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SUPERHETERODYNE RADIO RECEIVER
WITH IMAGE-FREQUENCY SUPPRESSION

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The invention relates to a superheterodyne radio-receiver with at least one long wave- and one medium wave-range, wherein use is made of image-frequency suppression, particularly when the receiver is tuned-in in the long wave range. The receiver comprises an input oscillatory circuit which is inductively coupled to the aerial circuit. In the case of medium wave reception, the coupling is accomplished through the intermediary of a medium wave aerial coupling coil and in the case of long wave reception through the intermediary of a long wave aerial coupling coil.

With simple radio-receivers of this type it was common practice to provide, between the aerial connection and the earth terminal, a series-connection consisting of the medium wave aerial coupling coil and a parallel-connection of the long wave aerial coupling coil and an adjustable condenser, which series-connection acted unchanged both in long wave and in medium wave reception. In parallel with this series-connection was connected, moreover, a further condenser, the so-called ballast condenser.

These receivers were generally adjusted with the use of a standard aerial with a capacity of 200 $\mu\text{mf.}$ With such an adjustment the above-mentioned receivers, when connected to aerials with a capacity of from approximately 150 to 10,000 $\mu\text{mf.}$, afforded an excellent reception.

Of late years, however, a steadily increasing use has been made in practice of aerials of smaller dimensions and of indoor aerials whose capacities are much smaller than those of aerials utilized before then. However, aerials of smaller dimensions have, on the one hand, a lower capacity and, on the other hand, a smaller effective height so that by reducing the dimensions the voltage transmitted to the receiver rapidly decreases. For this reason they proceeded to a better adaptation of the receivers to such small aerials; thenceforward the adjustment was effected with the aid of a standard aerial with a capacity of 80 $\mu\text{mf.}$, owing to which it is possible to utilize in practice aerials with a capacity of from approximately 50 to 500 $\mu\text{mf.}$ The adaptation was obtained by dimensioning the aerial circuit of the receivers otherwise; the ballast condenser was suppressed, the medium wave aerial coupling coil was replaced by another coil of

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larger selfinductance (for it is desirable that the resonant frequency of the aerial circuit should be lower than the lowest frequency which one must be able to receive in the tuning range concerned so that when the aerial capacity is decreased the selfinductance of the medium wave aerial coupling coil must be increased) and the coupling between the medium wave aerial coupling coil and the medium wave tuning coil was modified accordingly. After these changes had been made the reception was found to be greatly disturbed in the long wave range.

The present invention is based upon the recognition that these disturbances are due to the production of oscillations of the image frequency in the input oscillatory circuit and it provides means for the suppression of these disturbances.

According to the invention, in the case of long wave reception there is included in the aerial circuit of a radio-receiver of the above-mentioned type a parallel-connection of a condenser, which may be adjustable, and the long wave aerial coupling coil, which parallel connection has connected in series with it a coil which is capacitatively coupled to the input oscillatory circuit. There is substantially zero inductive coupling between the latter coil and the input oscillatory circuit. This latter coil has a natural frequency which exceeds the image frequency to be suppressed, and a selfinductance which is smaller than that of the medium wave aerial coupling coil. This coil may be separate from the medium wave aerial coupling coil or it may comprise a part of this aerial coupling coil.

Upon changing-over from long-wave reception to medium-wave reception, the said parallel-connection is preferably disconnected or short-circuited.

The variable condenser may be adjusted in such manner that when the receiver is tuned-in in the long-wave range, oscillations of the image frequency are suppressed in the input oscillatory circuit over a wide tuning range.

Particularly satisfactory results are obtained if the coil which is not inductively coupled to the input oscillatory circuit has a selfinductance of 1 mh. and the capacity of the variable condenser is adjustable between approximately 5 and 50 $\mu\text{mf.}$ The intermediate frequency utilized in the

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receiver amounted in this case to approximately 470 kc./sec.

Alternatively, it is possible to couple the input oscillatory circuit, in addition, capacitatively to the aerial circuit through the intermediary of a coupling condenser. This coupling condenser may be adjustable in such manner that, when the receiver is tuned-in in the long-wave range, oscillations of the image frequency are suppressed in the input oscillatory circuit over a wide tuning range.

The capacitative coupling of the coil, which is not inductively coupled to the input oscillatory circuit, and the input oscillatory circuit is brought about, as a rule, through the intermediary of the parasitic capacity which is present between the coil and the circuit. The value of the parasitic capacity is efficaciously adjusted between approximately 0.1 and 1 μf .

The invention will be explained more fully with reference to the accompanying drawing in which:

Fig. 1 is a schematic diagram showing one circuit arrangement according to the invention,

Fig. 2 is a schematic diagram showing a second circuit arrangement according to the invention, and

Fig. 3 is a schematic diagram showing a third circuit arrangement according to the invention.

Fig. 1 of this drawing represents a circuit-arrangement of the aerial circuit and the input oscillatory circuit of a superheterodyne radio-receiver according to the invention. In the shown position of the switches the receiver is tuned in the long wave range. A switch 1 is included in the aerial circuit. In the position for long wave reception, switch 1 connects the aerial to the one side of a series-connection consisting of a coil 2, which is not inductively coupled to the input oscillatory circuit, and a parallel-connection of a long-wave aerial coupling coil 3 and an adjustable condenser 4. The other side of the series-connection is connected to ground. When the switch 1 is shifted, the series-connection is replaced by a medium-wave aerial coupling coil 5. The long-wave aerial coupling coil 3 and the medium-wave aerial coupling coil 5 are inductively coupled to a long-wave tuning coil 6 and a medium-wave tuning coil 7 respectively. Adjustable condensers 8 and 9 of low capacity are connected in parallel with the coils 6 and 7 respectively. The input oscillatory circuit is constituted by a variable condenser 10. In parallel with condenser 10 are connected, with the aid of a switch 11, the tuning coil 7 and the condenser 9 in the case of medium-wave reception, and the tuning coil 6 and the condenser 8 in the case of long-wave reception. The input oscillatory circuit is capacitively connected, through the intermediary of a condenser 12, to the control grid of a discharge tube 14, which may be, for example, a high-frequency amplifying tube or a frequency changer. For the sake of simplicity the sources of direct current are omitted. In the drawing a condenser 13 is indicated in dotted lines; this condenser represents the parasitic capacity present between the coil 2 and the input oscillatory circuit.

The operation of the present circuit-arrangement, which operation is improved with respect to prior receivers may now be explained as follows. In the circuit-arrangement according to the invention oscillations of the image frequency are supplied to the input oscillatory circuit in two different ways, viz., on the one hand, through

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the parasitic capacity 13 and, on the other hand, through the coil 2 and the inductively coupled coils 3 and 5. The oscillations supplied to the input oscillatory circuit along these two paths are, however, out of phase by 180° so that in the case of exact adjustment the image frequency oscillations in the input oscillatory circuit are completely or substantially suppressed.

In order to obtain the exact phase difference of 180° it is necessary that the natural frequency of the coil 2 should exceed the image frequency to be suppressed. With the prior receivers this condition was no longer fulfilled after the replacement of the formerly utilized medium wave aerial coupling coil by a coil having a higher selfinductance. The consequence thereof was that the image frequency oscillations were no longer suppressed and that, in the case of long-wave reception, disturbances occurred.

From the above it may be seen that to ensure a correct functioning of the circuit-arrangement, the coil 2 must have a selfinductance which is smaller than that of the medium wave aerial coupling coil. Satisfactory results were obtained, for example, with a selfinductance of 1 mh. at an intermediate frequency of approximately 470 kc./sec. The value of the selfinductance of the medium wave aerial coupling coil amounted in this case to approximately 4 mh.

The variable condenser 4 is adjusted in such manner that the image frequency suppression takes place more or less uniformly over the whole of the long-wave tuning range.

Sometimes it may be necessary to re-adjust the value of the parasitic capacity 13 in order to achieve complete suppression of the image frequency disturbances. This may be effected by slightly modifying the position of the connecting wires in a simple manner.

When changing-over to medium-wave reception, the parallel-connection of the coil 3 and the condenser 4 (and in the present instance also the coil 2) is disconnected. This disconnection during medium-wave reception is not absolutely necessary, but by doing so we obtain a more satisfactory reception than if the said parallel-connections were incorporated, in series with the coil 5, in the aerial circuit.

Figs. 2 and 3 represent other embodiments of the invention wherein, for simplicity, the condenser 12 and the discharge tube 14 are omitted. In the circuit-arrangement according to Fig. 2, the coil which is not inductively coupled to the input oscillatory circuit is constituted by part of the medium wave aerial coupling coil 5. For this purpose that portion of the coil 5 which is comprised between the aerial connection and a tap 2' is short-circuited by means of the switch 1. When changing-over from long-wave reception to medium-wave reception, the parallel-connection of the coil 3 and the condenser 4 is short-circuited by means of a switch 15.

Fig. 3 represents a circuit-arrangement wherein, in the case of long-wave reception, the aerial circuit is coupled not only inductively but also capacitively, with the aid of a variable coupling condenser 16, to the input oscillatory circuit.

Here the adjustment of the image-frequency suppression is effected by means of the condenser 16; the condenser 4 may now be constructed as a fixed condenser.

In the case of long-wave reception, the coil 5 is located in parallel with the coil 2; this fact must, of course, be taken into account in dimensioning this coil. In the case of medium-

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wave reception, the coil 2 is disconnected by shifting the switch 1. Here again, as in the circuit-arrangement of Fig. 2, the parallel-connection of the coil 3 and the condenser 4 may, if desired, be short-circuited with the aid of a switch which is not shown.

What we claim is:

1. An image suppression network comprising a first inductance element having a given self-inductance and a natural frequency of oscillation higher than the frequency of the image to be suppressed, a first capacitance element connected in series with said first inductance element, a second inductance element connected in parallel with said first capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a third inductance element having a greater self-inductance than the first inductance element, a second tuned oscillatory circuit inductively coupled to said third inductance element, a source of desired signals, an output circuit, a second capacitance element between said first inductance element and said output circuit, and switching means to selectively apply said source of desired signals to said first inductance element and to couple said output circuit to said first tuned oscillatory circuit and to apply said source of desired signals to said third inductance element and to couple said output circuit to said second tuned oscillatory circuit.

2. An image suppression network comprising a first inductance element having given a self-inductance and a natural frequency of oscillation higher than the frequency of the image to be suppressed, a first variable capacitance element connected in series with said first inductance element, a second inductance element connected in parallel with said first variable capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a third inductance element having a greater self-inductance than the first inductance element, a second tuned oscillatory circuit inductively coupled to said third inductance element, a source of desired signals, an output circuit, a second capacitance element between said first inductance element and said output circuit, and switching means to selectively apply said source of desired signals to said first inductance element and to couple said output circuit to said first tuned oscillatory circuit and to apply said source of desired signals to said third inductance element and to couple said output circuit to said second tuned oscillatory circuit.

3. An image suppression network comprising a tapped first inductance element one of the tapped portions having a given-self-inductance and a natural frequency of oscillation higher than the frequency of the image to be suppressed, a first capacitance element connected in series with said first inductance element, a second inductance element connected in parallel with said first capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a second tuned oscillatory circuit inductively coupled to said first inductance element, a source of desired signals, an output circuit, a second capacitance element between said first inductance element and said output circuit, and switching means to selectively apply said source of desired signals to said tap on first inductance element and to couple said output circuit to said first tuned oscillatory circuit and to couple said output circuit to said second tuned oscillatory circuit and to short-cir-

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cuit said first capacitance element and to apply said source of desired signals to the free end of said tapped first inductance element.

4. An image suppression network comprising a first inductance element having a self-inductance of 1 millihenry and a natural frequency of oscillation higher than the frequency of the image to be suppressed, a first capacitance element variable between 5 and 50 micro-microfarads connected in series with said first inductance element, a second inductance element connected in parallel with said first capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a third inductance element having a greater self-inductance than the first inductance element, a second tuned oscillatory circuit inductively coupled to said third inductance element, a source of desired signals, an output circuit, a second capacitance element between said first inductance element and said output circuit, and switching means to selectively apply said source of desired signals to said first inductance element and to couple said output circuit to said first tuned oscillatory circuit and to apply said source of desired signals to said third inductance element and to couple said output circuit to said second tuned oscillatory circuit.

5. An image suppression network comprising a first inductance element having a given self-inductance and a natural frequency of oscillation higher than the frequency of the image to be suppressed, a first capacitance element connected in series with said first inductance element, a second inductance element connected in parallel with said first capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a third inductance element having a greater self-inductance than the first inductance element, a second tuned oscillatory circuit inductively coupled to said third inductance element, a source of desired signals, an output circuit, a second capacitance variable between 0.1 and 1 micro-microfarads between said first inductance element and said output circuit, switching means to selectively apply said source of desired signals to said first inductance element and to couple said output circuit to said first tuned oscillatory circuit and to apply said source of desired signals to said third inductance element and to couple said output circuit to said second tuned oscillatory circuit.

6. An image suppression network comprising a first inductance element having a given self-inductance, a first capacitance element connected in series with said first inductance element, a second inductance element connected in parallel with said first capacitance element, a first tuned oscillatory circuit inductively coupled to said second inductance element, a third inductance element having a greater self-inductance than the first inductance element, first switch means to selectively couple said first and third inductance elements in parallel, the parallel combination of said first and third inductance elements having a natural frequency of oscillation higher than the frequency of the image to be suppressed, a second tuned oscillatory circuit inductively coupled to said third inductance element, a source of desired signals, an output circuit, a second capacitance element between said first inductive element and said output circuit, a third capacitance element between said second

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inductance element and said first tuned oscillatory circuit, means to couple said source of desired signals to said third inductance element, and second switch means to selectively couple said output circuit to said first tuned oscillatory circuit and to said second tuned oscillatory circuit.

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