Nov. 17, 1942. F. W. EDWARDS 2,301,934

MULTIRANGE HIGH FREQUENCY SYSTEM

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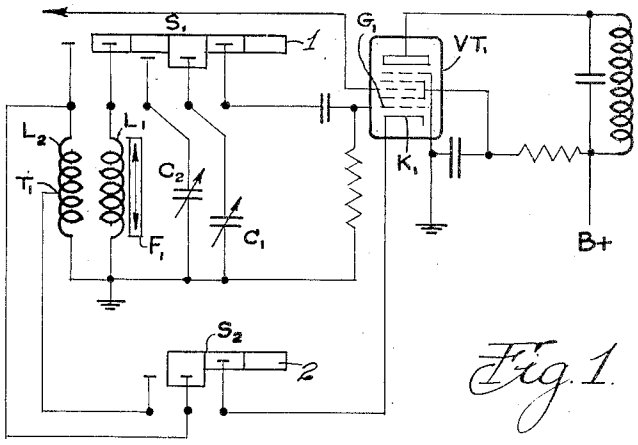


Fig. 1.

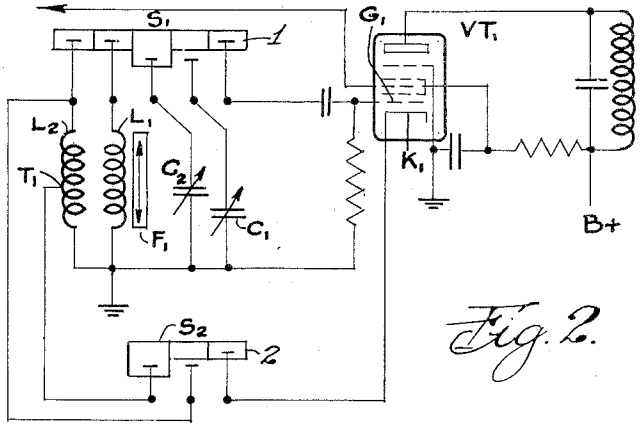


Fig. 2.

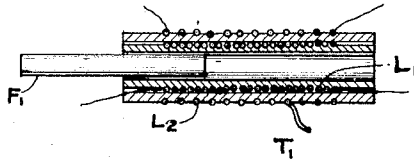


Fig. 3.

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Fig. 4

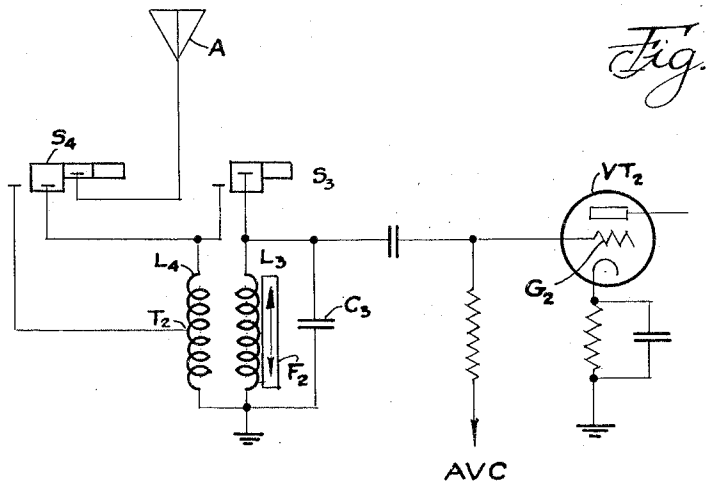
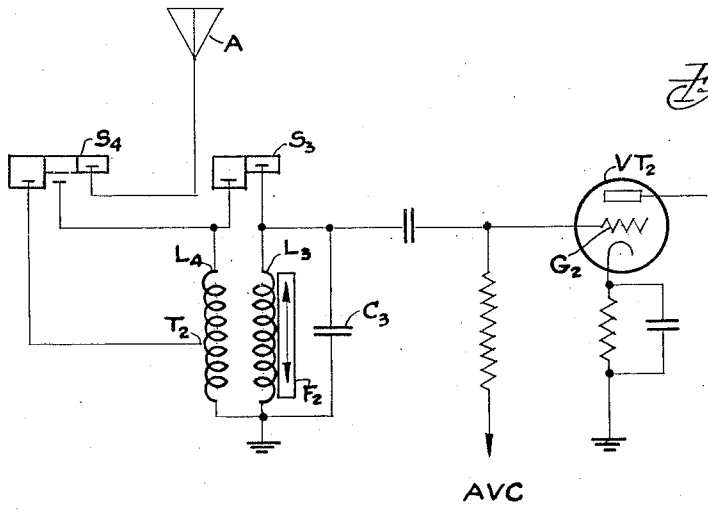


Fig. 5



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UNITED STATES PATENT OFFICE

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MULTIRANGE HIGH FREQUENCY SYSTEM

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Application January 5, 1942, Serial No. 425,583

6 Claims. (Cl. 250—20)

The invention relates to circuit arrangements for radio receivers of the type designed to cover more than one continuously tunable band of frequencies; in particular it relates to such receivers in which the tuning is accomplished by inductance variation through the employment of movable ferromagnetic cores.

In radio receivers of this type it is necessary to employ switching arrangements to change the inductance or capitance values or both, in each of the tuned circuits, when passing from one frequency band to another. If separate coils and condensers are used in each of the several wave-bands the switching is relatively simple, but the cost of the plural coils and condensers is excessive, and they require considerable space. Furthermore, if such a receiver is to be tuned by inductance variation through movable ferromagnetic cores, and the shift from frequency band to frequency band involves the use of additional inductance, plural cores must be provided for each circuit, or alternatively the plural coils of each circuit must be brought into physical alignment with a single core. In either case additional complication and expense are involved, and additional space is required.

Numerous expedients have already been proposed to reduce the cost and size of such arrangements, in many cases at a serious sacrifice in the electrical performance of the circuits. In some arrangements, for example, although the performance in one of the wave-bands was reasonably good, it was markedly inferior in the other wave-bands, due to the use of a single coil in each circuit, with taps to produce different inductance values, which resulted in serious losses in the unused coil portions on the higher frequency wave-bands and in a highly undesirable curtailment of the tuning range normally expected from a tuning core of a certain permeability.

A still further complication arose in cases where it was necessary to provide for inductive coupling to the multi-band tuning system; for example in oscillator circuits of the feedback type it was necessary in many cases to provide plural oscillator feedback coils as well as plural inductance coils for the oscillator tank circuit.

It is an object of the present invention to furnish an efficient arrangement of coils, and switch gear for a permeability-tuned plural band circuit in which the shift from band to band is accomplished primarily, if not entirely, by the addition or removal of an inductance and which includes provision for inductive coupling to said circuit such as may be necessary in regenerative systems or in antenna input circuits.

It is an additional object of the present invention to provide an arrangement of the type referred to in which minimum possible cost is secured by the employment of the minimum number of component parts and in which low cost is combined with good electrical performance and minimum space requirements.

It is also an object of the present invention to provide a compact and inexpensive plural band arrangement of the type referred to in which performance in any one frequency band is not materially sacrificed in order to secure low cost.

More specifically it is an object of the present invention to provide a permeability-tuned multi-band system of inductively coupled circuits in which the changeover from band to band is accomplished primarily by variation of the circuit inductances and wherein the inductive coupling between the circuits is appropriately changed as the frequency band is changed, there being at no time any unused coil or coil portions of a size that would deteriorate the Q value of the system or curtail the tuning range.

According to the present invention a resonant circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to inductively tune said resonant circuit and a second circuit such as an antenna system or a feedback circuit are inductively coupled by a second winding arranged concentrically around said first winding, switching means being provided to connect substantially all of said second winding into said second circuit so as to adjust the arrangement for tuning over a range of lower frequencies, and also to connect said second winding into said first circuit in parallel with said first winding while placing a tapped portion thereof into said second circuit so as to adjust the system for tuning over a range of higher frequencies. Thus in either position of the switching means there is no inoperative coil or winding in the system. At the same time proper positioning of the tap on the second winding permits of appropriately changing the inductive coupling between the circuits of the system when switching the resonant circuit from one range to the other, without any separate coupling coils being required.

The invention will best be understood by reference to the accompanying drawing which illustrates by way of example a permeability-tuned two-band arrangement. It will be understood that the invention is not limited to two-band arrangements and that the principles involved by

which economy and efficiency are combined are equally applicable to systems having other numbers of wave bands.

Fig. 1 is a schematic circuit diagram of the oscillator portion of a permeability tuned superheterodyne receiver embodying the invention.

Fig. 2 is a schematic circuit diagram similar to Fig. 1 showing the system illustrated in Fig. 1 in a different switching position.

Fig. 3 is a longitudinal section of the coil arrangement employed in the systems of Figs. 1 and 2.

Fig. 4 is a schematic circuit diagram of an antenna system embodying the present invention.

Fig. 5 is a schematic circuit diagram similar to Fig. 4 showing the system illustrated in Fig. 4 in a different switching position.

The oscillator system illustrated in Figs. 1 and 2 has two windings L_1 and L_2 arranged concentrically with one another as shown in Fig. 3 and acted upon by a common ferromagnetic core F_1 which is arranged to be movable relatively to said windings. The system also has condensers C_1 and C_2 and switching gear indicated generally by S_1 and S_2. Otherwise the figures show the conventional connections of an oscillator system through grid condensers by-passed by grid resistors to the appropriate grid electrodes of a pentagrid converter tube VT_1, for example of the type known as 6SA7. It will be understood that other types of vacuum tubes may be employed for the high frequency tuning system of the invention without departing from the spirit thereof.

In the position of switch gear S_1 and S_2 as illustrated in Fig. 1 the tank circuit of the oscillator arrangement comprises winding L_1 and condenser C_1 in parallel, with winding L_2 being connected between ground and cathode K_1 to provide the feedback. In this position movement of core F_1 relative to winding L_1 will tune the tank circuit over a certain range of frequencies. In the position of switches S_1 and S_2 as illustrated in Fig. 2 the oscillator tank circuit inductance comprises winding L_1 and L_2 connected in parallel to produce an inductance value considerably lower than that of winding L_1 alone. The inductor thus formed is now shunted by condenser C_2 instead of condenser C_1. Due to the smaller amount of effective inductance in the circuit and with an appropriate value for condenser C_2 the system now operates over a range of higher frequencies than what it covered with the connections as illustrated in Fig. 1. It will also be noted that whereas formerly all of winding L_2 was connected between ground and cathode K_1 of vacuum tube VT_1 it is now only a tapped portion of winding L_2 that provides the necessary feedback. Proper choice of tap T_1 on winding L_2 permits of establishing the appropriate amount of coupling required between the tank circuit and the feedback circuit for the higher frequency band.

Thus, operation of switch gear S_1 and S_2 allows the tuning range of the oscillator system to be shifted from a lower to a higher band or vice versa, by addition of an inductance to, or removal of an inductance from the tank circuit without there being in either switch position any unused coils or windings which might impair the Q value of the system or curtail its tuning range. Additionally the system is such that no separate feedback windings are necessary.

It will be noted that different condensers are employed for each of the two frequency bands, this being preferable since the condensers themselves are quite small in size and are made adjustable, thus providing alignment means in each of the two bands. However, it will be understood that for certain purposes the two condensers might be combined into a single condenser comprising a condenser unit with appropriate taps to provide the necessary capacitance values.

As shown in Figs. 1 and 2 the switch gear necessary to provide the required connections for the two frequency bands consists essentially of suitable contacts connected to the winding and condenser terminals whose connections are to be changed by movable contact members 1 and 2 which appropriately engage the contacts depending on their position as indicated in Figs. 1 and 2. It will be understood that while the switch gear is shown in two portions and as a translatory device it will in practice comprise a unitary structure and will preferably be of the rotary type for ease of control and low manufacturing cost.

A coil arrangement suitable for use in the system described in connection with Figs. 1 and 2, is shown in Fig. 3. Winding L_1 is wound on a suitable insulating tube and winding L_2 is wound on a second insulating tube whose internal diameter is just sufficient to slip readily over the completed inner winding. The outer winding L_2 is provided with a tap T_1 as shown. A core F_1 is arranged to slidably fit into the insulating tube upon which winding L_1 is wound. In the system illustrated in Figs. 1 and 2 core F_1 may be arranged to enter the coil system from either side; I prefer, however, to have it enter the grounded end of the coil arrangement first.

It is an additional feature of my invention by which I secure great economy and efficiency that movement of the ferromagnetic core within the concentrically arranged inner and outer windings not only varies the inductances of each of the windings but also varies the coupling between the windings thus producing the required inductance and coupling variations by use of a single core member in each of the circuits for all of the plural frequency bands.

The coil system just described is extremely simple to manufacture and much lower in cost than coil systems for plural band receivers heretofore employed.

Fig. 4 illustrates the invention as applied to a permeability-tuned antenna system such as may be used in superheterodyne receivers or in tuned radio frequency receivers. Inductances L_3 and L_4 and core F_2 correspond with inductances L_1 and L_2 and core F_1 respectively of the arrangement described in connection with Figs. 1 and 2, and switches S_3 and S_4 correspond with switches S_1 and S_2. Instead of two separate capacitances C_1 and C_2, however, the arrangement of Fig. 4 includes only one capacitance C_3 for both tuning ranges, the changeover from range to range being accomplished entirely by the addition or removal of inductance.

In the switch position illustrated in Fig. 4 the grid circuit of the first vacuum tube VT_2 comprises inductive winding L_3 and capacitor C_3 in parallel. The antenna circuit comprises antenna A and inductive winding L_4 which is inductively coupled to winding L_3.

In the position illustrated in Fig. 5 the input circuit comprises inductive windings L_3 and L_4 in parallel, with capacitance C_3 having remained the same. Antenna A is now connected to an appropriate tap T_2 of winding L_4. Due to the reduced effective inductance in the grid circuit, movement of core F_2 relative to windings L_3 and

L_4 will now tune the system over a higher range of frequencies than the frequency range which the core movement covered in the position shown in Fig. 4.

It will be noted that the arrangement illustrated in Fig. 4 provides for all of winding L_4 to be connected in the antenna circuit. It will be understood, however, that in instances where a lesser amount of coupling between antenna and grid circuit is desired matters may be arranged in such a manner within the scope of my invention that the switch position illustrated in Fig. 4 does not include all, but only the greater part of winding L_4 into the antenna circuit. It has been found that this will not appreciably impair performance of my system on the low range.

The following are specific structural data for a system according to the invention as illustrated in Figs. 1 and 2 and employing a coil arrangement constructed as shown in Fig. 3. It will be understood that I do not wish to be limited to the specific frequency ranges or other values set down since the invention is equally applicable to other frequency ranges and other values of the various constants and to receivers other than superheterodyne receivers. Likewise my invention is not restricted to use in antenna systems or feedback systems. It may, for instance be employed as interstage coupling circuit in tuned radio frequency receivers.

Frequency bands covered:
- Lower band, 3.5–8.0 megacycles.
- Upper band, 14.25–22.0 megacycles.
- Intermediate frequency, 0.455 megacycle.

Capacitances (adjustable):
- C_1, 247.5 micromicrofarads.
- C_2, 47.5 micromicrofarads.

Coil systems:
- Inner tube carrying winding L_1:
  - Inside diameter 0.205 inch.
  - Outside diameter 0.275 inch.
- Outer tube carrying winding L_2:
  - Inside diameter 0.320 inch.
  - Outside diameter 0.443 inch.
- Inner winding L_1:
  - Wire #26 tinned copper wire, 29½ turns; pitch 22 turns per inch. Inductance, 1.2 microhenrys.
- Outer winding L_2:
  - Wire #22 tinned copper wire, 15½ turns; pitch 12 turns per inch. Inductance, 0.9 microhenry.
- Tap on L_2:
  - 11½ turns from grounded end. Inductance 0.6 microhenry.
- Mutual inductance between L_1 and L_2:
  - 0.625 microhenry.
- Effective inductance in the upper band L_1 and L_2 in parallel:
  - 0.800 microhenry.

Core F:
- Diameter, 0.200 inch. Length, 1.375 inches. Material, 400 mesh powder of iron. Weight 3.55 grams. Effective permeability 4.76.

Having thus described my invention what I claim is:

1. Coupled high frequency circuit arrangement for multirange tuning including a tunable resonant circuit having an inductive winding, a second winding arranged concentrically with and inductively coupled to said first winding, a second circuit, and switching gear for connecting substantially all of said second winding into said second circuit to adjust said circuit arrangement for tuning over a range of lower frequencies and for connecting all of said second winding into said first circuit and in parallel with said first winding while connecting part of said second winding into said second circuit to adjust said circuit arrangement for tuning over a range of higher frequencies.

2. Coupled high frequency circuit arrangement for multirange tuning including a resonant circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to inductively tune said circuit, a second winding arranged concentrically around and inductively coupled to said first winding, a second circuit, and switching gear for connecting substantially all of said second winding into said second circuit to adjust said circuit arrangement for tuning over a range of lower frequencies and for connecting said second winding into said first circuit and in parallel with said first winding while connecting a part of said second winding into said second circuit to adjust said system for tuning over a range of higher frequencies.

3. Coupled high frequency circuit arrangement for multirange tuning, including a resonant circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to tune said circuit, a second winding arranged concentrically around and inductively coupled to said first winding, plural capacitors, a second circuit, and switching gear for connecting substantially all of said second winding into said second circuit and one of said capacitors into said first circuit to adjust said circuit arrangement for tuning over a range of lower frequencies and for connecting another one of said capacitors and all of said second winding into said first circuit and in parallel with said first winding while connecting part of said second winding into said second circuit to adjust said circuit arrangement for tuning over a range of higher frequencies.

4. A multiband antenna system for radio receivers and the like including an antenna circuit, a resonant circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to tune said circuit, a second winding arranged concentrically with and inductively coupled to said first winding and switching gear for connecting substantially all of said second winding into said antenna circuit to adjust said system for tuning over a range of lower frequencies and for connecting all of said second winding into said resonant circuit in parallel with said first winding while connecting a part thereof into said antenna circuit to adjust said system for tuning over a range of higher frequencies.

5. A multiband oscillator system for radio receivers of the superheterodyne type and the like including a tank circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to tune said tank circuit, a second winding arranged concentrically with and inductively coupled to said first winding, a feedback circuit, and switching gear for connecting substantially all of said second winding into said feedback circuit to adjust the system for tuning over a range of lower frequencies and for connecting all of said second winding into said tank circuit in parallel with said first winding while connecting part thereof into said feedback circuit to adjust said system for tuning over a range of higher frequencies.

6. A multiband oscillator system for radio receivers of the superheterodyne type and the like including a tank circuit having an inductive winding and a ferromagnetic element movable relatively to said winding to tune said tank circuit, a second winding arranged concentrically around and inductively coupled to said first winding, said second winding having a tap, plural capacitances, a feedback circuit, and switching gear for connecting substantially all of said second winding into said feedback circuit and one of said capacitances into said tank circuit to adjust said system for tuning over a range of lower frequencies and for connecting another of said capacitances and said second winding into said tank circuit and in parallel with said first winding while connecting the tapped part of said second winding into said feedback circuit so as to adjust said system for tuning over a range of higher frequencies.

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