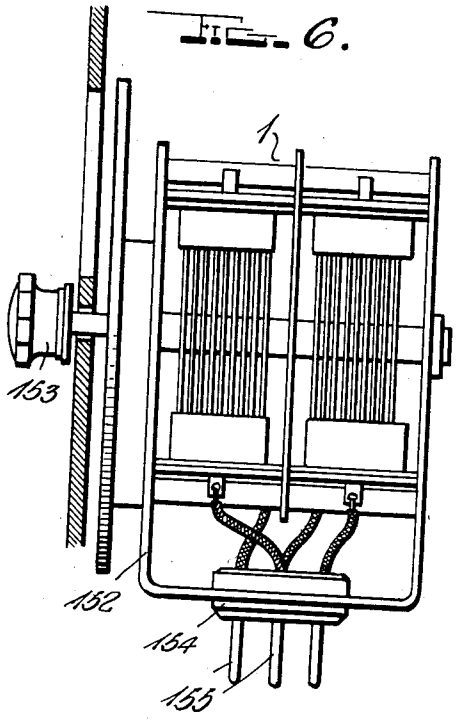

FIG. 7.

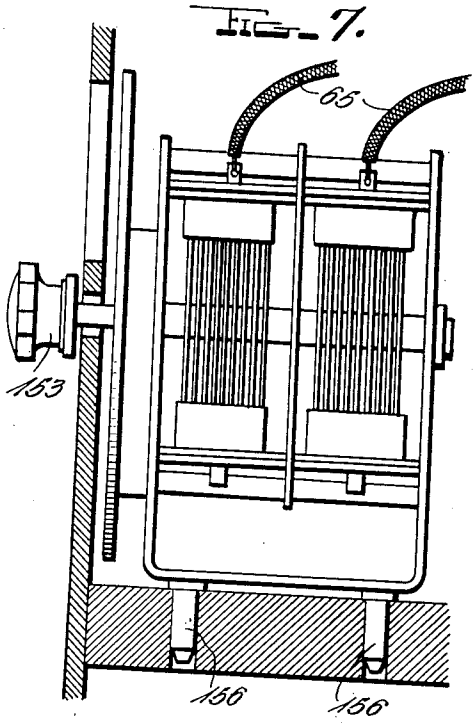

FIG. 13.

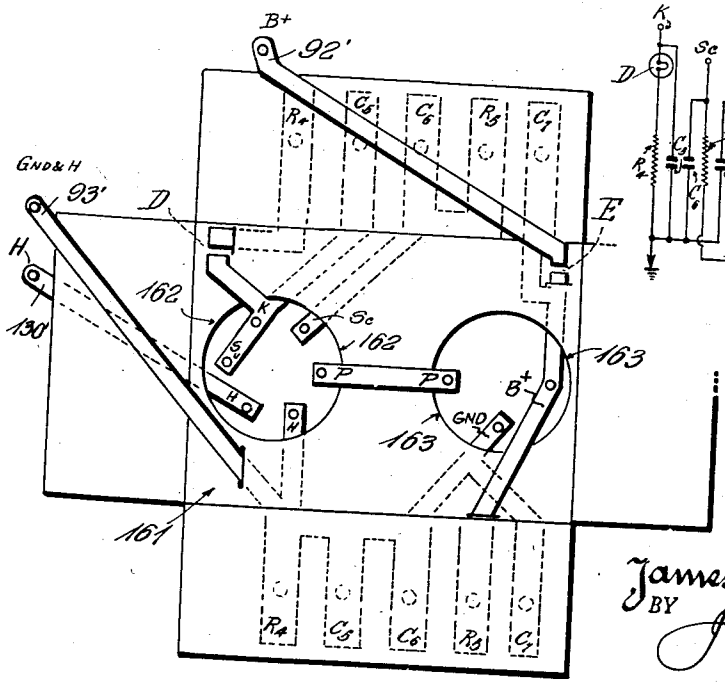

FIG. 14

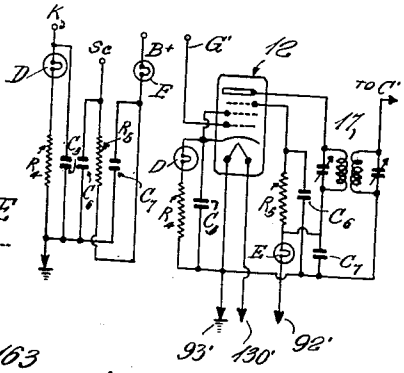

FIG. 15.

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FIG. 12.

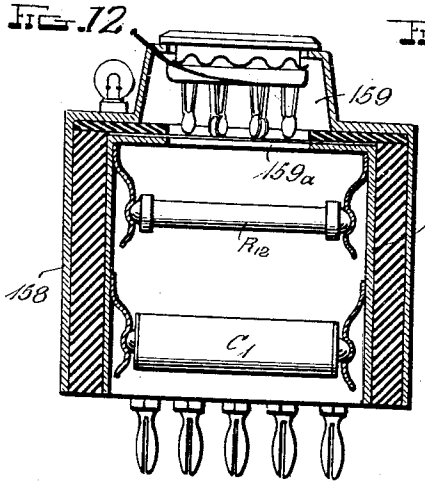

FIG. 11.

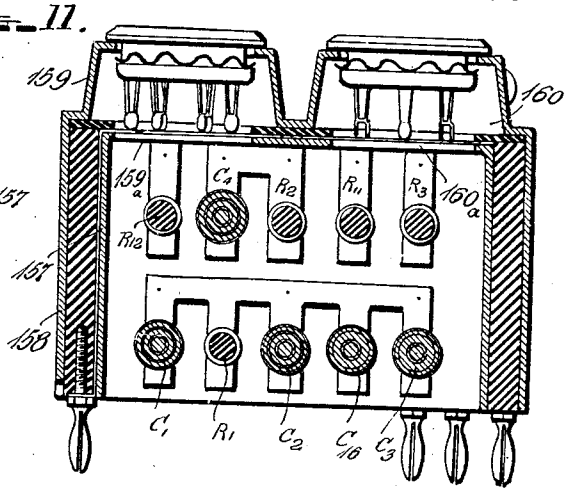

FIG. 9.

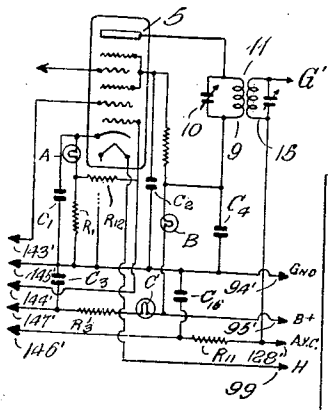

FIG. 10.

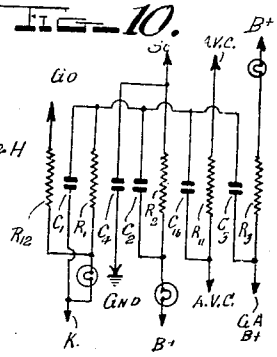

FIG. 8.

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Jan. 6, 1942. J. R. REID 2,268,619

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Fig. 16.

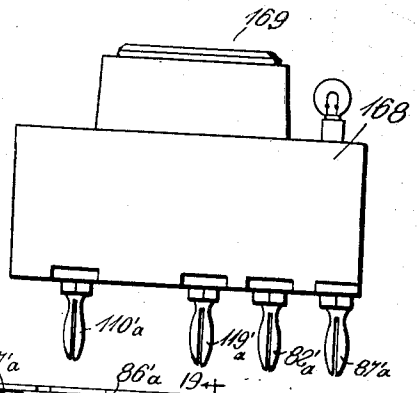

Fig. 17.

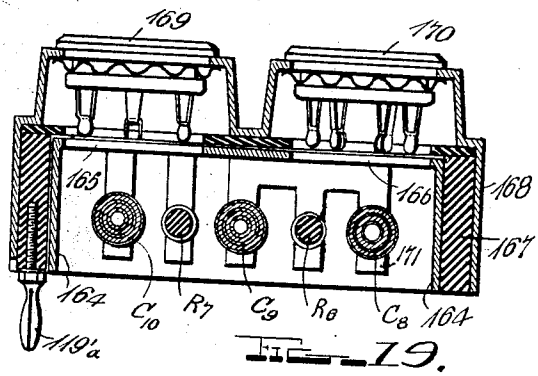

Fig. 19.

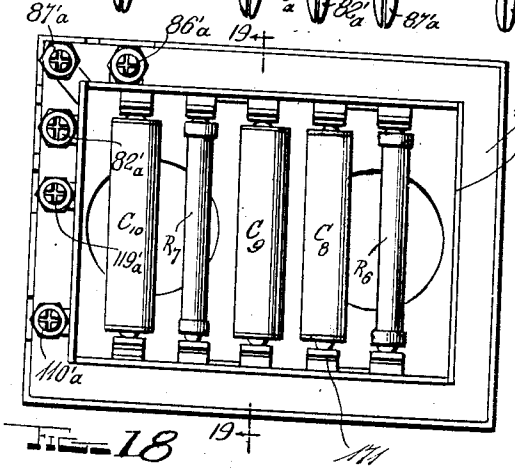

Fig. 18

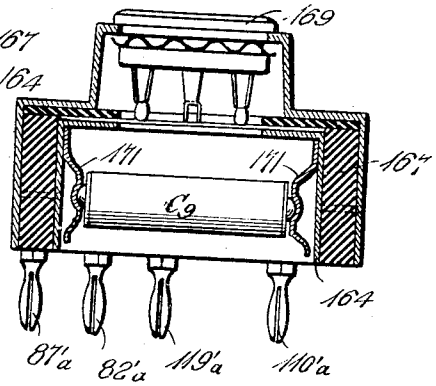

Fig. 21.

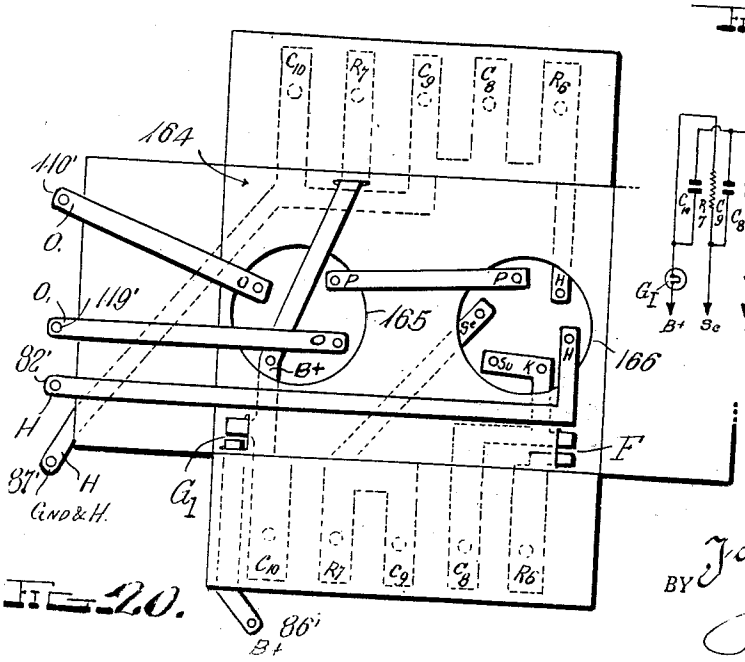

Fig. 20.

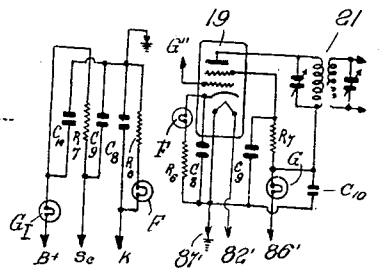

Fig. 22

INVENTOR.
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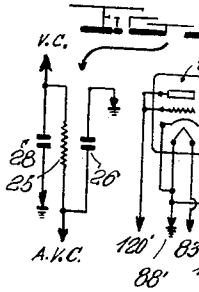
FIG. 24.



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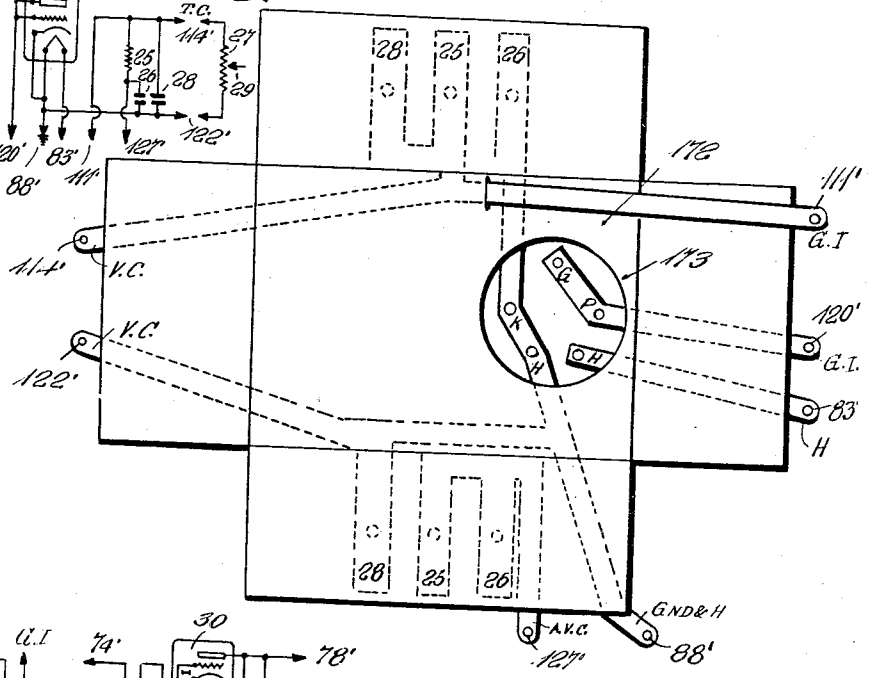

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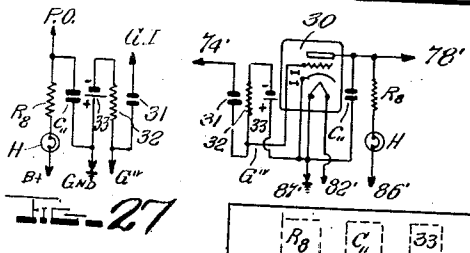

FIG. 27.

FIG. 28.

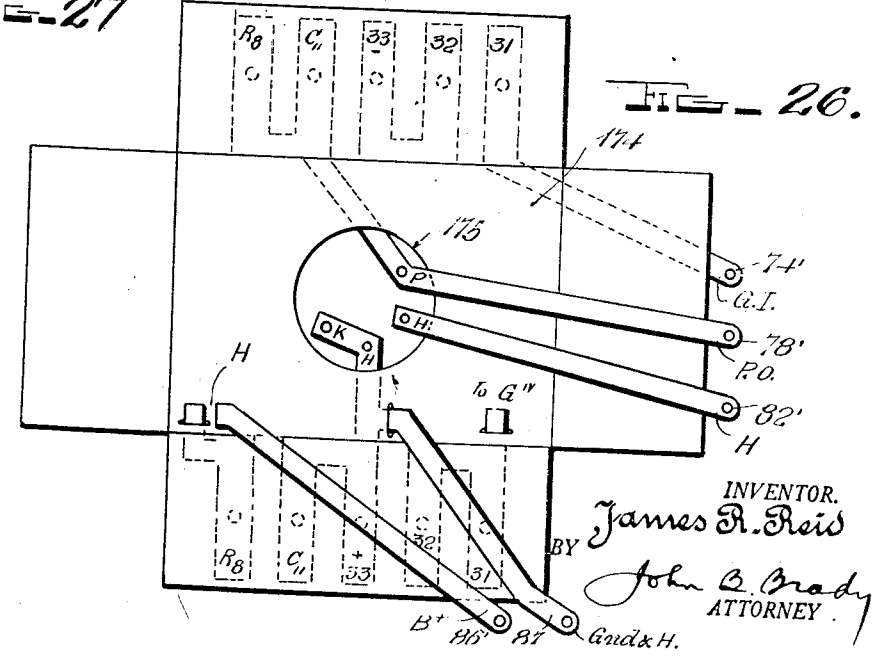

FIG. 26.

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FIG. 30.

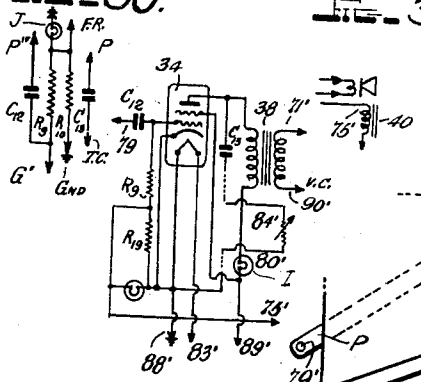
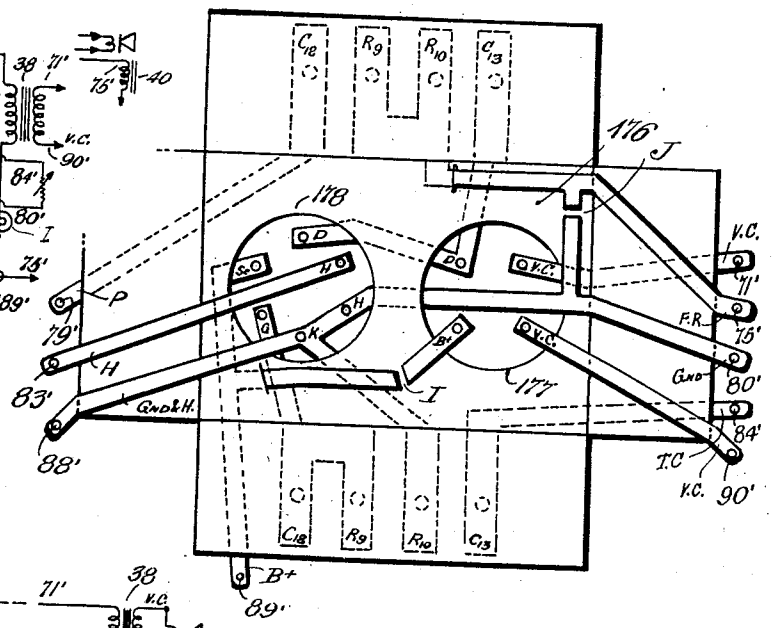


FIG. 31.



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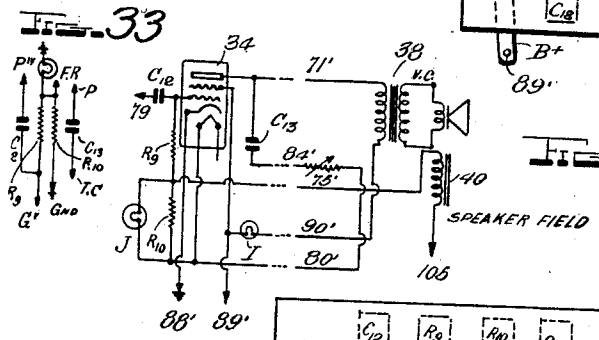

FIG. 33.

FIG. 34.

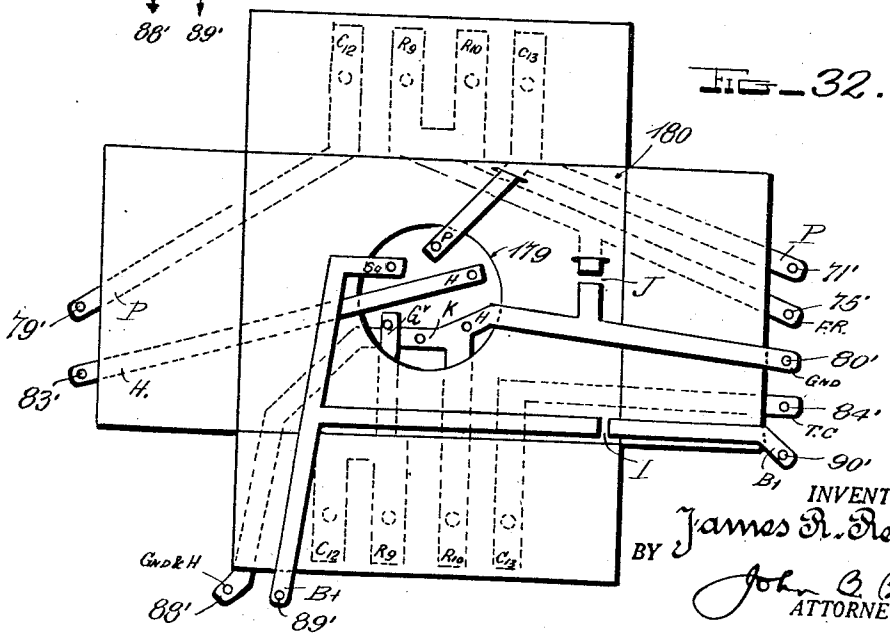

FIG. 32.

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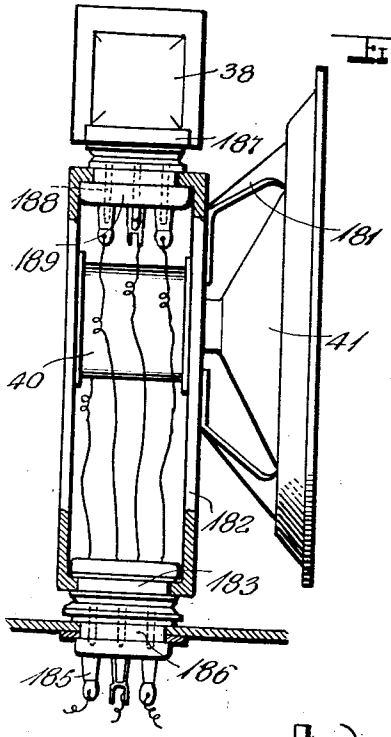

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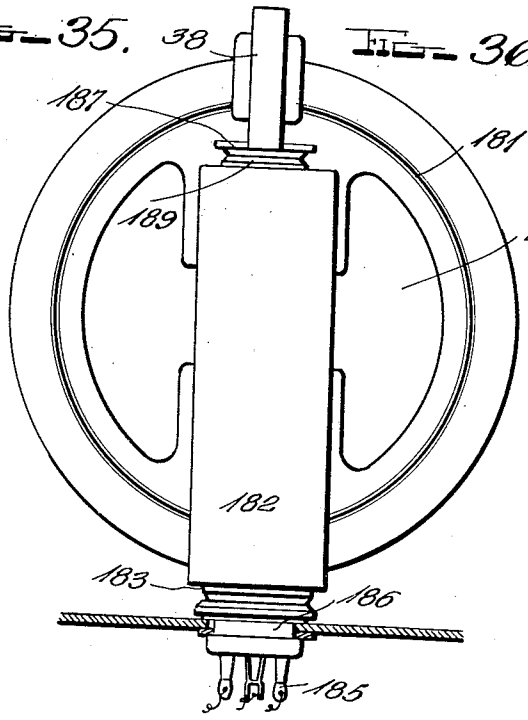

FIG. 36.

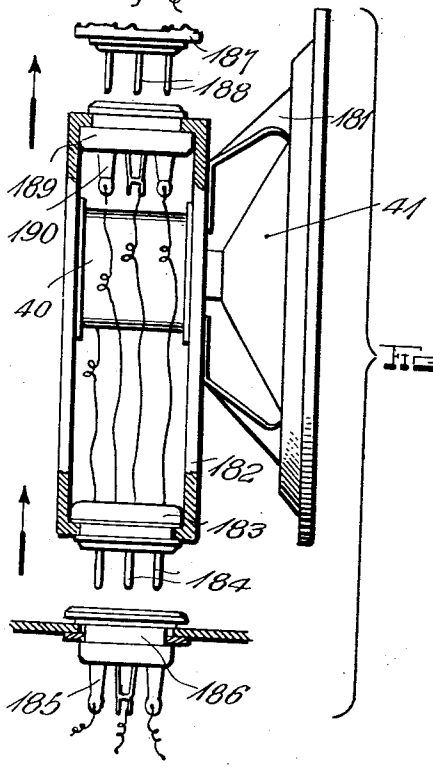

FIG. 37.

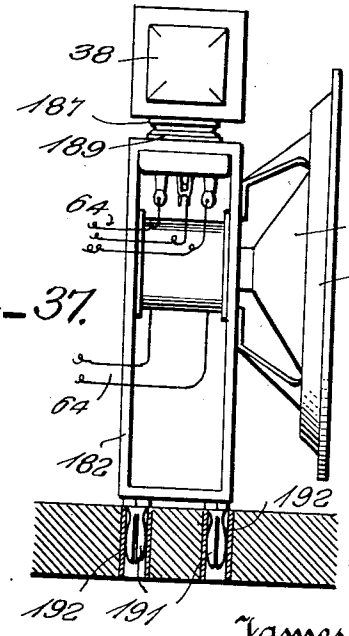

FIG. 38.

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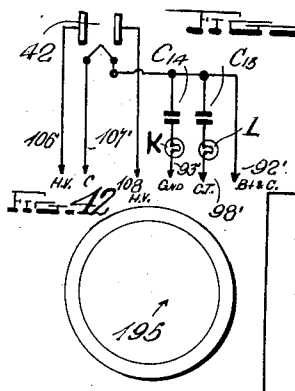

FIG. 40.

FIG. 42.

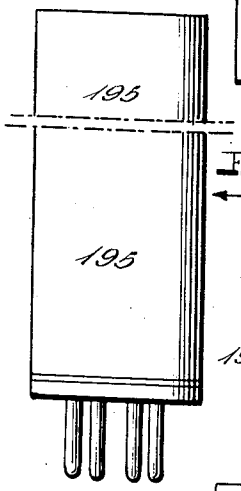

FIG. 41.

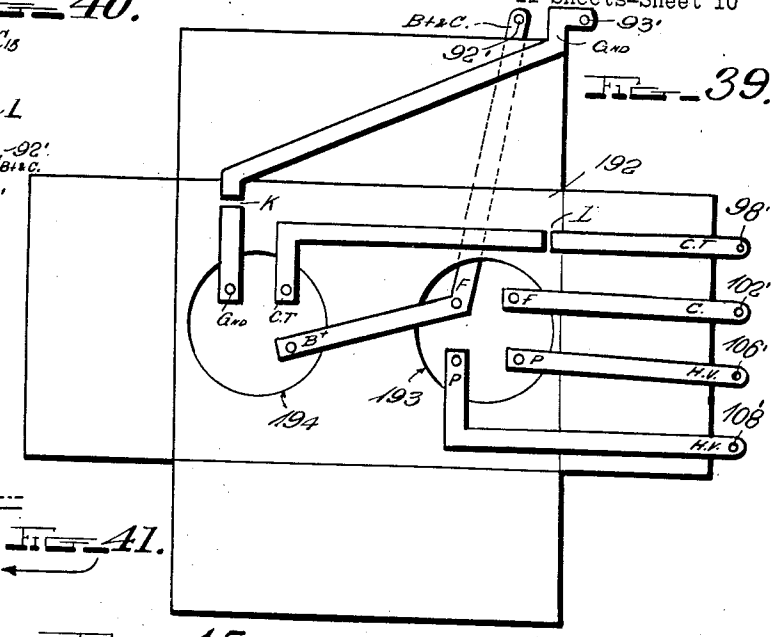

FIG. 39.

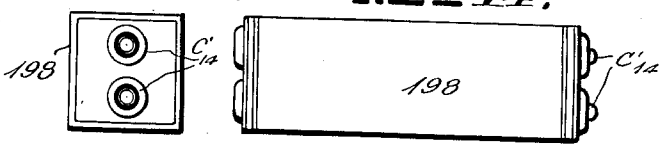

FIG. 45.

FIG. 44.

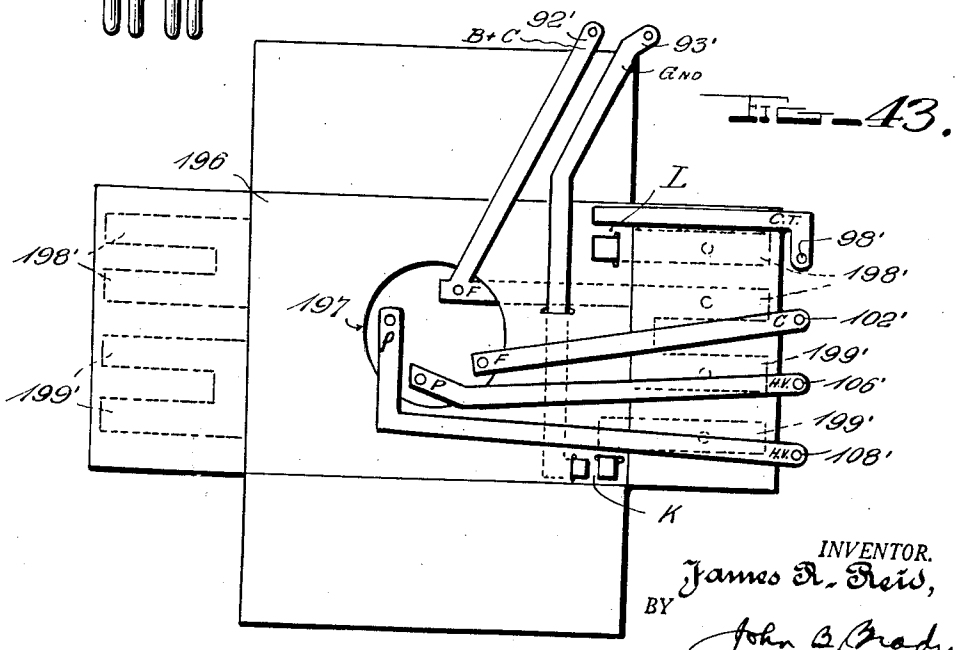

FIG. 43.

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FIG. 46.

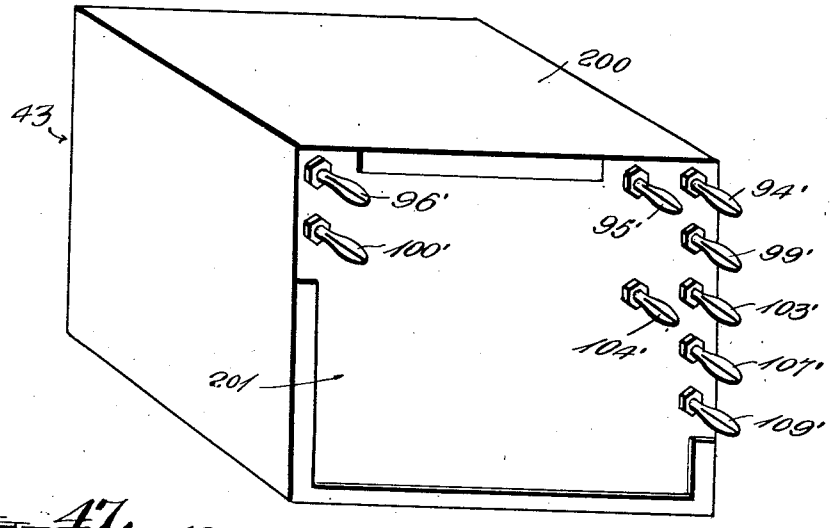


FIG. 47.

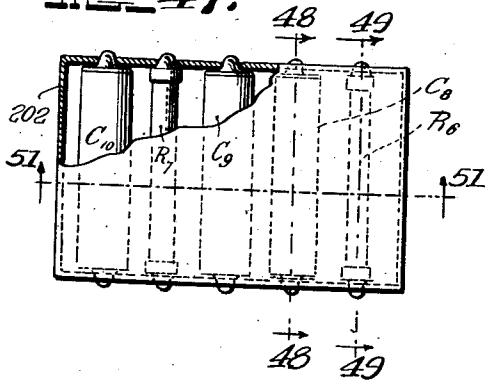


FIG. 48.

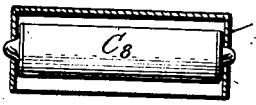


FIG. 49.

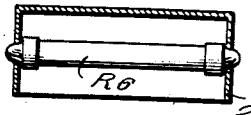


FIG. 50.

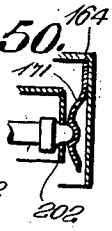


FIG. 51.

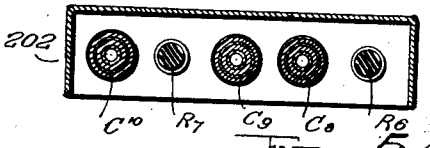


FIG. 52.

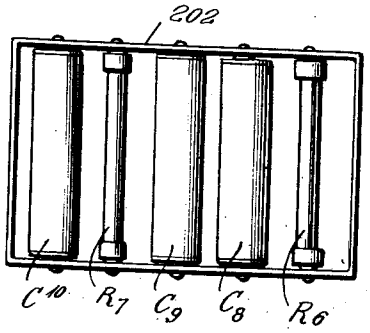


FIG. 53.

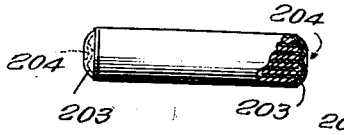
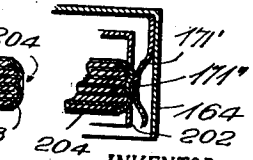


FIG. 54.



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BY John B. Grady
ATTORNEY

Patented Jan. 6, 1942

2,268,619

UNITED STATES PATENT OFFICE

2,268,619

RADIO RECEIVING APPARATUS

James R. Reid, Tampa, Fla., assignor, by direct and mesne assignments, of one-half to Joseph A. Beasley, Tampa, Fla., and one-half to John B. Brady, Washington, D. C.

Application January 8, 1938, Serial No. 184,062

8 Claims. (Cl. 250—16)

My invention relates broadly to radio receiving apparatus and more particularly to an improved construction and method of assembly for a radio receiving apparatus.

One of the objects of my invention is to provide an improved construction of radio receiving apparatus having a high electrical efficiency resulting from the substantial elimination of interconnecting buses or lead wires in the chassis of the receiver.

Another object of my invention is to provide a simplified construction of radio receiving apparatus in which the parts of the receiver are so assembled as to be readily accessible for repair and replacement.

Another object of my invention is to provide a construction of radio receiving apparatus which is inexpensive in manufacture and production and which is readily adaptable for standardization in the industry to allow compact assembly and distribution of radio receiving apparatus.

A further object of my invention is to provide a construction of radio receiving apparatus in which improved units may be substituted for obsolete units from time to time for maintaining the apparatus modern in all respects and capable of including the improvements in the art without the necessity of abandoning the original receiver.

A further object of my invention is to provide a construction of radio receiving apparatus which embodies a heart adapted to provide removable interconnection for separable units constituting the radio receiving apparatus for establishing extremely short interconnections between parts of the units for substantially reducing the losses and improving the electrical efficiency of the apparatus.

Still another object of my invention is to provide a construction of radio receiving apparatus having a centralized interconnection member with respect to which removable compact units may be readily assembled and electrically interconnected for completing the circuits of the radio receiving apparatus, tuning equipment and sound reproducing system, with minimum interconnecting leads or buses.

A further object of my invention is to provide a construction of radio receiving apparatus adapted to be assembled by means of coacting compact replaceable units in which selected units are provided with electrical indicators energizable from the normal operating current used for excitation of the respective units for indicating the operative condition of the units so that upon failure of the electrical indicator in any one of the units, such unit may be readily removed and replaced, allowing for quick and inexpensive servicing of the apparatus.

Still another object of my invention is to provide a construction of radio receiving apparatus composed of and constituted by a number of coacting replaceable units assembled in such manner that failure of any one of the units may be readily localized and the apparatus serviced and repaired and replacements made at minimum cost and with minimum expenditure of time.

Still another object of my invention is to provide a construction of electron tube apparatus constituted by a multiplicity of coacting replaceable units in certain of which protective devices are included for substantially eliminating the effect of destructive currents upon the elements of the unit in the event of emergency or abnormal conditions for the protection of the parts of the unit and coacting parts of related units.

A further object of my invention is to provide protective means for the power supply circuits and related parts therein of a radio receiver such as the windings of the power transformer, condensers and reactors of the main filter circuit and the field of the electrodynamic sound reproducer generally employed in the sound reproducer circuit of a radio receiving apparatus.

A still further object of my invention is to provide a radio receiving system constituted by a multiplicity of coacting replaceable units having electron tube circuits therein and in which selected electron tube circuits have the elements

thereof protected by means of electrical fuses and visual indicators which also serve in coaction with resistor elements in the electron tube circuits for deriving the proper bias and voltage potentials for the correct operation of the tube circuits.

A further object of my invention is to provide a system of replaceable units for assembling a radio receiving apparatus in which individual elements constituting the replaceable units are also readily replaceable for facilitating servicing and repair of the individual units.

Other and further objects of my invention reside in the construction of heart, replaceable units, indicators, chassis and the assembly of the replaceable units with respect thereto as will be set forth more fully in the specification hereinafter following by reference to the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of the radio receiver system of my invention; Fig. 2 is a plan view of the radio receiver of my invention; Fig. 3 is a side elevational view looking in the direction of arrow A in Fig. 2; Fig. 4 is a side elevational view looking in the direction of arrow B in Fig. 2; Fig. 5 is a perspective view of the heart of the radio receiver constituting my invention; Fig. 6 is a schematic view of one form of tuning unit which may be employed in the system of my invention; Fig. 7 is a view of a differen form of tuning unit which I may employ in the system of my invention; Fig. 8 is a plan view of the chassis for the first detector unit; Fig. 9 is a schematic circuit diagram of the apparatus carried on the chassis shown in Fig. 8; Fig. 10 is a schematic view of the condenser-resistor arrangement of the apparatus shown in Fig. 8; Fig. 11 is a longitudinal sectional view through the first detector unit; Fig. 12 is a transverse sectional view through the first detector unit; Fig. 13 is a plan view of the first intermediate frequency unit; Fig. 14 schematically shows the arrangement of the condenser-resistor units on the chassis illustrated in Fig. 13; Fig. 15 is a schematic circuit diagram of the equipment carried by the chassis illustrated in Fig. 13; Fig. 16 is an end elevational view of the second intermediate frequency amplifier unit; Fig. 17 is a longitudinal sectional view through the second intermediate frequency amplifier unit; Fig. 18 is a bottom plan view of the second intermediate frequency amplifier unit; Fig. 19 is a transverse sectional view taken on line 19—19 of Fig. 18; Fig. 20 is a plan view of the chassis of the second intermediate frequency amplifier unit; Fig. 21 shows the arrangement of the condenser-resistor elements on the chassis of the second intermediate frequency amplifier unit; Fig. 22 shows a circuit arrangement of the equipment carried by the chassis illustrated in Fig. 20; Fig. 23 is a plan view of the chassis of the second detector unit; Fig. 24 shows the arrangement of the condenser-resistor combination employed on the second detector unit; Fig. 25 is a schematic circuit arrangement of the elements carried by the chassis illustrated in Fig. 22; Fig. 26 is a plan view of the chassis of the first audio frequency amplifier unit; Fig. 27 shows the arrangement of the condenser-resistor units carried by the chassis illustrated in Fig. 26; Fig. 28 is a schematic circuit arrangement of the equipment carried by the first audio frequency amplifier stage illustrated in Fig. 26; Fig. 29 shows, in plan view, a preferred form of chassis for the second audio frequency amplifier stage; Fig. 30 illustrates the condenser and resistor arrangement for the elements carried by the chassis shown in Fig. 29; Fig. 31 shows a circuit arrangement of the elements carried by the chassis shown in Fig. 29; Fig. 32 is a plan view of the modified form of second audio frequency amplifier stage; Fig. 33 shows the schematic arrangement of the condenser-resistor units carried by the chassis illustrated in Fig. 32; Fig. 34 illustrates the circuit arrangement of the equipment carried by the chassis illustrated in Fig. 32; Fig. 35 is a side elevational view of one form of sound reproducer embodying my invention; Fig. 36 is an elevational view of the sound reproducer shown in Fig. 35; Fig. 37 is an elevational view showing the detachable arrangement of the input transformer; the sound reproducer and the mounting for the sound reproducer; Fig. 38 is a view showing a modified method of mounting the sound reproducer of my invention; Fig. 39 is a plan view of the chassis of one form of rectifier and filter unit employed in the system of my invention; Fig. 40 shows the circuit arrangement of the rectifier and filter unit illustrated in Fig. 39; Fig. 41 is an elevational view of the replaceable condenser unit employed in the rectifier and filter unit of Fig. 39; Fig. 42 is a plan view of the condenser unit shown in Fig. 41; Fig. 43 shows a modified form of chassis for mounting the modified arrangement of rectifier and filter unit employed in my invention; Fig. 44 is a side elevational view of a form of carton mounting for the condenser unit employed in the chassis illustrated in Fig. 43; Fig. 45 is an end view of the condenser unit illustrated in Fig. 44; Fig. 46 is a perspective view of the power transformer employed in the system of my invention; Fig. 47 is a top plan view partially broken away showing a carton unit for the condenser-resistor elements employed in certain of the units of the equipment of my invention; Fig. 48 is a transverse section on line 48—48 of Fig. 47; Fig. 49 is a transverse section on line 49—49 of Fig. 47; Fig. 50 is a detail of one method of mounting and establishing electrical connection with the condenser-resistor units; Fig. 51 is a longitudinal cross sectional view through the carton taken on line 51—51 of Fig. 47; Fig. 52 is a bottom plan view of the carton unit; Fig. 53 is a view illustrating a modified arrangement of condenser or resistor mounting having recesses in the end caps on the units; and Fig. 54 is a detailed sectional view showing the manner of mounting a condenser or resistor unit with a recess in the end cap thereon in lieu of a rounded protuberance of the form illustrated in Fig. 50.

My invention is directed broadly to a construction of radio receiver adapted for both television and sound broadcast reception in which the construction of the receiver is greatly simplified to permit quantity production at relatively low cost. The receiver of my invention is characterized by extreme simplicity and compactness and high electrical efficiency. The construction of the receiver of my invention departs widely from radio receiver construction heretofore known as I provide an arrangement whereby various coacting units constituting the radio receiver may be removably interconnected through a heart which substantially reduces the length of interconnecting busses or leads and eliminates the customary wiring in the chassis of the usual type of radio receiver as heretofore known. The radio receiver of my invention may embody a variety of electrical circuits and the circuit I have selected for illustration of my in-

vention herein is not to be regarded in the limiting sense but is to be considered only as explanatory of my invention and as illustrating one form of circuit to which my invention is adapted. The circuit illustrated includes a tuning unit, a unit comprising an oscillator, a radio frequency amplifier and a mixer tube circuit, one or more units comprising intermediate frequency amplifier circuits, a unit comprising a sound detector circuit, which also provides for automatic volume control of the system, a unit comprising the first audio frequency amplifier stage, and a unit comprising the second audio frequency amplifier stage, a separable electro-dynamic sound reproducer unit and a replaceable rectifier and filter unit, and a replaceable power transformer. I have termed the means by which the several coacting units constituting the radio receiver of my invention are assembled as the heart.

The assembly of the apparatus of my invention may be described as comprising:

1. Main chassis:
   - *a*. Chassis envelope
   - *b*. Heart
2. Units:
   - *a*. Chassis heart
   - *b*. Plugs or sockets
3. Parts:
   - *a*. Secured to the main chassis
   - *b*. Secured to the heart
   - *c*. Secured to the unit

For convenience I have described the parts noted above as follows:

1. (*a*) The main chassis is composed of a base and vertical metal envelope in which apertures are cut for access to connections.

   (*b*) The heart is composed of insulation plates between and on which are placed conductive plates and straps having plugs or sockets. These plugs or sockets extend outward to both sides of the heart so as to facilitate connections from the outside.

2. (*a*) The units are composed of insulation plates between and on which are placed conductive plates which make proper electrical connections between the various parts of the circuit.

   (*b*) The units are designed to have plugs or sockets to facilitate the connection into the chassis heart (1—*b*) through the apertures in the chassis envelope (1—*a*) thereby making proper electrical connections which complete the circuit or circuits for which it is designed.

3. (*a*) Parts of the apparatus such as the electro-dynamic speaker, tuning unit, etc., can be held to the main chassis by securing means such as plugs and sockets.

   (*b*) Parts of the apparatus such as the electro-dynamic speaker, tuning unit, power transformer, wave band switch, etc., can be connected electrically and held to the main chassis by the use of plugs or sockets which engage plugs or sockets in the heart thereby completing the circuit or circuits for which it is designed.

   (*c*) Parts of the radio such as the resistors and condensers are held in their proper position within the units by clips.

The use of the heart referred to above permits electrical connection to be established between coacting parts of the receiver with a minimum length of electrically conductive path between the parts, thereby increasing conductivity of the paths extending between the parts with the resulting increase in electrical efficiency of the apparatus and allowing minimum distributed capacity and induction between interconnecting conductors, a reduction in feed back, interaction, local interference and other undesirable effects incident to the wiring in the chassis of the usual type of radio receiver. By use of the heart consisting of a few small plates and metallic tubes with which the parts and the units are closely aligned, a great mass of interlocking or intermingling and complicated wires and soldered connections are dispensed with, thereby reducing the manufacturing cost to a minimum while increasing the electrical efficiency and compactness thereof. The fact that the several units constituting the radio receiver are independently removable and replaceable permits the modernizing of the radio receiver from time to time by substitution of an improved unit for an obsolete unit. This is particularly desirable at the present state of the art with respect to television receivers.

In order to set forth the special advantages arising out of the manufacture and use of the radio receiver of my invention, I have summarized the advantages as follows:

Accessibility

1. Main chassis:
   - *a*. Heart connections, electrical and securing means—The heart that connects up the various circuits in the units makes possible the accessibility to the units and their parts.
2. Units:
   - *a*. Electrical connectors and securing means—Every unit having its own electrical connecting and securing means makes possible the quick removal and access to all of its parts.
   - *b*. Ease of construction on flat surface—Each unit has an open bottom, making quick repair possible.
   - *c*. Parts removably connected to unit—All small parts connected to the units such as resistors and condensers can be quickly removed due to each having its own electrical and securing means.
3. Parts removably connected to main chassis—are accessible and quickly detachable because each has its own electrical connections and holding means—viz: speaker and tuning unit:
   - *a*. Parts removably connected to heart—such as viz:—Wave band switch, power transformer, etc. are accessible and quickly removable and replaceable because each has its own electrical and securing means.

Simplicity

1. Construction:
   - *a*. Heart—The heart consisting of so few parts saves many feet of complicated wiring and soldered connections.

b. Units—Units are constructed of so few parts and constructing material that they are very simple to assemble and connect up.

c. Parts—Such as transformers, speaker, condensers, etc., are very easily attached or removed because each has its own electrical connections and holding means thereby requiring no soldering or bolting or long connectors.

2. Design:

a. Few parts—Due to simplicity of design, fewer and less complicated parts are used.

b. Consolidation of parts—The units and other large parts are so compactly arranged on the main chassis, that comparatively a very small space is required.

c. Parts marked for identification and position in the units to make replacement simple and quick.

d. Units and parts are not interchangeable with each other on the main chassis due to the position of the connectors.

Standardization

1. Parts:

a. Standard connections are used to facilitate quick replacements.

b. Standard sizes and shapes to facilitate ready replacements.

c. Replacements of obsolete parts can be made for substitution of improved or modern parts.

2. Chassis is standardized so that new improvements in units and parts can be utilized.

a. All large parts and small parts as well as those contained in units are standardized so that improvements can be easily adapted.

b. Chassis and all parts are standardized so that new circuits can be immediately installed.

Cheapness of manufacture

1. Chassis:

a. Construction — The chassis can be stamped out, both the conductor and insulation plates by machines. The tubes or plugs can also be attached to conductive plates automatically. The chassis envelope is readily made by machine. To put together the few parts that complete a chassis is a simple matter of assembly only.

b. Simplicity—It is easy to see the simplicity of this chassis in comparison to the complicated wired chassis of other radio sets.

2. Units:

a. Construction—The units can be manufactured cheaply by machine as the insulation plates and conductors can be stamped out and quickly assembled.

b. Simplicity—The units are simple in construction as there are few parts and easily assembled.

Adaptability

1. To apparatus using electron emission tubes:

a. Television systems.

b. Telephone repeaters, etc.

c. Radio broadcast receivers.

d. Automobile receivers.

e. Radio transmitters.

2. Additional circuits in unit form may be added when increase in power of the radio is desired. This is accomplished by utilizing twin units or a double heart. An oversized chassis may contain the double heart which will allow the use of additional units.

Repairability

1. Detachable parts:

Each part large and small contains its own electrical connections and holding means by which elements are quickly and easily detachable. The parts are clearly marked and quick substitution by inexperienced persons is very simple.

2. Compactness:

Due to the arrangement of the various parts and units on the chassis and the small area occupied by the heart to which they are connected, the complete set is very compact. The units themselves being very small in size and simple, add greatly to the complete compactness of the apparatus.

Centralization:

Centralization of the units and large parts around the connecting heart make extremely short connections between themselves possible. Centralizing the parts and units makes possible the use of a few conductor plates in the place of many feet of intermingled wires.

Elimination of wires:

By using a heart as constructed of a very few small conductor plates and units containing a minimum of conductor plates, there is marked improvement in electrical efficiency and a substantial reduction in induction, local interference, of sapping of circuits, high resistance connection, of distributed capacity and induction, feed back, interaction, etc. By the use of a heart consisting of a few small plates to which the parts and units are closely aligned, a great mass of interlocking intermingling and complicated wires and soldered connections are dispensed with, thereby cutting the manufacturing cost to a minimum as well as increasing the efficiency of the radio.

Indication of trouble, localization of same, protection of parts:

By using indicators in the various circuits it is possible to acquire a comprehensive condition of the various parts of the set and which by being permanently connected in the circuit, immediately discloses and localizes a defective or weak part or tube, which can be immediately replaced thereby keeping the efficiency of the radio at a maximum.

Referring to the drawings in more detail, I have illustrated my invention applied to a superheterodyne type of radio broadcast receiver although it will be understood that various circuit arrangements may be employed and details are immaterial. I have indicated the tuning unit of my invention generally by reference character 1 connected through selectively tuned circuits 2 to the antenna system 3 and the ground system 4. The first of the sectionalized units includes the first detector oscillator and amplifier tube indicated generally at 5. The tube 5 includes a heater element 5_a and a cathode 5_b. Adjacent the cathode 5_b, there is provided the oscillator grid G_o. The anode grid G_a is located adjacent the oscillator grid G_o. The screen grid G_s is connected as indicated. The control grid is indicated at G and the anode is shown at P. I provide in the cathode circuit leading from cathode 5_b, the indicator and safety fuse A disposed in series with bias resistor R_1 which connects to the ground lead 6. It will be observed that condenser C_1 is connected in shunt with the safety indicator A and resistor R_1 for by-passing high frequency currents. The circuit from the oscillator grid G_o extends through selected windings of the group of inductances indicated at 7 and through voltage limiting resistor R_3 through safety indicator C to the high potential supply lead 8 indicated at B+. Resistor R_3 is by-passed to ground by condenser C_3. In circuit with the screen grid G_s, I provide voltage limiting resistor R_2 and safety indicator lamp B. The resistor R_2 is by-passed by means of condenser C_2. The indicator lamp B is by-passed by means of condenser C_4. The indicator lamp B is connected in series with the output circuit of tube 5 leading from plate P through inductance 9 tuned by condenser 10, constituting the primary winding of intermediate frequency transformer 11.

In the circuit arrangement for tube 5 as described, three indicators A, B and C serve to locate any defect which may exist in different parts of the circuit, such as in the case of indicator A, an open resistor R_1, a shorted condenser C_1, or a defect in other parts of the circuit; in the case of indicator C, an open resistor R_3 will be shown, or a shorted condenser C_3 will be indicated; and in the case of indicator B, an open resistor R_2 will be indicated, a shorted condenser C_2 can be located, or a shorted condenser C_4, or an open path in the primary winding 9 of intermediate frequency transformer 11 will be indicated. Indicators A, B and C can also be relied upon to show the operating condition of tube 5 and will grow dimmer as tube 5 ages. Indicators A, B and C will also show conditions of shorts between the tube electrodes.

The next removable section of the receiving set contains the first intermediate frequency amplifier tube 12 which contains heater 14_a and cathode 14_b, control grid G', suppressor grid S_u, screen grid G_s', and anode P'. The control grid G' connects to the secondary winding of intermediate frequency transformer 11, indicated at 15 in the input circuit of tube 12. Safety indicator lamp D is connected in a series path with the suppressor grid S_u and cathode 14_b, and in series with bias resistor R_4. Condenser C_5 provides a by-pass path around safety indicator lamp D and resistor R_4. The screen grid circuit leading from electrode G_s' includes current limiting resistor R_5 and indicator lamp E connected to the high potential lead indicated at 8 as B+. Condenser C_6 provides a by-pass around resistor R_5. Condenser C_7 by-passes safety indicator lamp E in circuit with the plate electrode P' through primary winding 16 of the second intermediate frequency transformer 17. Primary winding 17 is suitably tuned by means of condenser 18. The safety indicator lamps D and E serve to indicate a condition of an open resistor R_4 or a shorted condenser C_5 in the case of safety indicator lamp D and in the case of safety indicator lamp E, an open resistor R_5 is indicated or a shorted condenser C_6 is at once localized or a condition of short in condenser C_7 is shown. Indicator lamps D and E also enable any shorts between tube electrodes to be readily observed or any condition of open circuit in the primary winding 16 of the second intermediate frequency transformer 17 to be indicated. As tube 12 ages the safety indicator lamps D and E grow dimmer.

The third replaceable section of the receiver contains a second intermediate frequency amplifier tube which I have indicated generally at 19 as including a heater 19_a and a cathode 19_b with a control grid G'', a suppressor grid S''_u, a screen grid G''_s, and a plate electrode P''. I provide in circuit with the suppressor grid S''_u and cathode 19_b, the safety indicator lamp F in a series path with bias resistor R_6. The combination of the safety indicator lamp F and bias resistor R_6 is shunted by by-pass condenser C_8. I provide in circuit with the screen grid G''_s, a voltage limiting resistor R_7 arranged in series with safety indicator lamp G_1. Condenser C_9 forms a by-pass around the voltage limiting resistor R_7. Condenser C_{10} provides a by-pass around safety indicator lamp G_1. The safety indicator lamp G_1 is also disposed in the output circuit of the second intermediate frequency amplifier tube 19 and in series with primary winding 20 of intermediate frequency transformer 21 and connected with the plate P''. Primary winding 20 is suitably tuned as indicated at 22. Indicator lamps F and G_1 serve to show in the case of indicator lamp F, an open resistor R_6 or a shorted condenser C_8; and in the case of safety indicator lamp G_1, an open condition of resistor R_7 is indicated, a shorted condition of condenser C_9 is shown or a shorted condition of condenser C_{10} is indicated. Safety indicator lamp G_1 also shows a condition of open circuit in primary winding 20 of intermediate frequency transformer 21. As tube 19 ages, indicators F and G_1 grow dimmer. The indicator lamps F and G_1 also enable any condition of short circuit between the tube electrodes to be promptly detected.

The next replaceable section of the radio receiver is indicated generally as including an electron tube 22 connected to function as a diode detector. Tube 22 includes heater 22_a, cathode 22_b and control grid G''' and plate P'''. The control grid G''' and plate P''' are interconnected to serve as one electrode forming the second electrode of the diode with respect to cathode 22_b. The output or secondary winding 23 of the intermediate frequency transformer 21, tuned by means of condenser 24 connects with the diode detector circuit and with the grid circuits of the preceding tubes 5 and 12 through resistor 25 for purposes of automatic volume control. Condenser 26 is provided for filtering the energy supplied to the automatic volume control circuit. I provide the volume control potentiometer 27 in association with resistor 25 as shown and asso-

ciated with filter condenser 28 forming part of the filter network with condenser 26.

The unit including the automatic volume control circuit just described has been disclosed without the insertion of safety indicator lamp, but it should be understood that safety indicator lamps may be employed. I have found that the parts of the automatic volume control circuit are very substantial in practice and the danger of faults occurring in this portion of the circuit are not as serious as is the situation in other units making up the replaceable sections of the set.

The next replaceable unit for the apparatus of my invention is constituted by the first audio frequency amplifier stage indicated generally as including tube 30. Tube 30 contains heater 30_a and cathode 30_b, control grid G^{iv} and plate P^{iv}. The variable tap 29 on resistor 27 enables the energy at the selected amplitude to be impressed on the audio frequency amplifier stage and control grid G^{iv} thereof for insuring the impression of energy at desired amplitude on the audio frequency amplifier system. Control grid G^{iv} is maintained at the proper potential for amplification of energy on the straight portion of the amplification characteristic curve of the tube through bias resistor 32 connected in series with bias cell 33. The output circuit of tube 30 includes coupling resistor R_8 and condenser C_{11} associated therewith. Safety indicator lamp H is disposed in series with coupling resistor R_8. Any failure of coupling resistor R_8 or shorting of condenser C_{11} is at once indicated by safety indicator lamp H. Moreover, the condition of shorts between tube electrodes in tube 30 may be indicated by safety indicator lamp H. As tube 30 ages, the indicator lamp H grows dimmer.

The next unit of the replaceable unit system of the radio receiver contains the second audio frequency amplifier stage constituted by tube 34 containing heater 34_a and cathode 34_b, control grid G^v, screen grid G^{v_s} and a plate electrode P^v. The tube 34 has its input circuit coupled through condenser C_{12} with the output of the first stage of audio frequency amplification constituted by tube 30. A bias resistor R_9 is arranged for impressing the required operating potential on grid G^v. Bias resistor R_9 is connected in circuit with resistor R_{10} which connects to ground. A mid-tap 35 between resistors R_9 and R_{10} connects to the negative side of the main filter system as indicated at 36. The output circuit from plate P^v includes the primary winding 37 of output transformer 38 and the safety indicator lamp I to the positive side of the power supply system at 8 and to the positive terminal 39 of the main filter. A safety lamp J is connected in shunt with resistor R_{10}. The safety lamps I and J indicate respectively an open condition in the primary winding 37 of output transformer 38 or a condition of short in tone control condenser C_{13} in the case of safety indicator lamp I or in the case of safety indicator lamp J an open condition in resistor R_{10}. Indicator lamp I indicates any condition of short-circuit between tube electrodes and will also grow dim as tube 34 ages.

The rectifier and the main filter system are included in an independently replaceable unit. I have shown the elements of the main filter generally as including condensers C_{14} and C_{15} and the reactance 40 of the electro-dynamic sound reproducer, which I have indicated generally at 41. The main filter includes safety indicator lamps K and L connected as shown, in circuit with the elements of the full-wave rectifier tube 42. Safety indicator lamp K indicates a condition of open circuit in the speaker field 40 or a condition of short in condensers C_{14} or C_{15}. The condition of illumination of safety indicator lamp K also shows any condition of leakage in condensers C_{14} or C_{15} or any condition of ageing of rectifier tube 42. Safety indicator lamp L is disposed in the negative lead of the rectifier and provides a further method of indicating the condition of the circuit through the speaker field and the condition of the condensers C_{14} and C_{15}. Safety indicator lamp L also protects the filter elements in the event of a short within the rectifier tube 42.

The main power transformer is mounted with respect to the other units making up the apparatus so that it may be readily removed and replaced in the event of an open or short circuit in any one of the several windings. I have shown the main power transformer at 43 arranged as a replaceable unit and provided with a primary winding 44 energized from any suitable alternating current source connected at 45. The transformer is provided with suitable secondary windings such as the plate supply winding 46 connected with full-wave rectifier tube 42, the cathode heating winding 47 connected with the cathode of rectifier tube 42 and winding 48 connected to supply the heaters of the several tubes 5, 12, 19, 22, 30 and 34 of the radio receiver.

Throughout the radio receiver where I have indicated the safety indicator lamps A, B, C, D, E, F, G1, H, I, J, K and L, I proportion the filamentary element of each of the lamps for protecting the associated elements against destructive effects of excessive currents while being so proportioned as to permit the passage of desired normal operating current and also being so proportioned that such normal operating currents will excite the safety indicator lamps to a condition of luminosity whereby the several indicator lamps serve as individual assurances that the circuits of the respective units are operating properly and in normal manner. Any safety indicator lamp which is not energized at once gives an indication as to the location of the defect in the circuit. Inasmuch as the several replaceable units carrying the safety indicator lamps may be readily replaceable, an entire unit or part thereof is replaced in the circuit upon removal of the defective unit and the set immediately restored to operative condition with minimum expense and without the skill normally required of a service man in attending the usual type of radio receiver.

In order to summarize the functions of the indicator lamps, I have tabulated the several conditions which exist, assigning to the several replaceable units references as follows:

Unit #1'—first detector, oscillator, mixer and radio frequency amplifier stage

Unit #2'—first intermediate frequency amplifier stage

Unit #3'—second intermediate frequency amplifier stage

Unit #5'—first audio frequency amplifier stage

Unit #6'—second audio frequency amplifier stage

Unit #7'—rectifier and main power filter

The tabulation of the results shown by the indicators in the several units, is as follows:

Unit #	Indicator	Indication	Indicator	Indication	Replace part
1'	A	Out	B & C	Bright	C_1 (short)
1'	A	Dim	B	Bright	C_2 (short)
1'	A	Out	B & C	Out	R_1 (open)
1'	A	Dim	B	Out	R_2 (open)
1'	A	Dim	C	Bright	C_3 (short)
1'	A	Dim	C	Out	R_3 (open)
1'	A	Dim	B	Burnt out	C_4 (short)
1'	A	Dim	B	Out	I. F. T. #1' (open)
1'	A	Dim	B & C	Dim	Tube #5 (weak)
2'	D	Out	E	Bright	C_5 (short)
2'	D	Dim	E	Bright	C_6 (short)
2'	D	Out	E	Out	R_4 (open)
2'	D	Dim	E	Dim	R_5 (open)
2'	D	Out	E	Burnt out	C_7 (short)
2'	D	Out	E	Out	I. F. T. #2' (open)
2'	D	Dim	E	Dim	Tube #12 (weak)
3'	F	Out	G_1	Bright	C_8 (short)
3'	F	Dim	G_1	Bright	C_9 (short)
3'	F	Out	G_1	Out	R_6 (open)
3'	F	Dim	G_1	Dim	R_7 (open)
3'	F	Out	G_1	Burnt out	C_{10} (short)
3'	F	Out	G_1	Out	I. F. T. #3' (open)
3'	F	Dim	G_1	Dim	Tube #19 (weak)
5'	H	Bright			C_{11} (short)
5'	H	Out			R_8 (open)
5'	H	Dim			Tube #30 (weak)
6'	I	Out	J		Transformer #38 (open)
6'	I	Burnt out	J		C_{13} (short)
6'	I		J	Bright	R_{10} (open)
6'	I		J	Dim	C_{12} (short)
6'	I	Dim	J		Tube #34 (weak)
7'	K	Out	L	Out	Speaker Field (open)
7'	K	Burnt out	L	Burnt out	C_{14} (short)
7'	K	Out	L	Burnt out	C_{15} (short)
7'	K	Bright	L	Bright	C_{14} (leaky)
7'	K	Dim	L	Bright	C_{15} (leaky)
7'	K	Dim	L	Dim	Tube #42 (weak)

Referring to Fig. 2 of the drawings, I have shown a plan view assembly of the radio receiving apparatus which embodies the circuit of Fig. 1, heretofore described. The assembled equipment is shown in side elevation looking in the direction of arrow A in Fig. 3 and in side elevation looking in the direction of arrow B in Fig. 4. For convenience, I have shown the equipment mounted on a main base **50** which supports the heart shown generally at **51**. The heart may take a variety of forms but in the particular embodiment of my invention as illustrated, the heart extends in a substantially vertical plane and receives the several units in quick detachable and replaceable arrangement by insertion from opposite sides into the heart. In the plan view shown in Fig. 2, the units which appear in the figure are **3'**, the second intermediate frequency amplifier stage; **4'**, the second detector; **5'**, the first audio frequency amplifier stage; and **6'**, the second audio frequency amplifier stage. The heart **51** also has engaged therewith the detachable and replaceable volume control unit **52** controlled through shaft member **53** from control knob **54** on one side of the heart. On the other side of the heart, the tone control switch unit **55** may be engaged or disengaged with respect to the heart. The tone control unit **55** is controlled through suitable shaft **56** from knob **57** projecting to a control position adjacent knob **54**.

The wave band switch or frequency control unit is engaged within a recess **58** adjacent one end of the heart **51** and is indicated as a unit at **59**. The entire unit **59** is insertable into or removable from the recessed portion **58** of the heart **51** and carries terminal connectors thereon which engage with correspondingly aligned terminal connectors within the heart **51** for establishing and completing the connections through the high frequency circuits of the receiver in accordance with the diagram illustrated in Fig. 1. The wave band switch and wave band unit indicated at **59** has provision for the connection of the sets of inductively coupled units indicated at **2** in the wiring diagram at the set of contacts **60** (Fig. 3). The sets of oscillator inductor coils **7** in the diagram in Fig. 1, are connected to the unit **59** through sets of contacts indicated at **61** in Fig. 4. The selector switch for the sets of coils **2** and **7** connected respectively through sets of contacts **60** and **61**, is controlled through shaft **62** from knob **63** adjacent the volume control and tone control knobs **54** and **57** respectively.

The sound reproducer **41** illustrated in diagram in Fig. 1, is schematically shown in position with respect to the receiving apparatus at **41** in Fig. 2, connected through sets of leads **64** with the circuits of the radio receiving apparatus. The tuning unit comprising adjustable condensers **1** shown in diagram in Fig. 1, is illustrated in position with respect to the receiving apparatus in Fig. 2, connected through leads **65** with the wave change unit **59**.

The details of the heart are shown more particularly in Fig. 5. Referring to Fig. 5, the construction of the heart will be understood by considering these views collectively in superimposed relation. The heart is constituted by two laminations of insulation material indicated in Fig. 5 at **66** and **67**. The laminations **66** and **67** carry the electrically conductive members forming the combining means for the circuits through the heart. Insulated plate members **68** and **69** serve as confining supporting and spacing means for the laminations **66** and **67** and for the conductive elements carried thereby. The entire structure of the heart is suitably secured together by means

extending through the laminations and is electrically shielded by means of a metallic casing represented generally at 70. The conductive elements carried by the laminations 66 and 67 are in the form of short transversely extending metallic tubular members, certain of which are electrically bonded by buses carried by the laminations.

The arrangement of the electrically conductive members on the laminations 66 and 67 is shown more clearly in the perspective view in Fig. 5 from which it will be observed that lamination 66 carries tubular conductive members illustrated at 71, 72 and 73, tubular conductive members 71 and 72 being interconnected by bus 137; lamination 67 of the heart carries transverse tubular members 110 and 111 interconnected by bus 112 and transversely extending tubular members 114 and 115 interconnected by bus 116; lamination 66 carries short tubular transversely extending members 75, 76 and 77, tubular members 75 and 76 being interconnected by bus 139; lamination 67 carries tubular member 74 interconnected by bus 118 with tubular member 117 projecting in a direction opposite to the direction of projection of member 74, the member 117 being transversely aligned with member 77; lamination 66 also carries transverse tubular members 78, 79, 80 and 81, tubular members 78 and 79 being interconnected by bus 138; lamination 67 carries transversely extending members 119 and 120 interconnected by bus 121 and also transverse tubular members 122 and 123 interconnected by bus 124; lamination 67 carries transversely extending tubular members 82 and 83 interconnected by bus 131; lamination 66 carries tubular members 84 and 85; lamination 66 also carries transversely extending tubular members 86, 89, 90 and 91, members 90 and 91 being interconnected by bus 125; lamination 67 carries tubular members 87 and 88 interconnected by the substantially square plate 126. The tubular members 87 and 88 extend transversely through the entire heart; lamination 67 also carries tubular members 127 and 128 interconnected by bus 129; lamination 66 also carries transversely extending tubular members 92, 95, 96 and 97; lamination 67 carries transversely extending tubular members 93 and 94 interconnected by plate 126 which pass entirely through the heart. It will be observed that the transversely extending members 92 and 95 also pass wholly through the heart as is the case also with respect to the tubular members 82 and 83 carried by lamination 67; tubular members 87 and 88 are carried by lamination 67; and tubular member 96 is carried by lamination 66; lamination 67 also carries transverse tubular member 128 which is interconnected through bus 129 with tubular member 127; lamination 66 also carries transversely extending tubular members 98, 100 and 101; lamination 67 carries tubular member 99 and also tubular member 130 connected therewith through bus 131. Tubular members 100 and 101 are interconnected through bus 132; lamination 66 also carries transversely extending members 102 and 103 interconnected by bus 133; a separable connector 134 is arranged to fit within a groove 134a in lamination 66 and pass through an aperture 135 in lamination 66 and support a tubular member 105. The opposite end of connector 134 connects to tubular member 104 and to tubular member 93; lamination 66 also carries transversely extending tubular members 106 and 107 interconnected by bus 136; and lamination 66 carries transversely extending tubular members 108 and 109 interconnected by bus 137. The lamination 66 is recessed as indicated at 141 to receive the right elbow connector shown at 147.

It will be understood that the tubular conductive members which are carried by lamination 67 project through aligned apertures in lamination 66. I have illustrated, for example, aperture 74a in lamination 66, aligned with conductive member 74, supported by lamination 67. Similarly, apertures 82a, 83a, 87a and 88a in lamination 66 allow for the passage of tubular conductive members 82, 83, 87 and 88 carried by lamination 67. Lamination 66 is apertured at 93a, 94a and 99a for the passage of tubular conductive members 93, 94 and 99 on lamination 67, respectively. Lamination 67 is apertured at 86a, 92a and 95a for the passage of the projecting ends of tubular members 86, 92 and 95, carried by lamination 66. The member interconnecting tubular conductive members 86, 89, 92 and 95 on lamination 66 is shaped as shown at 140. The member interconnecting tubular conductive members 82, 83, 99 and 130 is shaped as represented at 131 and is insulated from interconnecting member 140 by virtue of the fact that it is disposed in a plane spaced from the plane of interconnecting member 140. As has been hereinbefore noted, certain of the tubular members project in opposite directions transversely of the heart while others of the tubular members are selectively arranged so that some of the tubular members project in one direction from the heart while others of the tubular members project in the opposite direction from the heart. The laminations 66 and 67 are recessed in front thereof as represented at 58. The parts of the laminations which interengage are provided with semicylindrical recesses indicated generally at 141 in lamination 66 and 142 in lamination 67 which are aligned with each other to receive between them the conductive tubular members 143, 144, 145, 146, 147. These tubular members 143—147 inclusive, are each provided with right angular bends and extend transversely with respect to and away from lamination 67 and through the confining, supporting and spacing plate 69. The tubular members 143—147 inclusive terminate within the recess 58 and receive quick detachable connecting means from the wave change unit 59.

As heretofore noted, tubular members 73 and 80 are interconnected by bus 148; tubular members 77 and 84 are interconnected by bus 149; tubular members 81 and 96 are interconnected by bus 150; and tubular members 85 and 97 are interconnected by bus 151. The several buses heretofore described are suitably housed within recesses provided in the laminations.

The entire unit as heretofore noted, is contained in the metallic shield or casing 70 and care is taken to cut away the metallic shield around each of the connecting means to avoid any possibilities of short-circuit. I have shown the two interior plates 66 and 67 of the heart carrying tubular members aligned with coacting apertures and arranged in cooperation with aligned apertures in the confining, supporting and spacing plates 68 and 69; but it should be understood that plugs instead of tubes may be used interchangeably or other forms of connecting devices may be employed and the tubular members have merely been selected as one illustrative embodiment of my invention.

For convenience, I have tabulated the func-

tions of the transverse connectors carried by the laminations 66 and 67 as follows:

71–72—plate output (Fig. 32) or voice coil of speaker (Fig. 29).
73—tone control.
74—grid input to first audio frequency amplifier stage.
75–76—field return from speaker.
77—tone control.
78—plate output to second audio frequency amplifier stage.
79—plate input to second audio frequency amplifier stage (in common with 78).
80—ground to tone control (in common with 73).
81—output from switch to power transformer.
82—heater input to first audio frequency amplifier stage (82 projecting from lamination 67 through plate 69 serves as the heater input to the second intermediate frequency amplifier stage).
83—heater input to second audio frequency amplifier stage (83 projecting from lamination 67 through plate 69 serves as the heater input to the second detector stage).
84—output to tone control (in common with 77).
85—input to switch for alternating current power supply.
86—positive B voltage input to first audio frequency amplifier stage (in common with 89, 92 and 95), (85 projecting from lamination 67 through plate 69 serves as the positive B voltage input to the second intermediate frequency amplifier stage).
87—ground and heater input to first audio frequency amplifier stage.
88—ground and heater input to second audio frequency amplifier stage (88 projecting from lamination 67 through plate 69 serves as the heater and input to second detector stage).
89—positive B voltage input to second audio frequency amplifier stage (in common with 86, 92 and 95).
90–91—voice coil of speaker (Fig. 29) or positive B voltage (Fig. 32).
92—rectifier cathode input and positive B voltage output to all stages (92 projecting from lamination 66 through plate 69 serves as the positive B voltage input to the first intermediate frequency amplifier stage).
93—ground input to rectifier (93 projecting from lamination 67 through plate 69 serves as the ground and heater input to the first intermediate frequency amplifier stage).
94—ground output to rectifier (94 projecting from lamination 67 through plate 69 serves as the ground and heater input to the first detector stage).
95—cathode output to rectifier (95 projecting from lamination 66 through plate 69 serves as the positive B voltage input to the first intermediate frequency amplifier stage).
96—input from switch to power transformer (in common with 81).
97—alternating current power supply input to switch.
98—center tap input to rectifier.
99—heater output to tubes (99 carried by lamination 67 and projecting therefrom through plate 69 serves as the input to the first detector stage).
100–101—alternating current input to power transformer.
102—cathode input to rectifier.
103—cathode output to rectifier.
104—center tap output to rectifier and speaker field.
105—input to speaker field.
106—high voltage input to rectifier.
107—high voltage output to rectifier.
108—high voltage input to rectifier.
109—high voltage output to rectifier.
110—output to second detector.
111—input to second detector.
114—output to volume control.
115—input to volume control.
117—grid input to first audio frequency amplifier stage.
119—output to second detector.
120—input to second detector.
122–123—ground to volume control.
127—A. V. C. output to second detector.
128—A. V. C. input to first detector.
130—heater input to first intermediate frequency amplifier stage.

The detachable tuning unit indicated generally in Fig. 2 is shown schematically in different embodiments in Figs. 6 and 7. In Fig. 6 I have shown the manner of mounting the frame 152 of the tuning unit which includes condensers 1 controlled by adjustable shaft operated from knob 153. The frame 152 of the condenser carries a socket member 154 supporting pin-like contacts 155 in insulated relation and electrically connected with the tuning condenser units 1 and also electrically connected with indicator lights for illuminating the indicator dial if desired. The entire tuning unit may be readily inserted into or removed from a suitable receptacle providing means for both mechanically supporting the tuning unit and establishing electrical connection therewith.

In lieu of the electrical connections through the sets of pins 155, I may mount the tuning unit directly upon legs as represented at 156 in Fig. 7 which are insertable into or removable from a suitable socket mounting, but in which the legs 156 do not perform the function of completing electrical circuit connections. In this arrangement the flexible leads indicated at 65, connect the tuning unit with the wave change unit 59 as shown diagrammatically in Fig. 2.

The details of the first detector, oscillator, mixer and radio frequency amplifier stage heretofore designated at 1' are set forth more clearly in Figs. 8, 9, 10, 11 and 12. In order to make clear the structure of each of the units, I have shown each of the units in plan view with parts flattened out to illustrate the relation of the elements. For example, in Fig. 8, the chassis of insulation material for unit 1' is designated generally at 157 with the sides thereof folded outwardly. Chassis 157 serves as insulated mounting means for buses of minimum length which are secured to the insulation material comprising the chassis 157 in proper position for mechanically mounting the resistor and condenser units and establishing a connection with the plug connectors which interengage with the tubular mem-

bers carried by the heart. The chassis of insulation material indicated at 157, when folded into such limits as will allow the insertion of the insulated chassis into the casing 158 which supports the socket members 159 and 160 which permits soldered connections to be established between the terminals of the socket devices and the buses carried by the insulated chassis 157. The insulated chassis 157 is apertured at 159_a and 160_a immediately below the receptacle devices 159 and 160 for permitting access of the buses to the soldered terminals of the sockets 159 and 160 supported by the casing 158. While I have mentioned soldering the connections I realize that there are many methods of establishing the desired connections and I intend no limitations with respect to any particular method of establishing such connections. The buses which I have illustrated as carried by the insulated chassis 157 may pass through slits formed in the insulation material of the chassis in order to provide the shortest and most direct connections possible. This procedure also enables one bus to be passed on the exterior of the insulated chassis while the other bus is passed on the interior of the insulated chassis for thereby enabling the connections to be made within a compact space and at the same time a high degree of insulation maintained between the buses. The insulation chassis 157 in unfolded arrangement shows the bust connectors carried beyond the limits of the insulated chassis. This is necessary because the buses serve to establish connection with contact members supported with respect to the casing, which contact members engage with corresponding conductive members in the heart. In order to make clear the manner in which the contacts carried by the first detector unit engage with the tubular connectors within the heart, I have indicated by prime letters the contacts on the unit which coact and cooperate with the tubular members in the heart. That is to say, contacts 143', 144', 145', 146' and 147' on the unit establish connection with the transversely extending ends which project normal to plate 69 of the heart as continuations of tubular members 143, 144, 145, 146 and 147. Contacts 128' and 95' establish connection with tubular members 128 and 95 respectively. Contacts 94' and 99' establish connection with tubular members 94 and 99 respectively. A flexible feed line extends from the secondary winding 15 of intermediate frequency transformer 11 which is received in the socket 159 to the control grid of the tube 12 in unit 2'. The signal energy delivered to the tube 5 is transferred from unit 59. I have shown the connecting means for the safety indicator lamps A, B and C at the spaced ends of adjacent bus connectors carried by the insulated chassis 157. The safety indicator lamps are insertable through an insulated sleeve in the casing and establish connection with the bus members in the positions I have indicated in Fig. 8.

In order to make clear the circuit elements contained in unit 1', I have detailed the arrangement of the units in Fig. 9. In order to show the arrangement of the resistor and condenser elements within the unit 1', I have detailed these in Fig. 10. Fig. 11 shows a longitudinal section through the unit 1' while Fig. 12 shows a transverse section through the unit 1' making it clear that a substantial double depth is provided in unit 1' as distinguished from other units hereinafter described.

Fig. 13 illustrates unit 2' constituting the first intermediate frequency amplifier stage from which it will be observed that the same general plan of the insulated chassis is carried out with respect to this unit as well as the other units. The insulated chassis is shown at 161 forming a carrier for the bus bar connections which support the resistor and condenser elements in the first intermediate frequency amplifier stage. The sheet of insulation material 161 is apertured at 162 and 163 within which the bus bar connections terminate for providing connection means for the tube 12 and the second intermediate frequency transformer 17 as shown. As explained in connection with Fig. 8, the insulation sheet 161 forming the chassis for unit 2' is suitably slitted to permit passage of the bus bar connectors on opposite sides of the insulation sheet so that the bus bar connectors may be compactly assembled but insulated one with respect to the other. The bus bar connectors terminate in connections for plug connectors which I have indicated at 92', 93' and 130' adapted to establish connection with the tubular members 92, 93 and 130. I show provision on the chassis in Fig. 13 for establishing connection with safety indicator lights D and E which bridge the gaps between the bus bar connections as illustrated.

Fig. 14 represents the electrical arrangement of the condenser and resistor elements which are carried by the bus bar members supported by the insulation material of the chassis 161, corresponding reference characters being applied to the condenser and resistor elements as those appearing in Fig. 1 in the first intermediate frequency amplifier stage.

Fig. 15 illustrates the circuit arrangement of the unit 2' showing the elements carried by the unit 2' and corresponding to the circuit elements illustrated in Fig. 1.

I have shown unit 3' which is the second intermediate frequency amplifier stage, in Figs. 16, 17, 18, 19, 20, 21 and 22. The insulated chassis for unit 3' is represented at 164 serving as a support for the bus bar connectors. The insulation sheet is apertured at 165 and 166 to provide access for the intermediate frequency transformer 21 and electron tube 19. The bus bar connectors on chassis 164 terminate in connections 82', 86', 87', 110' and 119' which connect to correspondingly numbered resilient plugs indicated in Figs. 16, 17, 18 and 19, at $110'_a$, $119'_a$, $82'_a$, $87'_a$ and $86'_a$. The insulated casing for unit 3' is indicated at 167 within which the insulated chassis 164 carrying the bus bar connectors is mounted. The exterior portion of each of the units is covered by metallic shields which are represented in the casing unit 2' by reference character 168 serving to electrically shield the elements within the unit and support the socket devices 169 and 170. Socket devices 169 and 170 respectively receive the transformer 21 and the tube 19 respectively. The bus bar connectors terminate in resilient tongues which are shaped as represented at 171 to receive the conductive ends of the resistor and condenser elements. I have shown the condenser elements C_{10}, C_9 and C_8 and resistor elements R_7 and R_6 in position ready for immediate replacement in the event of an open circuit through a resistor or a short-circuit through a condenser. Unit 3' carries safety indicator lamps G_1 and F which connect across the gaps in the buses as shown in the plan arrangement in Fig. 20. The safety indicator lamps are carried by the casing

but connect with the buses supported by the chassis 164.

Fig. 23 represents in plan view the chassis for the second detector unit containing the elements illustrated schematically in Fig. 24, electrically connected as shown in Fig. 25. The insulated chassis for the second detector is indicated by reference character 172 apertured at 173 to allow access to the connections of tube 22. The bus bar members carried by the chassis 172 terminate in plugs 122', 114', 127', 88', 83', 120' and 111'. The plugs carried by the bus bars thus described engage with the tubular members of the heart indicated at 122, 114, 127, 88, 83, 120 and 111, respectively. The tongues formed by the bus bar connections serve as mounting means for the circuit elements shown generally in Fig. 24. Electrical circuits for the second detector tube 22 associated with the elements carried by the second detector unit are shown more clearly in Fig. 25.

The first audio frequency amplifier stage or unit 5', is illustrated in detail in Figs. 26, 27 and 28. Fig. 26 shows in plan view the arrangement of the insulated chassis 174 apertured at 175 for the connection of the circuits of electron tube 30. As before noted, the bus bar connections carried by the sheet of insulation 174 may pass through the insulated sheet so that the bus bars may extend on opposite sides of the insulated sheet without short-circuit therebetween. The unit 5' has provision for the connection of safety indicator lamp H therein by virtue of the gap provided between the bus bar connectors carried by the chassis. The bus bar connectors terminate in plugs 74', 78', 82', 87' and 86' adapted to establish quick detachable connection with tubular members 74, 78, 82, 87 and 86 in the heart, respectively.

Fig. 27 illustrates the arrangement of the elements carried by the unit 5'. In Fig. 28 I have shown the connections between the elements with the tube 30 connected into the first audio frequency amplifier stage.

The second audio frequency amplifier stage or unit 6' may take either of two forms. The preferred form is shown in Figs. 29, 30 and 31 in which the output transformer is carried directly by the second audio frequency amplifier unit. However, it is entirely possible and sometimes desirable to detachably mount the output transformer on the sound reproducer, in which event the second audio frequency amplifier stage is modified to take the form illustrated in Figs. 32, 33 and 34. The choice of either form also depends upon the choice of form of speaker unit as will be hereinafter explained. The flexibility permitted by this arrangement is desirable because of the improvements which may be adapted to the chassis of the radio receiver of my invention from time to time.

Referring particularly to Fig. 29, the chassis is illustrated as being constituted by the insulation sheet 176 which is apertured at 177 and 178 respectively for the connection of transformer 38 and tube 34 respectively. Provision is made for mechanically supporting the circuit elements in position by means of tongues formed by the bus bar connectors. Provision is made for the connection of safety indicator lights I and J. The bus bar connectors are brought out to plugs which I have indicated at 71', 75', 80', 84', 90', 89', 88', 83' and 79', which are adapted to establish quick detachable connection with tubular members 71, 75, 80, 84, 90, 89, 88, 83 and 79.

In Fig. 30, I have shown the arrangement of elements connected in the unit 6' and in Fig. 51 I have shown the connection of such units with tube 34 using corresponding reference characters as set forth in Fig. 1. It will be understood that the insulated chassis 176 is mounted within a casing of the same general character as heretofore explained.

In the modified form of unit 6', as shown in Fig. 32, the output transformer is not mounted on the unit so that there is but one aperture 179 provided in the insulated chassis 180 for receiving the terminals of electron tube 34. Provision is made for the inclusion of the safety indicator lights I and J in the circuit and similar provision is made for mounting the circuit elements in the tongues provided by the circuit connecting means. The terminals are brought out in a similar manner as explained in connection with Fig. 29.

In Fig. 33, I show schematically the elements carried by the second audio frequency amplifier unit arranged as in Fig. 32.

In Fig. 34, I have shown diagrammatically the connection of the second audio frequency amplifier stage of unit 6' with the sound reproducer, which will be more fully described hereinafter.

The sound reproducer may be mounted in the position illustrated at 41 in Fig. 2 and may comprise the arrangement shown in Figs. 35, 36, 37 and/or 38. In Fig. 35, the sound reproducer is illustrated as having a frame support 181 and a magnetic system 182 which directly carries the socket device 183. Pin terminals 184 on socket device 183 are adapted to establish connection with contacts represented at 185 contained within receptacle 186. The field magnet system of the sound reproducer is indicated at 40 and adapted to be connected through pin terminals with a set of contact members 185. The output transformer 38 directly carries a socket device 187 with pin terminals thereon indicated at 188, adapted to engage removable connection with receptacle 189 carried by frame 182. Receptacle 189 includes contact members 190 through which connection is made with pins 184 to complete the input circuit from the last audio frequency amplifier stage to the output transformer 38 and from which connection is made from the secondary of the output transformer to the voice coil of the sound reproducer 41.

Figs. 35 and 36 show side elevation and rear views, respectively, of the sound reproducer mounted in the socket receptacle.

Fig. 37 shows the manner in which the sound reproducer is removed from the socket for quick replacement and also the manner in which an output transformer may be readily removed or inserted in the event that the output transformer appears defective.

In Fig. 38 I have shown an arrangement in which magnetic system 182 of the sound reproducer is provided with pin supports 191. The pin supports 191 engage socket receptacles 192 in a suitable base permitting the sound reproducer to be readily removed and replaced. In this form of the invention however, connections to the field winding 40 and to the primary winding of input transformer 38 are made through sets of leads represented at 54, the connections being taken to the heart, as represented in Fig. 2.

I have illustrated unit 7', that is the rectifier and power filter, in Figs. 39–42 in one form and in Figs. 43–45 in a modified form. The unit 7' is also flexible in its construction and arrangement

because the unit may employ a tubular condenser of the electrolytic type according to the arrangement of Figs. 39, 41 and 42, or a carton type insertable condenser according to the arrangement illustrated in Figs. 43, 44 or 45.

In either form of rectifier and filter unit 7', the wiring diagram illustrated in Fig. 40 remains the same.

In the form of the rectifier and power filter illustrated in Fig. 39, the chassis of insulation material is represented at 192 apertured at 193 and 194. The aperture 193 provides space for the termination of bus bars to which electrical connection is established by tube 42. Aperture 194 provides space for the termination of bus bars to which connection is established by the contacts of the replaceable condenser unit shown generally at 195, which houses the condensers C_{14} and C_{15}. The bus bars carried by the insulated chassis 192 are separated at the positions indicated at K and L for receiving the safety indicator lights indicated in diagram in Fig. 1, the lights being carried by the casing of unit 7' within which the insulated chassis 162 fits. I have represented the buses carried by insulated chassis 192 as terminating in connectors 92', 93', 98', 102', 106' and 108'. This form of the unit 7' provides for the detachable condenser 195 having contact members carried by the end thereof adapted to established connection with correspondingly aligned contacts carried by insulated chassis 192.

In the modified arrangement of the unit 7' illustrated in Figs. 43–45, the insulated chassis 196 is provided having a single aperture 197 therein operative to receive the contacts of rectifier tube 42. In this form the condenser is not replaceable through the top of the casing, but instead each condenser is formed into an insertable carton 198, one of which contains condenser unit C'_{14} and the other of which contains condenser unit C'_{15}. That is to say, condenser C'_{14} is housed in one carton 198, and condenser C'_{15} is housed in a similarly shaped carton, not shown, but identified as 199 so that the two cartons may be readily inserted in the holding and connection means, on insulated chassis 196, 198' and 199', respectively. The insulated chassis 196 carries terminal connectors on the ends of the buses as indicated at K and L, electrically connected as indicated in Fig. 40. The left hand resilient members 198' and 199' serve as securing means for the removable cartons 198 and 199, while the right hand spring means 198' and 199' serve not only as holding means, but also as connecting means. The buses carried by chassis 196 terminate in connectors which connect to plugs as represented at 92', 93', 98', 102', 106' and 108'.

The main power transformer 43 is detachable with respect to the heart and has been represented in perspective view in Fig. 46. The casing for the power transformer is shown at 200 formed from metallic material and supporting an insulated plate 201 which carries a multiplicity of plug connectors which I have illustrated at 96' and 100' constituting the connections for the primary winding 44; plugs 107' and 109' constituting the outside terminals of secondary winding 46; and plug 104' constituting the mid-tap connection for winding 46; plugs 94' and 99' constituting the connections for cathode heater winding 48; and plugs 103' and 95' constituting the connections for the cathode heater winding 47 leading to the cathode of rectifier tube 42; plug 95' is the B+ voltage. I do not intend that the arrangement shown in Fig. 46 is to be considered in the limiting sense, but it is merely one arrangement which may be employed for the power transformer.

Figs. 47–54 illustrate a modified form of replaceable carton unit which I may employ in lieu of the individual arrangement of condenser and resistor units illustrated in Figs. 17, 18 and 19. In Figs. 47–54 the carton arrangement for the several condenser and resistor units has been illustrated to show the ease by which a defective condenser-resistor combination may be readily removed from the radio receiver unit casing and replaced with a similar carton unit. I have illustrated the carton unit formed from insulation material at 202. The insulation material of carton 202 has walls of sufficiently flexible material to permit the condenser-resistor units to be readily inserted and retained therein. The condenser-resistor units have been represented, for purposes of explaining my invention at C_{10}, R_7, C_9, R_6, and C_8 corresponding to the individual units in Figs. 17, 18 and 19. The side walls of the carton 202 are apertured to receive the rounded or recessed ends of the condenser or resistor units. For purposes of illustration in Figs. 48–52, I have shown the condenser and resistor units as having protruding capped ends of rounded contour which ends are engaged by resilient members 171 carried by insulated chassis 164 similar to the arrangement illustrated in Figs. 17, 18 and 19. However, in lieu of the rounded protuberances of the end caps, I may employ end caps as illustrated in Figs. 53 and 54 at 203, each of which are recessed or indented at 204 but with the circular ends around the recessed portions 204 supported in the apertures provided in the walls of the carton 202. While I have illustrated a condenser in Figs. 53 and 54 provided with caps having recessed ends, it will, of course, be understood that similarly shaped caps may be applied to the resistor units. In this arrangement, the resilient members have the shape indicated at 171' with an inwardly directed protuberance 171'' adapted to engage the recess 204 in the end cap 203. Similar resilient engagements are provided for each of the condenser-resistor units supported by the carton. Thus it will be seen that the entire carton 202 is readily removable from the chassis of the unit in which the carton is employed for replacement of an entirely new carton or replacement of individual units within the carton. The insulated carrier 202 provides a convenient means for removing all of the units and permitting replacement thereof quickly so that at a subsequent time individual condensers or resistors may be renewed in the carton and the carton thus prepared for replacement into the chassis at any subsequent time.

I have described my invention in certain preferred embodiments, but I fully realize that many modifications will suggest themselves and I have in mind other forms in which my invention may be carried out. Accordingly, I desire that it be understood that no limitations are intended or shall be imposed upon my invention other than set forth in the appended claims.

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

1. Radio receiving apparatus comprising in combination a substantially vertically extending main chassis, connecting means extending transversely of said chassis, certain of said connecting means terminating at opposite sides of said chassis, independent replaceable units incorporating

parts of said radio receiving apparatus and terminating in detachable connectors, said detachable connectors being connectible with said transversely extending means on opposite sides of said chassis for completing an electrical circuit through all of the units constituting said radio receiving apparatus, said main chassis having a cut-out portion adjacent one end, connecting means terminating in said cut-out portion and a separable unit engageable within said cut-out portion having circuit elements thereon connected with said connecting means, said separable unit projecting beyond the opposite sides of said main chassis.

2. Radio receiving apparatus comprising in combination, a circuit interconnecting member extending in spaced substantially parallel planes and carrying circuit terminals thereon and having a recess formed in a portion thereof, coacting members each including portions of a radio receiving circuit, terminals carried by said coacting members, one of said coacting members establishing interfitting relationship with the recess formed in said circuit interconnecting member and projecting on opposite sides of the circuit interconnecting member, and means for establishing connection between the terminals on said coacting members and the circuit terminals carried by said circuit interconnecting member for completing a radio receiving circuit through said coacting members.

3. Radio receiving apparatus comprising a circuit interconnecting member extending substantially in a plane surface and carrying circuit terminals thereon, coacting members each including portions of a radio receiving circuit, terminals on said coacting members connected with the portions of the radio receiving circuit, the end of said circuit interconnecting member being recessed transversely of the longitudinal axis of the plane surface thereof and having certain of the circuit interconnecting members carried thereby terminating within the recessed portion and connected to terminals therein, one of said coacting members extending beyond the limits of said circuit interconnecting member and establishing interfitting relationship with the transversely extending recessed portion of said circuit interconnecting member with the terminals thereof electrically connected with the terminals within the recessed portion of said circuit interconnecting member, and means for establishing connection between the terminals carried by others of said coacting members with other terminals of said circuit interconnecting member for completing a radio receiving circuit through said coacting members.

4. Radio receiving apparatus comprising in combination with a casing, terminal members disposed within the casing and extending along opposite interior side walls thereof and electrically connected with parts of an electrical circuit carried by the casing, a removable carton substantially conforming with the interior contour of said casing and carrying circuit elements therein, each having contact portions alignable with and detachably engageable between the terminal members extending along the opposite interior side walls of said casing for completing a portion of a radio receiving circuit through said casing.

5. Mounting means for electrical apparatus comprising in combination with a substantially hollow casing open at the bottom thereof and providing a support for electrical apparatus on the top thereof, pairs of aligned resilient terminal members within said casing and electrically connected with parts of the electrical circuit through the electrical apparatus carried by the casing, a removable carrier shaped to conform with the interior contour of said casing, reactance members each removably supported within said carrier and each having terminals thereon shaped to conform with and be engaged by the resilient terminal members within said casing when said reactance members are inserted through the open bottom of said casing for completing a portion of a radio receiving circuit through said casing.

6. Mounting means for electrical apparatus comprising in combination with a substantially hollow casing having an open bottom portion, pairs of aligned resilient terminal members within said casing disposed adjacent opposite interior side walls thereof and electrically connected with parts of an electrical circuit carried by the casing, a carrier member insertable into and removable from said hollow casing through the open bottom portion thereof, and a multiplicity of reactance members removably mounted in parallel spaced relation in said carrier member and terminating in shaped ends conforming with and engageable by said resilient terminals within said casing for completing a portion of a radio receiving circuit through said casing.

7. Radio receiving apparatus comprising in combination a main chassis constituted by a laminated insulated sheet-like structure carrying bus bar members intermediate the laminated layers thereof, connecting means extending transversely from said bus bars and terminating in opposite sides of said chassis, independent replaceable units incorporating parts of said radio receiving apparatus and terminating in detachable connectors, said detachable connectors being connectible with said transversely extending connecting means on opposite sides of said chassis for completing an electrical circuit through all of the units constituting said radio receiving apparatus, a tuning unit extending substantially through said main chassis normal to the axis thereof, connecting means on said main chassis, and coacting connecting means on said tuning unit for completing electrical connections between said tuning unit and said replaceable units.

8. Radio receiving apparatus comprising a longitudinally extending chassis for connecting means formed in the end thereof, a transversely extending structure carrying tuning means and having connecting means disposed centrally thereof for establishing detachable electrical connection with the connecting means carried by said chassis, said chassis and tuning unit conjointly constituting a substantially T-shaped structure, connecting means extending transversely of said chassis, certain of said connecting means terminating at opposite sides of said chassis, and independent replaceable units incorporating parts of said radio receiving apparatus and terminating in detachable connectors, said detachable connectors being connectible with said transversely extending means on opposite sides of said chassis for completing an electrical circuit through all of the units constituting said radio receiving apparatus.

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