

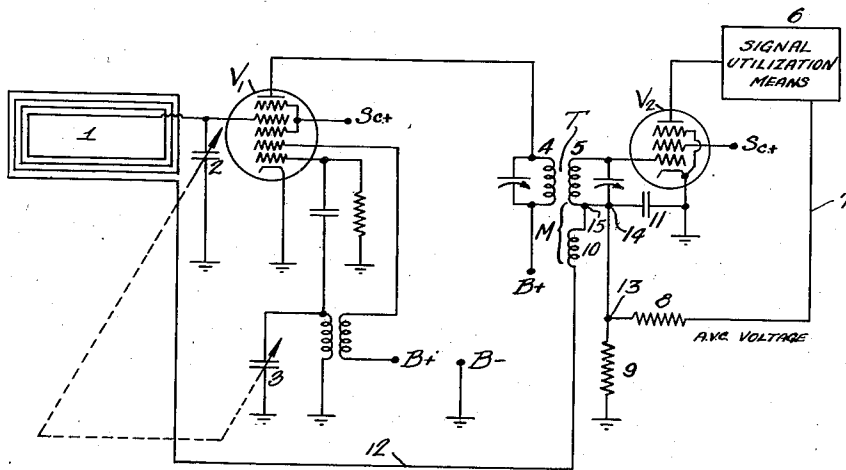
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LOOP EQUIPPED RADIO RECEIVER

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LOOP EQUIPPED RADIO RECEIVER

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This invention relates to radio receivers adapted for operation with loop antennas, and more particularly to means for substantially improving the sensitivity of radio receivers and the apparent Q, or ratio of reactance to resistance, of loop antennas.

In order to improve the portability of radio receivers and to simplify their installation, it has been found desirable to employ compact resonant loop antennas capable of being disposed within the cabinets or housings containing the radio receiver chassis. Due to the small physical size of loops capable of being mounted within the smaller radio cabinets, and to the proximity of the loop to the various metal parts comprising the chassis and other receiver components, the Q of such self-contained loops is generally very low in practice. Thus where a Q of 100 or more might be desirable it has been found that in practice the Q of the loop antenna circuit, particularly at the low frequency end of the tunable wave band, may fall as low as 25 or less. The importance of securing a high effective or apparent Q will be apparent when it is considered that both the selectivity of the input stage and the overall gain of a loop-equipped receiver are direct functions of the Q of the loop antenna employed.

It has been found that the effective or apparent Q of a loop may be conveniently improved in a radio receiver of the superheterodyne type by introducing regeneration at the carrier frequency between the output of the frequency converter tube and the loop.

According to this invention, there is provided a radio receiver of the superheterodyne type which includes in cascade a resonant loop antenna circuit, a frequency converter stage, an intermediate frequency amplifier and coupling network therefor, and means for coupling a portion of said loop antenna circuit to said intermediate frequency coupling network, whereby the apparent Q of said loop circuit is increased.

The invention may be clearly understood by reference to the accompanying drawing, the single figure of which is a diagrammatic illustration of a portion of a superheterodyne radio receiver embodying the present invention.

Referring to the drawing, there is shown a resonant loop circuit which includes the loop antenna 1 and the tuning condenser 2. The voltage across the condenser 2 may be impressed on the input grid of the frequency converter tube V₁ as shown. The oscillator circuits associated with the first and second grids of tube V₁ and

tuned by the variable condenser 3 are well known in the art and require no description. The intermediate frequency output of the converter tube V₁ may be applied to the input of the intermediate frequency amplifier tube V₂ by means of a coupling network which comprises a transformer T having primary and secondary windings 4 and 5 tuned to the intermediate frequency. The output of the amplifier V₂ may be supplied to a suitable signal utilization means 6, such as a second detector and audio frequency amplifier, which may include an automatic volume or gain control source, the output of which may be supplied via the lead 7, the resistor 8, and the secondary winding 5 to the gain control electrode of the amplifier V₂. If desired, only a fraction of the AVC voltage developed may be employed, for example by providing a voltage divider network 8—9 from the junction of which the gain control or AVC voltage may be derived.

Now although the coupling network 4—5 is tuned to the intermediate frequency, it will be found that an appreciable amount of radio frequency energy is associated with the said coupling network, the effect being most pronounced for radio frequencies most nearly of the order of the intermediate frequency. In accordance with this invention, coupling is provided between the said coupling network and the resonant loop circuit whereby an overall regenerative action is effected, thereby improving both the gain and selectivity of the receiver.

In the particular embodiment illustrated, the resonant loop circuit comprises, in series, and starting from the common ground connection, the tuning condenser 2, the loop antenna 1, the feedback connection 12, the feedback coil 10, and the by-pass condenser 11 to ground. The feedback coil 10 may be coupled either to the primary 4 or to the secondary 5 of the intermediate frequency transformer T, or to both windings if desired. In one experimental model which gave very satisfactory results, the tuning range of the loop circuit extended from 540 to 1550 kilocycles, while the intermediate frequency was 455 kilocycles. The feedback coil 10 consisted of 2½ turns coupled to both the primary and the secondary, but more closely to the latter.

The maximum regenerative feedback occurs at the low frequency end of the tuning range, and falls off gradually at the high frequency end of the range. This is a desirable relation inasmuch as the effective height of the loop, its Q, and its selectivity are normally least at the low frequency end of the tuning range. For example, in the ex-

perimental model referred to above, the Q of the loop, without regeneration, was approximately 75 at 1550 kilocycles, but only 25 at 540 kilocycles. When regeneration at the signal frequency was provided in accordance with the present invention, the effect was greatly to improve the effective Q of the loop circuit at the 540 kilocycle end of the band, while increasing it only very slightly at 1550 kilocycles. Thus the use of regeneration as herein described not only improves the performance of a receiver, but also tends to make the performance more uniform over the tuning range of the receiver.

The manner in which the regeneration varies over the desired wave band may be controlled in a number of ways. If the transformer T is double tuned and less than critically coupled its selectivity will be relatively high, and as a result the desired feedback will be appreciable only very near the 540 kilocycle end of the band. This narrowing of the band over which feedback is effective may be made even more pronounced by coupling the coil 10 substantially only to the secondary winding 5. On the other hand if the transformer T has a wide band-pass characteristic the decrease in regeneration with increasing signal frequency may be made to take place more gradually.

In addition to the regenerative feedback of radio frequency energy above referred to, it may also be pointed out that an appreciable feedback of intermediate frequency energy also takes place, and this effect is also greatest at the low frequency end of the tuning range, for at this end of the range the resonant frequency of the loop circuit will most closely approach the intermediate frequency. Only one feedback path 12 need be employed for feeding back signals of both the incoming radio frequency and of the intermediate frequency, and the same coupling coil 10 is effective at both frequencies. The relative magnitudes of the R. F. and I. F. feedback voltages will depend upon the overall design of the circuits and upon the gain of the tube V_1 . Thus although the invention is primarily directed to a means for improving the effective Q of the loop antenna circuits it is also contemplated, where desired, to make use of I. F. feedback through the converter tube V_1 as explained above.

In the particular circuit shown the radio frequency feedback is regenerative, while the intermediate frequency feedback is degenerative. If both were regenerative the circuit might tend toward instability, particularly where the two feedback frequencies differed by only a relatively small amount, as they do when the loop circuit is tuned to 540 kc., the intermediate frequency being constant at 455 kc. The effect of I. F. degeneration is to reduce the apparent Q of the intermediate frequency transformer T , while the effect of R. F. regeneration is to increase the apparent Q (decrease the effective losses) of the loop antenna L . Accordingly, in this particular embodiment the circuit employed tends to increase the selectivity and sensitivity of the loop circuit (and hence the gain of the antenna stage) while slightly reducing the gain and selectivity of the I. F. amplifier stage. This is a desirable condition since it is desirable to increase the selectivity of the circuits ahead of the converter tube in order to discriminate more effectively against image frequencies, it being well known that selectivity in the I. F. amplifier is ineffective in discriminating against such frequencies.

Obviously if it is desired to provide feedback

only at the signal (R. F.) frequency, intermediate frequency feedback can readily be avoided by inserting an I. F. trap circuit in the feedback path 12. Similarly, if it be desired to provide feedback only at the intermediate frequency this can be accomplished by inserting in the path 12 a band pass filter designed to transmit only signals of the intermediate frequency.

By connecting the low potential end of the feedback coil 10 to the A. V. C. voltage source, as illustrated, the gain-controlling voltage may be applied to the input grid of the frequency converter tube V_1 by way of the connection 12 and the loop L . Specifically the connecting means between the A. V. C. voltage source (which is included in the rectangle 6) and the input grid of the converter V_1 consists of a path which comprises the following elements and junction points: conductor 7, resistor 8, junctions 13, 14, and 15, coil 10, conductor 12, and the loop winding L . This connection eliminates the need for a separate A. V. C. connection to the gain controlling element of the tube V_1 and reduces the cost of manufacture accordingly. It should be understood however that the invention is not restricted to the use of any particular gain control connections.

Although the invention may be applied to any type of radio receiving equipment, its use is most advantageous in smaller receiving sets whose gain is limited and with which it is necessary to employ small and relatively inefficient loop antennas. Moreover, although the invention has been described with particular reference to the embodiment illustrated, it will be understood that the invention is capable of various forms of physical expression, and is therefore, not to be limited to the specific disclosure.

I claim:

1. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency end of the said band is approached.

2. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, said intermediate frequency coupling network comprising at least one winding tuned to the intermediate frequency, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said network forming an element

in said feedback path, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency end of the said band is approached.

3. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, said intermediate frequency coupling network comprising a double tuned transformer, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said transformer functioning as an element in said feedback path, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency end of the said band is approached.

4. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said intermediate frequency coupling network including a winding inductively coupled to said loop antenna circuit, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency end of the said band is approached.

5. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said intermediate frequency coupling network including a winding inductively

coupled to a winding of few turns serially connected in said loop antenna circuit, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency end of the said band is approached.

6. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling network and an intermediate frequency amplifier, a common source of automatic volume control voltage for said frequency converter stage and for said intermediate frequency amplifier, and a radio frequency feedback path connected between the output circuit of said frequency converter stage and said loop antenna circuit for producing regeneration at said radio frequencies, said control voltage being applied to the signal input element of said converter stage through said radio frequency feedback path, said feedback path being constructed and arranged to provide maximum feedback at the low frequency end of the said band of frequencies, said feedback decreasing substantially as the high frequency of the said band is approached.

7. A radio receiver of the superheterodyne type comprising in cascade, a resonant loop antenna circuit, said circuit having at least a loop antenna winding and a variable condenser for tuning said circuit over a predetermined band of radio frequencies, a frequency converter stage providing an intermediate frequency signal which lies outside of and below said band of frequencies, an intermediate frequency coupling transformer and an intermediate frequency amplifier, a winding of few turns serially connected in said loop antenna circuit through a feedback path, said winding being placed in inductive relation to at least one of the windings of said transformer to feed back signals of radio frequency to the input of said converter stage in regenerative phase, said feedback path providing maximum feedback at the low frequency end of the said band of frequencies, and a source of automatic volume control voltage, said voltage being applied to a gain control element in said intermediate frequency amplifier, and also to the signal input element of said frequency converter through a path comprising, in series, said winding of few turns, said feedback path and said loop antenna.

8. A radio receiver according to claim 1 characterized in that some intermediate frequency energy is fed back from said intermediate frequency coupling network to the input circuit of said frequency converter stage by way of the said radio frequency feedback path, said intermediate frequency feedback being in a degenerative sense.

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