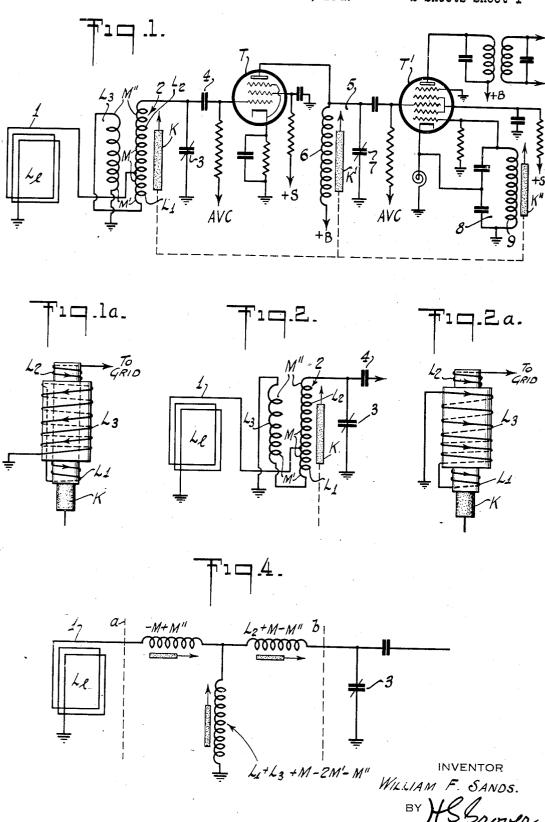
LOOP INPUT SYSTEM FOR RADIO RECEIVERS

Filed Dec. 30, 1942

2 Sheets-Sheet 1

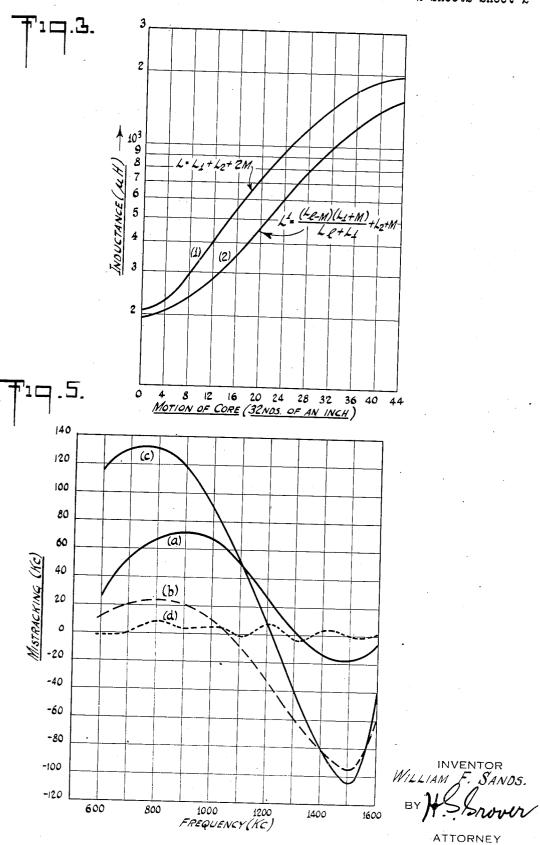
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UNITED STATES PATENT OFFICE

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LOOP INPUT SYSTEM FOR RADIO RECEIVERS

William Francis Sands, West Collingswood, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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9 Claims. (Cl. 250-20)

The present invention relates to a loop input system for radio receivers, and more particularly to a loop input system utilizing a permeability tuned auto-transformer, providing efficient, coupling means from the loop antenna to the input 5 of the first tube of the receiver.

In the copending application of G. L. Beers, Serial No. 473,806, filed January 28, 1943, assigned to the same assignee as this application, tuned loop input system which provides a substantially uniform response over the tuning band, and in which the loop is tapped to a point between 25 to 35% of the turns from the grounded end functions as an auto-transformer. However, due to shunting the loop inductance across a portion of the coil constituting the tuned input circuit of the receiver, mistracking will occur between tuned circuits that are uni-controlled therewith.

According to the present invention improved performance is secured by the use of an auxiliary coil which is interposed between ground and the low potential end of the auto-transformer and 25 which is wound over said auto-transformer and in opposing phase thereto, so that improved tracking is obtained between the input circuit to which the loop antenna is coupled and other permeability tuned circuits which have no inductive load across their windings or a portion thereof.

The invention will be understood from the following description, when considered in connection with the accompanying drawings and its scope is pointed out in the appended claims.

In the drawings,

Fig. 1 shows a permeability tuned loop input circuit which embodies the present invention;

Fig. 2 is a variant of the circuit of Fig. 1:

Figs. 1a and 2a show arrangements of the coil windings utilized in the modifications disclosed respectively in Figs. 1 and 2;

Fig. 3 illustrates curves showing the variation in inductance of identical coils with and without the antenna load shunted across a portion of the coil;

Fig. 4 shows the equivalent T network of the coupling means, between the loop antenna and the grid of the first tube, utilized in Figures 1 50 and 2; and

Fig. 5 are curves showing the improvment in the tracking obtained with the use of the present invention.

loop antenna of inductance Le having one end thereof directly connected to ground while the other or high potential end is tapped onto a permeability tuned inductance 2, dividing the same into a lower portion L1 and an upper portion L2. Preferably the tapping point is such that the portion L₁ is between 25 to 35% of the entire coil 2. The high potential end of the coil 2 is coupled through a coupling capacitor 4 to there is disclosed and claimed a permeability 10 the signal grid of a tube T, which in the above mentioned Beers' application may be the first radio frequency amplifier tube, or the detectoroscillator. A capacitor 3 forming part of the input circuit to the tube T is connected between the of the permeability tuned inductance coil which 15 grid end of coil 2 and ground. A ferromagnetic core K movably mounted within and entering the low potential end of the coil 2 serves to tune the input circuit over the signal frequency band for which the receiver is designed. The portion of the tuned input circuit and other permeability 20 the circuit just described is disclosed in the above copending application.

However, when the first tube of the receiver is a radio frequency amplifier as indicated at T in Fig. 1 of the drawings, it is found that due to shunting the loop inductance across a portion of the tuning coil 2 included in the signal input circuit to said amplifier, serious mistracking occurs between said tunable input circuit and the other tunable circuits of the receiver, such as the sig-30 nal frequency circuit 5 included in the output of said R. F. stage and the oscillator circuit 8 associated with the detector oscillator tube T', it being assumed that the permeability tuned coils 2 and 6 of the respective signal frequency circuits 35 are identical.

In order to compensate for such mistracking, thus obtaining improved performance, I provide an auxiliary coil L3 which is interposed between ground and the low potential end of the autotransformer 2. The coil La is wound over the auto-transformer and is serially connected with the parts L1 and L2 thereof in such manner as to produce a negative mutual inductance i. e., "bucking" connection. This may be achieved by winding L_3 and the auto-transformer 2 (L_1 — L_2) in the same or opposite directions. In Fig. 1 and more clearly in Fig. 1a the coils are shown to be wound in opposite directions. In this case the upper end of auxiliary coil L3 is connected to the lower end of the coil L1 and the lower end of L3 is connected to ground. In Fig. 2 and more clearly in Fig. 2a the coils are shown to be wound in the same direction. In this case the lower end of auxiliary coil Ls is connected to the lower end Referring to Fig. 1 there is represented at 1 a 55 of coil L1 and the upper end coil L3 is connected

to ground. In either case, the performance is substantially the same, except for minor effects due to a change in capacity coupling.

For a better understanding of the invention, the following analysis will be made. The inductance (L) of the auto-transformer L₁, L₂, without the loop connected to the tapping point, is given by:

$$L = L_1 + L_2 + 2M$$
 (1)

With the loop connected to the tapping point, as shown in Figs. 1 and 2 but without the auxiliary coil L₂, the overall inductance (L') is given by:

$$L' = \frac{(L_e - M)(L_1 + M)}{L_1 + L_e} + L_2 + M$$
 (2)

The variation over the tuning range of the inductance L (without the loop connection) and that of the inductance L' (with the loop connection), as determined in each case by movement of the tuning core through its entire range, are given 20 by the curves I and 2 of Fig. 3. It will be seen that, at each point, both the magnitude and slope of the two curves are different. In a receiver having only the antenna circuit for preselection, the oscillator winding may be redesigned to track with 25 the loop loaded antenna auto-transformer. However, in a receiver with more than one signal frequency circuit, compensating means must be provided either in the antenna circuit, or in the remaining signal frequency and the oscillator cir- 30 cuits. The signal frequency circuits may be compensated by shunting small fixed coils, having the same inductance as the loop antenna, across tapping points identical with that on the antenna coil. The oscillator coil would then be redesigned 35 as in the case of only one circuit for preselection, noted above.

A simpler means is that provided by the present invention, where only the antenna circuit is modified in the manner explained above, namely, by having the coil Lo, of suitable density, variation of pitch and location with respect to L1 and L2, wound over the auto-transformer.

The auxiliary correcting coil or winding L_2 has a mutual inductive coupling M' with the tapped portion L_1 and also a mutual coupling M'' with the portion L_2 . Also a mutual inductive coupling M exists between the coil portions L_1 and L_2 of the auto-transformer. By virtue of the presence and polarity of L_2 , M' and M'', additional inductive terms appear in each of the three arms of the equivalent T network which is shown between the dash lines able of Fig. 4 and from which there may be derived the overall inductance (L'') of the input circuit. Said inductance is given by:

$$L'' = \frac{(L_{s} - M + M'')(L_{1} + L_{2} + M - 2M' - M'')}{L_{1} + L_{3} + L_{s} - 2M'} + L_{2} + M - M''$$
(3)

Now, for satisfactory tracking it is desired that either (a) L be equal to L' at each point across the tuning range, or (b) the slope of the inductance change be the same for both L and L' across the band. The first condition (a) may not always be maintained except possibly when M' is rather small or equal to zero. The second condition (b) is easier to produce and obviously depends upon both the magnitude and sign of all self and mutual inductances in equation (3) above, which in turn may be controlled by the magnitude, position, sign, and variation of pitch of the windings.

The improved tracking condition obtained with the present invention is shown by Fig. 5. The tracking curve a is for an arbitrary adjustment of a permeability tuned (auto-transformer) loop 75 the loop antenna is connected.

antenna circuit without the auxiliary winding Lo. Curve b shows the tracking for the same arrangement but with the core inserted slightly further into the auto-transformer. Curve c illustrates the effect of the winding Lo when it is connected in the aiding sense in which case the tracking is seen to be considerably worse. The final curve d is for the same coil Lo connected in a bucking manner or in phase opposition, and the deviation or mistracking is seen to be reduced substantially to zero across the entire tuning range.

In one particular embodiment of the invention I have used the following components with satisfactory results. The auto-transformer L1-Lc 15 consisted of a universal progressive, 136' long, winding 288 turns of 8-.0022" Litz wire tapped at 72 turns from the low end. The coil form was of "Bakelite," with dimensions of 0.205" I. D. and 0.229" O. D. The powdered iron core K was 0.200" diameter and 1%" long. The coil Ls was wound in the opposite direction over the lower portion of the auto-transformer, and consisted of 40 turns of #36 enameled wire with a winding pitch of 160 turns-per-inch. The loop consisted of 15.6 turns (close-wound) of #22 enameled wire in a shallow groove on the outside of the wooden cabinet of the receiver. The dimensions of the loop were 12.5" x 8.75".

While I have shown and described certain preferred embodiments of the invention, it will be understood by those skilled in the art that modifications and changes may be made without departing from the spirit and scope of the invention.

What I claim is:

1. In a radio receiver, an input circuit for said receiver having a tuning coil, a magnetic core associated therewith for tuning the circuit over a frequency range, a loop antenna connected across a portion of said coil, and a winding connected in series with the tuning coil and coupled thereto in phase opposition.

2. A receiver input circuit in accordance with the invention defined in claim 1 wherein the series winding has its turns wound over the tuning coil and in the opposite direction with respect to the tuning coil turns.

3. A receiver input circuit in accordance with the invention defined in claim 1 wherein the series winding has its turns wound over the tuning coil and in the same direction with respect to the tuning coil turns.

4. In a radio receiver, a plurality of tunable circuits for said receiver each having a tuning coil and a magnetic core associated therewith for simultaneously tuning the circuits over a frequency range, a loop antenna connected across a portion of one of said coils, and a winding connected in series with the latter tuning coil and coupled thereto in phase opposition in order to compensate for the mistracking between the tunable circuits occasioned by the connection of the loop antenna to said one of the coils.

5. In a radio receiver, a plurality of tunable circuits for said receiver each having a tuning coil and a magnetic core associated therewith, said cores being moved in unison for tuning the circuits over a frequency range, a loop antenna connected across a portion of one of said coils, and an auxiliary coil wound over and connected in series with the latter tuning coil and coupled thereto in phase opposition whereby tracking is maintained between the tunable circuits throughout the tuning range in spite of the change in overall inductance of the tuning coil to which the loop antenna is connected.

- 6. An antenna input system for radio receivers comprising a high-frequency coil which is provided with a tap at a point closer to the low potential end of the coil, a winding connected in series with the coil between the low potential end thereof and ground, said winding being wound over the coil with its turns in such direction with respect to the coil turns that said winding and coil are coupled in phase opposition, a ferromagnetic core movable relatively to the coil, a 10 capacitance effectively in shunt with the whole of said coil and the series winding forming a secondary resonant circuit tunable by movement of said core to any desired signal within a range of frequencies, and an inductive element exposed to said signals and effectively in shunt across the tapped portion of the coil and the series winding forming a primary resonant circuit.
- 7. An antenna input system as defined in claim 6 wherein the coil and winding are wound in opposite directions, the grounded end of the winding being adjacent the low potential end of the coil, and the other end of the winding being connected to the low potential end of the coil.

- 8. An antenna input system as defined in claim 6 wherein the coil and winding turns are wound in the same direction, the grounded end of the winding being adjacent the high potential end of the coil, the other end of the winding being connected to the low potential end of the coil.
- 9. An antenna input system for radio receivers comprising a high-frequency coil which is prowided with a tap at a point closer to the low potential end of the coil, a winding in series with the coil at the low potential end and coupled thereto in phase opposition, a ferromagnetic core movable relatively to the coil, a capacitance effectively in shunt with the whole of said coil 15 and the series winding forming a secondary resonant circuit tunable by movement of said core to any desired signal within a range of frequencies, an inductive element exposed to said signals and effectively in shunt across the tapped portion of the coil and the series winding forming a primary resonant circuit which is tuned by motion of said core to a frequency higher than the frequency of said signal.

WILLIAM FRANCIS SANDS.