Sept. 15, 1936. J. K. JOHNSON 2,054,424

VARIABLE INDUCTANCE TUNING DEVICE

Filed May 5, 1934 3 Sheets-Sheet 1

Fig. 1,

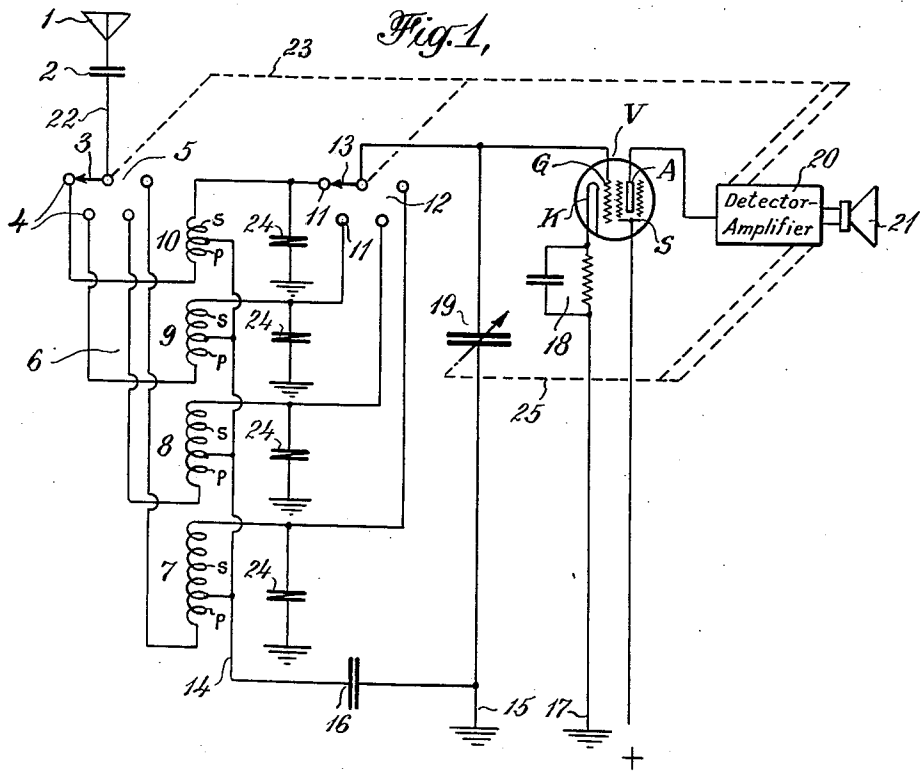

Fig. 2,

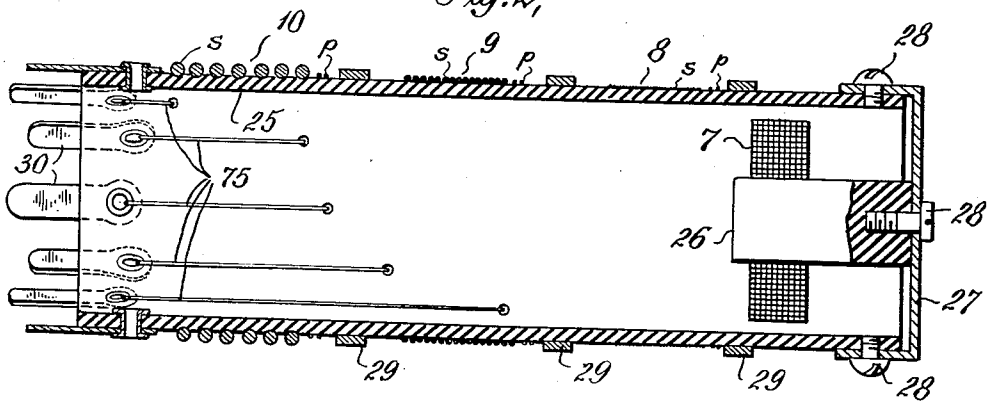

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Fig. 4.

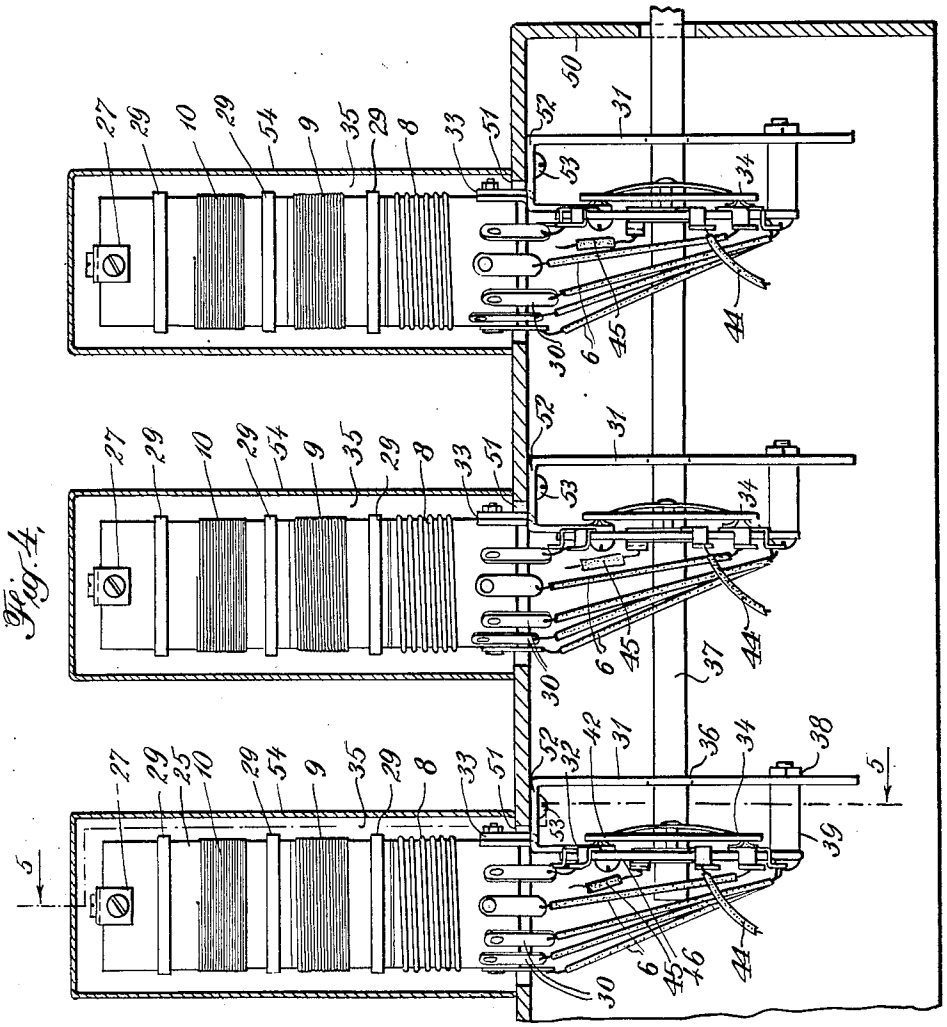
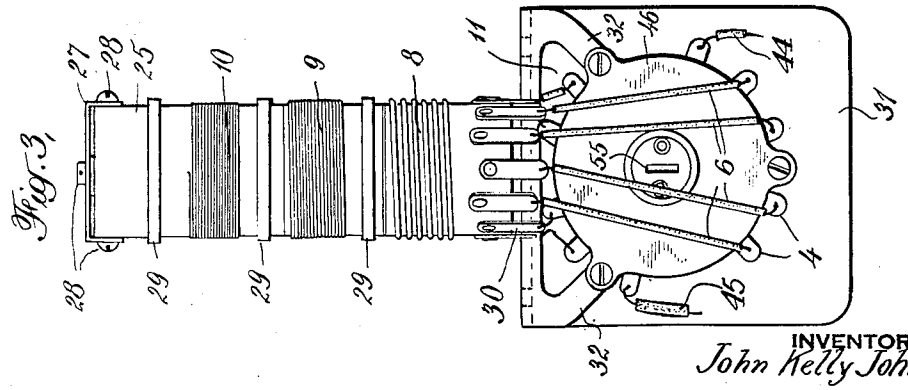


Fig. 3.



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Filed May 5, 1934 3 Sheets-Sheet 3

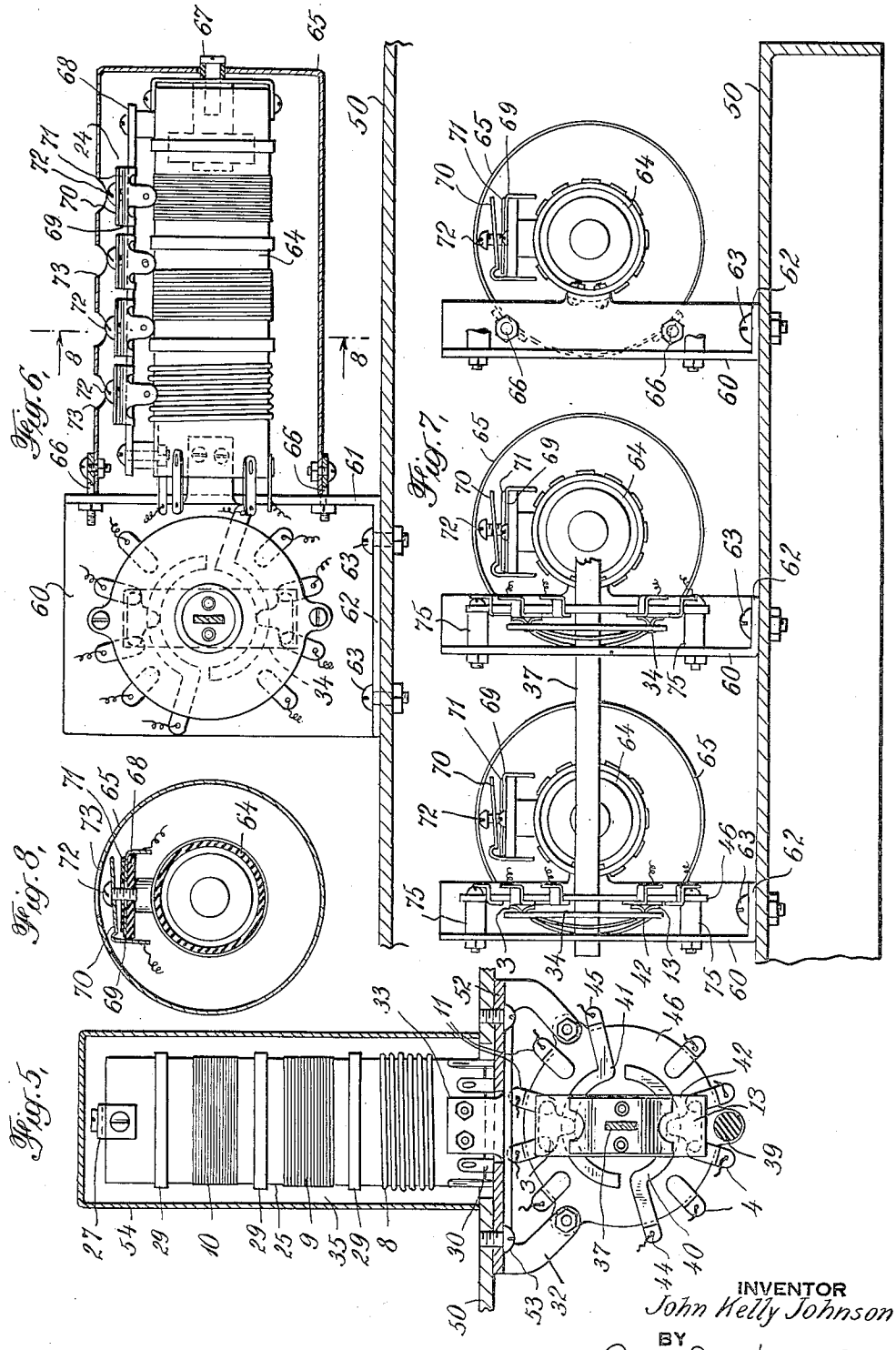

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 5.

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UNITED STATES PATENT OFFICE

2,054,424

VARIABLE INDUCTANCE TUNING DEVICE

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Application May 5, 1934, Serial No. 724,198

16 Claims. (Cl. 171—119)

This invention pertains primarily to improvements in so-called "all wave" radio broadcast receivers, that is, to receivers tunable throughout a plurality of progressively disposed frequency bands.

For receivers of this character the same set of variable condensers may be employed for tuning by continuous gradation throughout each frequency band, by associating with each condenser a plurality of coils of graduated inductances, one for each frequency band to be covered. The coils may be individually and selectively connected to their associated tuning condensers by means of a series of gang operated switches, whereby manipulation of a unitary control adjusts operation from one frequency band to another as desired.

Physical embodiment of such systems of tuning has presented a combination of mechanical and electrical problems. Economy of manufacture, appearance, and ease of maintenance and repair, dictate a physical embodiment of parts which entail a minimum of expense as to construction and assemblage; an embodiment wherein the resulting assembly is compact and of workmanlike appearance; and one which may be expeditiously disassembled. A poor mechanical design is apt to result in a multiplicity of coil forms, an excessively large number of switch contacts, a complicated circuit, unsightly appearance of the chassis, a crowded arrangement rendering difficult the matter of wiring and soldering of connections and removal of parts for repair.

Moreover, a poor mechanical design almost inevitably affects deleteriously the electrical performance of the system in consequence of coupling and standing wave effects resulting from such factors as ill conceived and inadequate shielding, unnecessarily long wiring leads improperly placed, and coils ineffectively wound and relatively disposed.

Especially at the higher frequency bands of operation, the problem of eliminating pernicious couplings and standing waves becomes particularly acute. Standing waves result primarily from the distributed coil capacities whereby a coil is particularly susceptible to naturally occurring resonance at frequencies corresponding to harmonics or overtones of its fundamental frequency. Thus extremely minute couplings extant between coils of higher and of lower inductance, suffice to establish standing waves corresponding to overtones of the former which are responsive to signaling frequencies received by the latter. Standing waves are objectionable as producing at certain frequencies: marked decrease in sensitivity, loss of selectivity due to broadening of the resonance characteristics, dead spots resulting from stopping of the oscillator in superheterodyne circuits, and the like.

The present invention effectively solves the mentioned and other mechanical and electrical problems by providing a self-contained, multi-coil, high frequency transformer and coil switch assembly, which is removably mountable as a unit on the receiver chassis. In the preferred embodiment a unit may be removed intact from the receiver, as for purposes of repair, by disconnection of but a few leads and removal of but a few mounting screws. This avoids the necessity of disconnecting each switch lead from its corresponding transformer terminal, as is required in repairing parts where coils and switches are separately affixed to the receiver panel.

The transformer structure comprises a plurality of coils of different inductances, adapted to cover the several frequency bands, spaced in the order of decreasing inductance along a tubular insulating core. The coils of lower inductance are wound single layer and of progressively increasing wire gage and winding pitch, to maintain the overall length, and hence the cubical core content, substantially the same for all coils. By this novel construction the power factors and distributed capacities are kept within reasonable limits and rendered more nearly uniform for all coils. This assures effective and comparable performance throughout all frequency bands. Moreover, it eliminates distributed capacity and resulting short-circuiting effects for the coils of lower inductances, tending otherwise deleteriously to influence operation in one or more frequency ranges.

The transformer core is preferably secured adjacent the coil of lowest inductance to a lug of a metallic bracket which additionally supports a rotary switch to complete the unitary assembly. Short and substantially linear connections extend from the coil terminals to successive switch contacts. Since the coil-to-switch leads are of substantially invariable length for all units, their influence on the electrical performance can be taken care of in the design, and a factor of uncertainty present in many existing coil structures of this type, thus avoided.

By mounting each rotary switch with its axis substantially perpendicular to the axis of its associated coil structure, a convenient arrangement is secured for "ganging" successive switches for single dial operation. To this end the rotor

elements of the switches are suitably slotted and successive units so mounted in alignment on a panel, so as to permit of simultaneous actuation by a single linear shaft passing through the slots. This shaft is easily withdrawn to permit of removing a unit for replacement or repair.

Effective shielding of units is accomplished in several steps. For shielding the individual coils of the transformer structure from one another, short-circuiting rings may be disposed along the insulating core between successive coils, in the manner described in my copending application Serial No. 713,119, filed February 27th, 1934, Patent No. 2,038,294, issued April 21, 1936. A shielding can, which may be supported on the mounting bracket, houses the transformer structure. The mounting bracket of a unit is provided with a shielding face substantially parallel and coextensive with the switch for shielding successive switches from one another when aligned on the panel for single dial operation.

In the drawings:

Fig. 1 is a circuit diagram of the novel transformer and switching assembly herein, employed as part of a tuned coupling interposed between the antenna circuit and the input tube of an "all wave" radio broadcast receiver, the remaining portion of which is shown in barest schematic form.

Fig. 2 is a longitudinal section of the transformer drawn, for purposes of clarity, to a scale slightly more than the actual dimensions.

Fig. 3 is a view in front elevation of the transformer and switch assembled on a mounting bracket in accordance with the invention.

Fig. 4 shows in side elevation a pluralty of the Fig. 3 units in situ on the mounting panel of a receiver chassis. This view includes a gang control for the switches, and the preferred addition of individual transformer shielding cans shown in longitudinal section for exposing the transformers housed therein.

Fig. 5 is a section along 5—5 of Fig. 4 for elucidating the rotary switch construction.

Figs. 6 and 7 are respectively front and top elevations, partly in section, of modified transformer and coil switch assemblies in situ on a mounting panel.

Fig. 8 is a section along 8—8 of Fig. 6.

Referring to the Fig. 1 circuit, an antenna 1 is connected through a condenser 2 and over lead 22 to a movable wiper 3 contacting seriatum with arcuately disposed terminals 4 of a rotary switch 5. Terminals 4 are joined respectively by leads 6 to the lower terminals of a series of coils 7, 8, 9, and 10, of successively decreasing inductance in the order enumerated. The upper terminals of each of these coils are connected respectively to arcuately disposed terminals 11 of a rotary switch 12, similar to 5, the wiper 13 of which is actuated by a unitary control 23, simultaneously actuating wiper 3 of switch 5. Each of coils 7 to 10 inclusive is tapped at an intermediate point to a conductor 14, grounded at 15 through a by-passing condenser 16. The coils are thus divided by the associated tap into a primary portion P between switch 5 and ground 15, and a secondary portion S between ground 15 and switch 12.

Wiper 13 of switch 12 is connected to the signal control grid G of a vacuum tube V having its cathode K grounded at 17 through a grid biasing circuit 18 comprising a resistor and shunt by-pass condenser. A variable tuning condenser 19 is connected between grid G and ground. Tube V comprises the input tube of a radio receiver the remainder of which, illustrated schematically by rectangle 20, terminates in the usual loud speaker or signal indicating device 21.

The fixed contacts 4 and 11 of switches 5 and 12 are so connected to coils 7 to 10 respectively, that manipulation of the unitary control 23, selectively associates coil 7, 8, 9 or 10 with the antenna 1 and the grid G of tube V to provide operation within a desired frequency band. Irrespective of the particular coil thus associated, the same variable reactor or tuning condenser 19, is operable to tune the system by continuous gradation within limits of the frequency band established by the coil inductance. The coil inductances differ in such amounts as in conjunction with condenser 19, to provide tuning throughout progressively displaced and preferably slightly overlapping frequency bands. As a refinement and by way of avoiding open-circuited coil terminals and accurately allocating the bands in frequency, adjustable padding condensers 24 may be connected between the grid terminal of each coil and ground.

The portion 20 of the receiver may be provided with additional multi-band tuned coupling systems generally similar to that interposed between the antenna and the input tube. In such contingency all of the coil switches may be ganged to the unitary control 23, as indicated. Likewise the rotor elements of the several tuning condensers may be ganged to a unitary control 25, as shown.

Referring to Fig. 2, the transformer coils 7 to 10 inclusive, are mounted upon, and longitudinally spaced in their order of decreasing inductance along, a tubular core 25 of insulating material. Coil 7, of largest inductance, adapted for example to cover the broadcast band of 550 to 1500 kilocycles, and of multi-layer universal gear wound construction, is mounted within the core 25 on a form 26 affixed to the tube by means of the bridge 27 and screws 28. Coils 8, 9, 10, adapted to cover tuning bands of successively higher frequencies, are wound, single layer, about form 25. For the secondary portions *s*, the gauge of wire and the winding pitch is increased as the coil inductance decreases, in order, as explained, to maintain the power factor within reasonable limits for all coils and to maintain the overall dimensions of successive coils approximately the same. The coil ends are terminated by leads 75 at lugs 30 affixed to the end of form 25 adjacent coil 10 of lowest inductance.

Using the coil designations of Figs. 1 and 2, the following coil data is illustrative of a transformer assembly in accordance with the present invention:

Coil	Number of turns	Wire gauge and covering	Winding pitch turns per inch
7 *p*	2	38 SSE	38–40 gear wound.
s	165	2S #38 DSC	Do.
8 *p*	1¼	38 SSE	Close.
s	38	32 E	Do.
9 *p*	1¼	38 SSE	Do.
s	16¼	24 E	36.
10 *p*	2½	38 SSE	Close.
s	6½	16 E	12.

Coils 9 and 10 are wound in grooves .01 inch deep.

For purposes of electrically isolating the coils from one another at high frequencies, short-cir-

cuited rings 29, for example copper bands, are disposed between coils, after the manner described in my copending application referred to above. Equivalent shielding between successive coils may be obtained by substituting for the rings 29, conductive discs disposed internally of tube 25 at spacings corresponding to those of rings 29.

The multi-coil transformer unit of Fig. 2, may be assembled into a self-contained unit with its associated switches 5 and 12, Fig. 1, in the manner of Figs. 3, 4, and 5. To this end a shielding bracket 31 is provided, which is stamped from a single sheet of conductive material, such as steel or aluminum, having an edge incised, punched and reflexed, to provide oppositely extending lugs 32 and 33 for mounting the rotary switch unit 34 and transformer assembly 35 respectively. The face of the bracket 31 is punched at 36 to admit the switch shaft 37, and also at 38 to receive the threaded end of a lug 39 supporting switch 34 at its lower extremity.

The rotary switch comprises the two sets of arcuately disposed terminal lugs 4 and 11, Fig. 5, and associated semi-circular contact bands 40 and 41, mounted on an insulating disc 46, and traversed respectively by the bridging wipers 3 and 13 affixed to a rotary switch arm 42 of insulating material.

The coil lugs 30, joined to the high potential terminals of coils 7 to 10 respectively, are connected by the short and substantially linear leads to the upper arc 11 of switch lugs; while the coil lugs 30 joined to the low potential terminals of the respective coils 7 to 10, are connected by short and substantially linear leads 6 to individual contacts of the lower arc 4 of switch contacts.

Referring more particularly to Fig. 4, several coil-switch assemblies, each in accordance with Figs. 3 and 5, are assembled on a receiver panel 50 for unitary switching manipulation by shaft 37. The panel 50 is punched to provide aligned apertures 51 through which the transformer units 35 are projected until the horizontal portions 52 of brackets 31 abut the under side of the panel. Mounting is effected by screws 53 extending through apertures of the brackets and threaded into the panel. The coil units 35 are individually shielded from one another by means of the shielding cans 54 crimped or otherwise affixed to the panel.

The rotary switches 34 are all faced in the same direction to permit of extending the unitary actuating shaft 37 through slotted apertures 55 (Fig. 3) of the rotary wiper supports 42. The switches are further so faced that their associated shielding brackets 31 are interposed between adjacent switches as shown.

The Fig. 4 embodiment is of exceedingly economical, compact, and easily assembled and disassembled construction. Each coil and switch assembly is a self-contained unit as shown in Fig. 3, wherein the wiring leads from the coils to the switch are of standard and substantially invariable length for each unit, thereby permitting of uniform quantity production.

To mount a transformer-switch unit, such as Fig. 3, upon the panel 50, necessitates threading of but two screws 53 into the panel. The unit is, with equal facility, electrically connected into a circuit, such as Fig. 1, by merely soldering the two switch lugs 44 and 45, to appropriate circuit leads, such as the antenna lead 22 and the lead extending to grid G of tube V respectively, of Fig. 1, and by further soldering lead 14 to the proper lug 30.

By arranging the coils in their order of decreasing inductance along the core 25, with the coil of lower inductance adjacent the switch, the switch leads to the coils of larger inductance pass in proximity to the coils of lower inductance, but the leads to the coils of lower inductance do not traverse the coils of higher inductance. The advantage of this design results from the fact that the coils of higher inductance are, in general, unresponsive to the relatively high fundamental and overtone frequencies at which the coils of lower inductance are inherently resonant. On the other hand, the coils of higher inductance are apt, by virtue of their distributed capacities tending to provide overtone resonance effects, to be responsive at the relatively higher reception frequencies to which the coils of lower inductance are tuned. It is therefore important to minimize transfers of high frequency energy from the higher frequency lower inductance coils to those of higher inductance and lower frequency.

The shielding precautions of the Fig. 4 assembly are unique in several respects. The individual coils, 7, 8, 9, and 10, are, as stated, electrically isolated from each other at high frequency by virtue of the interposed short circuited rings 29. Each coil unit 35 is shielded from the others by the individual shielding cans 54. Due to the fact that the transformers project through apertures in the metallic panel 50, the latter acts as a shielding partition between the transformer units 35 and their associated switches 34. Switches 34 are in turn shielded from each other by means of their associated interposed shielding brackets 31.

The mechanical assembly of the Fig. 4 embodiment with its complete but economical individual shielding of circuit components, the novel coil layout inherently minimizing coupling and standing wave effects, together with the unit coil-switch assembly employing short, substantially linear connecting leads, has resulted in practice in multi-band radio receivers continuously tunable throughout the entire "all wave" range with a maximum of sensitivity and selectivity.

Equally desirable performance is obtainable from the slightly modified construction of Figs. 6, 7, and 8. The coil-switch bracket 60 has a pair of perpendicular edges 62 and 61 bent at right angle to the shielding face; the one to permit of mounting the bracket on the panel by means of screws 63, and the other for affixing the coil unit 64 and associated shielding can 65 directly to the bracket, the latter by means of the threaded lugs 66, affixed to the can as shown. The shielding can is centered with respect to the coil unit by means of a screw 67 threaded into the central coil form support. The face of the bracket is punched for mounting the switch 34 on lugs 75. In consequence, the switch, bracket, coil assembly and associated shielding can, are removable as a unit from the receiver chassis.

The tubular coil form has mounted thereon in spaced relation, a longitudinally extending insulating strip 68, supporting a row of padding condensers 24, such as are shown diagrammatically in Fig. 1. These padding condensers comprise in each instance, a metallic lower plate 69 and a resilient metallic upper plate 70 separated by a mica strip 71. The capacities are adjustable by screws 72 threaded through the

lower plate. The shielding cans are apertured, as at **73**, over each screw head, to facilitate such adjustments.

The axis of each coil switch is, as in the previously described modification, arranged substantially at right angles to that of the associated coils, thereby to facilitate coaxial alignment of the several switches on panel **50** for purposes of unitary actuation by shaft **37**.

I claim:

1. A self-contained high-frequency transformer and switching unit comprising: a plurality of coaxial shielding rings alternating with coils of different inductances along an insulating support, a rotary switch affixed to an extremity of said support with its axis substantially perpendicular to the axis of said coils, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said unit to a panel.

2. A self-contained high-frequency transformer and switching unit comprising: a plurality of coaxial shielding rings alternating with coils of decreasing inductances along an insulating support, a switch with an associated parallel shielding plate affixed to said support adjacent the coil of lowest inductance, a shaft for operating said switch, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said unit to a panel.

3. A high-frequency transformer and switch assembly comprising: a plurality of coaxial conductive shielding rings alternating with coaxial coils of decreasing inductances along an insulating support, the turns of said coils being, in said order, increasingly distributed, a rotary switch and associated parallel shielding plate integral with said support adjacent the coil of lowest inductance, short and substantially linear connecting leads from the respective coils to contacts of said switch, a shielding can for said coils electrically and mechanically secured to said plate, and means for removably mounting said assembly upon a panel.

4. A self-contained high-frequency transformer and switching unit comprising: a plurality of coaxial shielding rings alternating with coils of decreasing inductances along an insulating support, a switch with an associated parallel shielding plate affixed to said support adjacent the coil of lowest inductance, a shaft for operating said switch, said shaft being substantially perpendicular to the axis of the coils, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said unit to a panel.

5. A high-frequency transformer and switch assembly comprising: a plurality of coaxial conductive shielding rings alternating with coaxial coils of decreasing inductances along an insulating support, the turns of said coils being, in said order, increasingly distributed, a rotary switch and associated parallel shielding plate integral with said support adjacent the coil of lowest inductance, the axis of said switch being substantially perpendicular to the axis of the coils, short and substantially linear connecting leads from the respective coils to contacts of said switch, a shielding can for said coils electrically and mechanically secured to said plate, and means for removably mounting said assembly upon a panel.

6. In combination with a conductive panel, a self-contained high-frequency transformer and switching unit comprising: a plurality of coaxial shielding rings alternating with coaxial coils of decreasing inductances along an insulating support, a shaft-actuated switch and associated parallel shielding plate affixed to an extremity of said support, the shaft of said switch being substantially perpendicular to the axis of said coils, short and substantially linear connecting leads from the respective coils to contacts of said switch, means removably affixing said unit to said panel with said transformer and switch on opposite sides thereof, and a shielding can housing said transformer.

7. In combination with a supporting panel, a plurality of high-frequency transformer and switching units, each comprising: a plurality of coaxial coils of decreasing inductances spaced along an insulating support, a shaft-actuated switch affixed to an extremity of said support, the axis of the shaft of said switch being substantially perpendicular to the axis of said coils, short and substantially linear connecting leads from each of the respective coils to contacts on its associated switch, means removably mounting said units upon said panel, and a common shaft for simultaneously actuating said switches.

8. In combination, a plurality of high-frequency transformer and switching units each comprising: a plurality of coaxial coils and conductive rings alternately spaced along an insulating tubular support, coil-switching means affixed to an extremity of said support, means removably affixing said units to a conductive panel partitioning said transformers from said switches, and means electrically grounded to said panel individually shielding said switches and transformers.

9. In combination, a plurality of high-frequency transformer and switching units each comprising, a plurality of coaxial conductive rings alternating with coaxial coils of decreasing inductances along an insulating support, a rotary switch and associated parallel shielding plate affixed to said support adjacent said coil of lowest inductance, the switch axis being substantially perpendicular to the axis of the coils, short and substantially linear connecting leads from the respective coils to contacts of said switch, means including said shielding plate removably affixing said units to a conductive panel partitioning said transformers from said switches, a common shaft actuating said switches, and conductive cans grounded to said plates for shielding said transformers.

10. A shielding bracket for mounting a multi-coil high-frequency transformer and coil-switch assembly comprising: a single conductive plate having a shielding face perforated for reception of a switch-actuating shaft and a switch mounting bolt respectively, and a reflexed edge incised to provide oppositely extending mounting lugs for said transformer and switch respectively, said edge being perforated for reception of mounting screws.

11. A shielding bracket for mounting a multi-coil high-frequency transformer and coil-switch assembly comprising, a single conductive plate having a shielding face perforated for reception of a switch-actuating shaft and a switch mounting bolt respectively, and an incised edge bent perpendicular and thence parallel to the face to provide oppositely extending transformer and switch mounting lugs, said perpendicular portion being perforated to receive panel mounting screws.

12. The combination with a multi-coil high-

frequency transformer and a coil switch, of a shielding bracket for mounting said coil and switch, said bracket comprising: a single conductive plate having a face perforated for reception of a switch-actuating shaft and a switch mounting bolt, and a reflexed edge incised to provide oppositely extending lugs supporting said transformer and switch respectively, said edge being perforated for reception of mounting screws.

13. The combination with a multi-coil high-frequency transformer and a rotary coil switch, of a shielding bracket for mounting said coil and switch on a conductive panel, said bracket comprising: a single conductive plate having a face perforated for reception of a switch-actuating shaft and a switch mounting bolt, and an incised edge bent perpendicular and thence parallel to said face to provide oppositely extending lugs supporting said transformer and switch respectively, said perpendicular portion being perforated for reception of panel mounting screws.

14. A self-contained high-frequency transformer and switching unit comprising: a plurality of coils of different inductances spaced along an insulating support, a shaft-actuated switch, a metallic bracket integrally mounting said coil and switch, said bracket having a portion adapted to shield said switch from other switches actuated by the shaft of said switch, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said bracket to a panel.

15. A self-contained high-frequency transformer and switching unit comprising: a plurality of coaxial shielding rings alternating with coils of different inductances along an insulating support, a shaft-actuated switch, a metallic bracket integrally mounting said coil support and switch, said bracket having a portion adapted to shield said switch from other switches actuated by the shaft of said switch, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said bracket to a panel.

16. A self-contained high-frequency transformer and switching unit comprising: a transformer structure consisting of coaxial shielding rings alternating with coils of different inductances along an insulating support, a shielding can surrounding said transformer structure, a shaft-actuated switch, a metallic bracket integrally mounting said transformer structure, shielding can and switch, said bracket having a portion adapted to shield said switch from other switches actuated by the shaft of said switch, short and substantially linear connecting leads from the respective coils to contacts of said switch, and means for removably affixing said bracket to a panel.

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