

May 6, 1930.

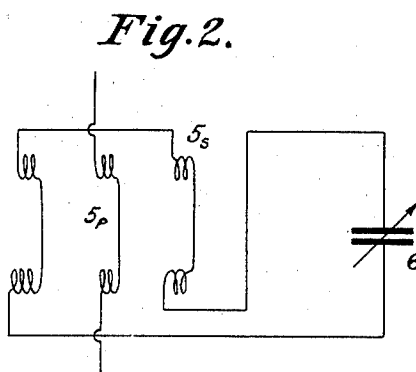
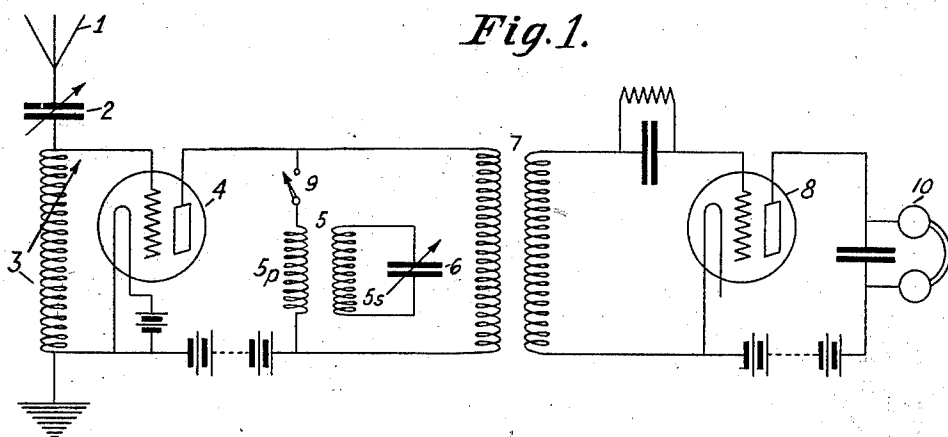
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FREQUENCY TRAP FOR RADIO SIGNALING APPARATUS

Filed Aug. 31, 1922

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

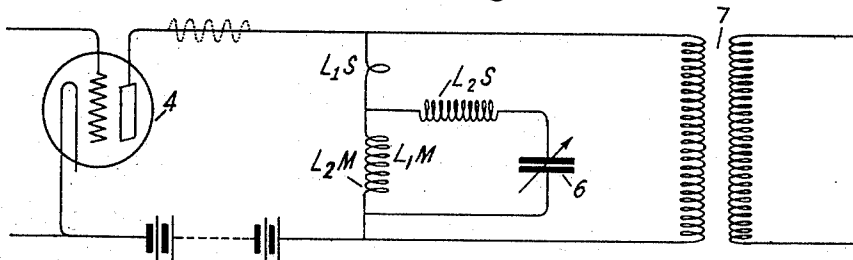


Fig. 4.

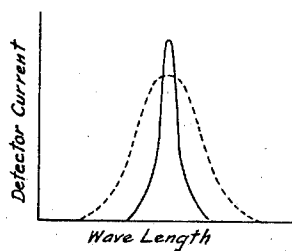
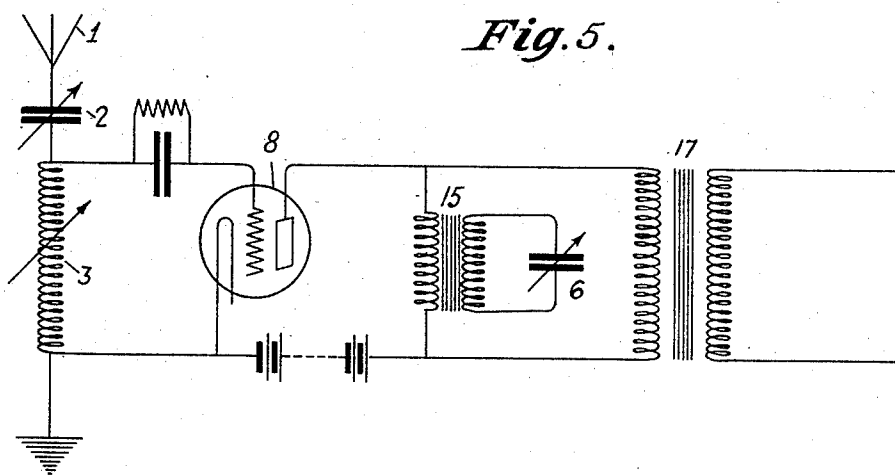


Fig. 5.



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FREQUENCY TRAP FOR RADIO SIGNALING APPARATUS

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This invention relates to circuits for reducing interference in the reception of radio signals and in general may be explained by the fact that means are provided for preventing the flow of current corresponding to signals of undesired wave lengths in the detector circuit.

My invention is illustrated in the accompanying drawing, in which

Fig. 1 is a diagram of connections of my invention.

Fig. 2 is a detailed view of the circuit of my coupling coil and condenser.

Fig. 3 is a diagram of the equivalent circuit of my coupling coil and condenser.

Fig. 4 is a graphic illustration of the detector current curve for the arrangement shown in Fig. 1 as compared with arrangements previously known in the art, wherein the curve for the previously known arrangements is shown as a dotted line, and

Fig. 5 is a modification of my invention applied to an audio frequency circuit.

Various arrangements known as frequency traps or rejectors have been proposed in the past for reducing interference in the reception of radio signals; in particular, it has been suggested to make use of the phenomenon of parallel resonance by placing a loop resonant circuit in shunt across radio frequency circuits thus providing a by-pass to short out all but the desired frequency. This by-pass is required to be of infinite impedance to currents of the desired frequency, and of low impedance to currents of other frequencies; therefore it is usually necessary to use a low inductance with very low resistance and a large capacity.

This arrangement and other similar ones have not proved successful in practice, because of the fact that it is difficult and expensive to construct capacities suitable for the purpose in a compact, portable and easily adjustable form, and also because of the fact that when it is attempted to tune the shunt circuit to loop resonance, the tuning of the entire receiving systems is disturbed, making retuning necessary, and even at times making it necessary to carry on all the tuning simultaneously.

This is due to the fact that the impedance of the tuned circuit is of substantially the same order of magnitude as that of the circuit in which it is placed, and a change in impedance of the tuned circuit makes a comparable change in the impedance of the entire circuit. Furthermore, since the capacities used are necessarily very large it is difficult to tune properly in a short time over any wide range.

In the previously known systems oscillations received upon the antenna were impressed on the grid circuit of an amplifier, and the output circuit of this amplifier was coupled by means of a coupling coil to the grid circuit of a detector having a variable condenser shunted across the secondary of the coupling coil connecting the amplifier and detector. This arrangement has not proved satisfactory for reasons that will be explained.

As pointed out above, in order to obtain a maximum reduction of interference, it is necessary to provide a large capacity in the tuning circuit, but on the other hand, in order to obtain a maximum power output, it is necessary that the impedance of the grid circuit be matched with that of the tuning circuit, and this requires that the capacity of the tuning circuit should be low. These two requirements are contradictory and as usual in such cases, a compromise is made between the two. This is done by using a smaller capacity in the tuned circuit than in the first case, and utilizing the capacity of the tube. As is well known, the tube capacity is not purely reactive, but has some leakage, and furthermore, the capacity varies with each tube used. As a result of attempting to meet two contradictory requirements, the results are not especially satisfactory from either point of view, and the arrangement presents other defects, one of the most prominent of which is an increased tendency of the tube to break into oscillation, and another is a variation of the tuning with a change of tubes.

The objects of this invention are to provide a rejector circuit which will not increase the tendency of the tube to oscillate; to provide a rejector of a low resistance giving

low damping values, and to provide a circuit giving a sharp tuning characteristic and greater selectivity. Other objects are to provide interference reducing means which may be easily and cheaply constructed in a compact and readily portable form, to provide an arrangement by which the rejector circuit may be tuned without disturbing the tuning of the set, and to provide tuning means having a wide range of selection which may still be tuned sharply in a short time. Other objects will be apparent from the specification.

I have found that by making use of a coupling coil having its primary shunted across the circuit from which the signal is to be selected, and its secondary closed through a variable condenser, it is possible to provide an arrangement whereby the rejector circuit can be very sharply tuned, without in any manner disturbing the tuning of the remaining apparatus in the set, and have further found that this circuit presents great advantages over all other known arrangements from the standpoint of efficiency of operation and ease and cheapness of construction. This arrangement of coupling coil and condenser I term a "frequency trap".

If the proper degree of coupling between the primary and secondary of the coupling coil, and the proper ratio of turns be chosen it is possible to use considerably smaller values of capacity, making it possible to construct a very compact arrangement, which shall at the same time have a large effective value of capacity and a low resistance and inductance referred to the primary circuit, and be capable of being sharply tuned over a wide range very quickly.

Referring to Fig. 1, signals are received by means of the antenna 1, which is provided with the usual tuning means, comprising a variable condenser 2, and inductance 3. The incoming oscillations received on the antenna are directly impressed upon the grid and filament circuit of the thermionic tube amplifier 4. In the output circuit of this tube, I place the primary 5_p of a coupling coil 5, having a variable condenser 6 across the secondary 5_s. This constitutes the trap circuit. Connected across the terminals of the primary of this coupling coil, I provide a radio frequency transformer 7. The secondary circuit of this transformer is connected to a detector 8 in the usual manner. The current from the detector may be indicated in the telephone receivers 10 or may be led to any other suitable indicating means, or to an amplifier.

I provide the primary and secondary of the coupling coil with turns preferably in the ratio of four turns in the secondary to each turn in the primary, and I also prefer to construct this coupling coil in the manner shown in Fig. 2, that is, with the secondary 5_s surrounding the primary 5_p, for the reasons to be

explained later. I may also provide a switch 9 for the purpose of disconnecting the trap circuit.

For a better understanding of my invention it is permissible to consider my coupling coil and condenser as replaced by its equivalent circuit as shown in Fig. 3.

There the primary winding is considered as divided into two parts, L_1S , which sets up the primary leakage flux, and L_1M which sets up the mutual flux. In a similar manner, the secondary circuit may be resolved into its components L_2S and L_2M , the former representing the part of the secondary winding which establishes the secondary leakage flux and the latter, that which is linked with L_1M . For the sake of simplicity, the primary and secondary resistances are not shown.

Since the secondary of coil 5 completely encloses the primary, the primary leakage flux will be low, and I have therefore represented L_1S by a single loop, indicating that this value is as small as possible. The primary and secondary are constructed to have a low value of mutual inductance, but the secondary has a comparatively high leakage, which is shown diagrammatically by the comparatively large number of turns in L_2S .

For the best reception, it is desired that four conditions shall obtain in the trap circuit; first, low effective resistance, providing low damping; second, low effective inductance giving a low impedance to signals of frequency lower than those desired; third, large effective capacity, giving low impedance to signals of higher than desired frequency, and fourth, infinite impedance to signals of desired frequency.

It will be seen that it is possible to construct a circuit according to Fig. 1 having low effective primary resistance, since the effective resistance of the trap as a whole is equal to $R_1 + \frac{R_2}{n^2}$, where R_1 is the primary resistance, R_2 the secondary resistance and n the ratio of transformation given by $\frac{I_1}{I_2}$, where I_1 and I_2 are respectively, the currents in the primary and secondary.

The second condition, low effective inductance, is obtained by using a low value of mutual inductance and providing against leakage in the primary.

The third condition, large effective capacity, is made possible by the use of the condenser in the secondary circuit, since the resultant capacity of the secondary referred to the primary is given by the capacity of the secondary multiplied by the square of the transformation ratio, or stated differently, the resultant capacitive impedance of the primary is equal to the capacitive impedance of the secondary divided by the square of transformation ratio, assuming practically no effective capacity in the primary itself.

This is particularly important, because it makes possible the use of a standard air condenser of a capacity of .005 microfarads, giving in the primary an effective capacity of the order of .08 microfarads for a transformation ratio of four.

The fourth condition is of course obtained by tuning the trap so that for the frequency

desired $\omega L = \frac{1}{\omega C}$ where L and C respectively represent the effective inductance and capacity of the trap referred to the primary.

The operation of my receiving apparatus is as follows: If no interfering signals are expected, switch 9 may be left open and the apparatus tuned in the usual manner to obtain the best tone in the telephones. If, however, interference appears, all that is necessary is to close switch 9, and tune the rejector circuit by means of condenser 6 until the interfering effects are eliminated. It will be seen that changing the tuning of the trap will not affect the tuning of the set, because the plate circuit in which the trap is located is of great impedance relative to that of the trap. If desired, the impedance of the plate circuit may be increased by the insertion of an impedance in the plate circuit as shown in dotted lines in Fig. 3.

As will be seen from Fig. 4, by using my trap circuit, it is possible to obtain a much better elimination of interfering signals, especially in a range rather close to the frequency of the desired circuit. In connection with this figure, it should be noted that the detector current curve for arrangements in accordance with my invention is illustrated by a solid line and compared with the detector current curves of arrangements previously known in the art, as hereinbefore described, which are shown by the dotted line curve.

This trap may be applied equally well to audio frequency circuits, as shown in Fig. 5. Here the incoming oscillations are impressed across the filament and grid of a detector tube 8. Connected in the plate circuit of the detector tube is a transformer 15 which may have a core of magnetic material. As in the first case, the secondary winding 15, is closed through a variable condenser 6. I use a higher ratio of turns for the trap than for the radio frequency trap, preferably about 1:8. Across the primary of this transformer I connect an audio frequency transformer 17, whose secondary is connected to a vacuum tube amplifier (not shown) to which in turn the telephones may be connected.

In accordance with the foregoing it will be seen that I have provided a simple and effective means for reducing interference which may be easily and cheaply constructed in a compact form, and one which will at the same time have low effective resistance, and high

impedance at substantially only a single frequency, giving low damping and sharp tuning, and one in which the rejector circuit may be tuned without disturbing the tuning of the set, and by which a large range may be quickly covered.

It is apparent that while I have shown radio receiving apparatus, my invention may be applied to receiving apparatus for carrier current telephony, or so called "wired wireless", and other modifications and changes which will be apparent to those skilled in the art may be made without departing from the scope of my invention.

Having described my invention, what I claim is:

1. In a radio signaling system, an antenna circuit, means for tuning said circuit to predetermined signaling frequencies, means for detecting and receiving said predetermined signaling frequencies, a trap circuit including a transformer having a variable capacity element connected in shunt with the secondary winding thereof for eliminating interference effects in said detecting and receiving means, and a substantially non-reactive coupling connecting said trap circuit and said antenna system.

2. A signaling system comprising in combination a signaling circuit, means for tuning the circuit to predetermined signaling frequencies, transformer means having a transformation ratio greater than unity and having a variable capacity element connected in shunt with the secondary winding thereof connected with said signaling circuit for confining predetermined frequencies thereto, and a coupling connecting said receiving circuit with said signal confining circuit for preventing reflections from said last named circuit upon said receiving circuit.

3. In a signaling system, a receiving circuit, means for tuning said circuit to predetermined desired signaling frequencies, a second circuit including a transformer having a transformation ratio greater than unity connected with said receiving circuit, a capacity element shunting the secondary winding of said transformer for providing together with said transformer secondary a trap circuit for interference frequencies, and a non-reactive coupling connecting said trap circuit with said signaling circuit for avoiding reflections of undesired received frequencies as absorbed by said trap circuit from affecting said signaling circuit.

4. A signaling system including a signaling circuit, inductive and capacitive means for tuning said circuit to predetermined desired frequencies, a second circuit electrically connected with said signaling circuit including an inductance of small value compared with said tuning inductance and normally transparent to a broad band of frequencies, a tuned circuit including a relatively small

capacity and a relatively large inductance
coupled with said last named inductance for
rendering said second named circuit opaque
to signaling frequencies but transparent to
5 all other frequencies for confining the pre-
determined desired frequencies to the signal-
ing circuit and by-passing all undesired fre-
quencies through said second named circuit,
and a non-reactive coupling connecting said
10 signaling circuit and said second named cir-
cuit for preventing reflections from said sec-
ond named circuit from affecting the tuning
of said signaling circuit.

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