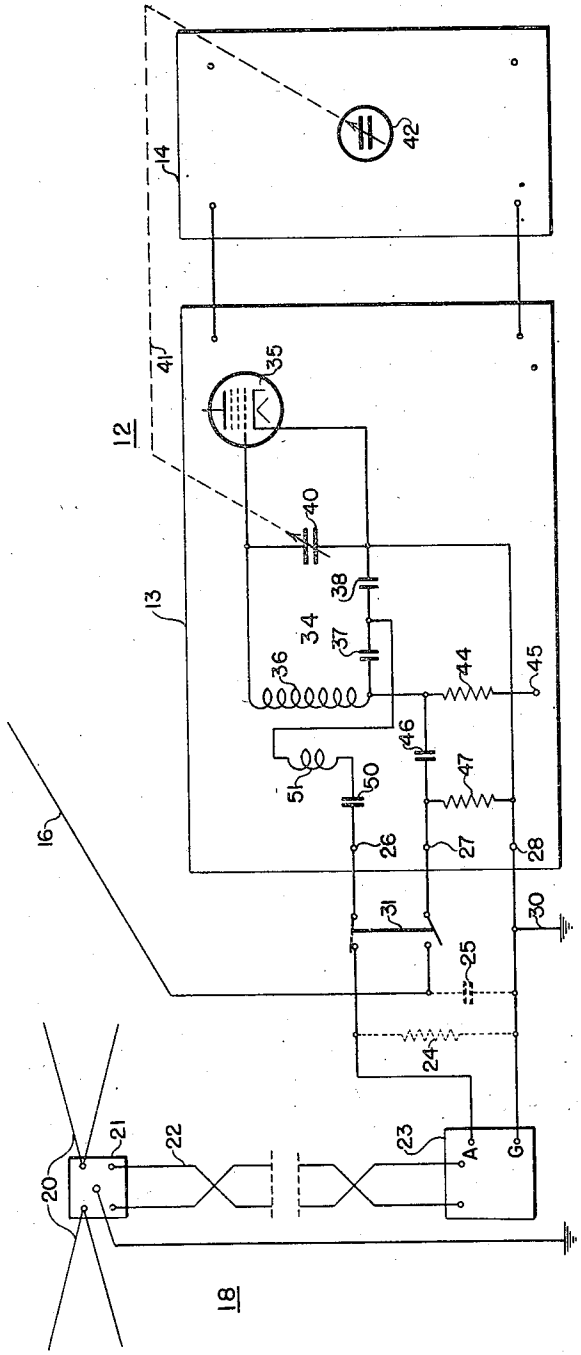
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COUPLING SYSTEM

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COUPLING SYSTEM

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This invention relates to a circuit arrangement for selectively coupling to a tuned circuit or system any one of a plurality of associated circuits having impedance characteristics of different kinds. While the invention is of general application, it is particularly suitable for coupling different types of antenna circuits to the first tunable circuit of a radio receiver.

It is well known that in coupling an input circuit to a tuned or tunable circuit there is a tendency for the impedance of the input circuit to be reflected in some degree into the tuned circuit and alter its resonant frequency. In the design of such a coupling arrangement, therefore, it is highly desirable to minimize the impedance reflected thereby from the input circuit to the tuned circuit, at the same time, however, providing sufficient coupling to secure the desired signal transfer.

This is particularly true in the design of a coupling arrangement for interconnecting an antenna and the first tuned circuit of a radio receiver in which provision must be made to insure that the alternative use of antennas of different types or designs does not substantially affect the resonant frequency of the tuned circuit and especially that it does not, if the first tuned circuit is tunable, affect the alignment thereof in a predetermined relation to other circuits tunable conjointly therewith.

One common type of antenna is a capacitive antenna. This is defined as an antenna having an impedance characteristic which is mainly capacitive over the range of frequencies utilized. A provision for insuring that the first tuned circuit of a radio receiver is not excessively affected by antennas capacitive in character and of different capacitive values is disclosed in Fig. 2 of United States Letters Patent No. 1,943,405 granted January 16, 1934 on the application of Harold A. Wheeler.

Another type of antenna, advantageously employed under certain circumstances, is a mainly resistive antenna. This is defined as an antenna having an impedance characteristic the mean value of which over the range of frequencies utilized is mainly resistive. An example of such a system is that described in a copending application of Harold A. Wheeler, Serial No. 25,735, filed June 10, 1935, for Wave-signal-collecting systems. Such a system may comprise a doublet antenna, an antenna filter, a transmission line and a receiver filter connected in the order named, the receiver filter being adapted for coupling to the first tuned circuit of the radio receiver, preferably with optimum coupling, in order to provide the most desirable normal operation. It is also preferable to maintain this condition of optimum coupling for all frequencies within the tuning range of the tuned circuit. Another example of a mainly resistive antenna is a long wire whose length is greater than a quarter wavelength of the received signal wave.

Inasmuch as the design of a coupling arrangement for the first tuned circuit of a radio receiver is materially different for coupling with a mainly capacitive source than for coupling with a mainly resistive source, the manufacturer of radio receivers for users, some of whom may employ a mainly resistive antenna and others of whom may employ a mainly capacitive antenna, is faced with the problem of devising some means by which the receiver is readily adaptable for use with antenna of either type.

It is an object of this invention to provide a circuit arrangement for alternatively coupling to a tuned circuit or system any one of a plurality of associated circuits having impedance characteristics of different kinds without affecting substantially the resonant frequency of the tuned circuit or system.

It is another object of this invention to provide such a coupling arrangement readily adapted for alternatively coupling the same radio receiver to either of two antennas having different and approximately predetermined impedance characteristics without substantially affecting the resonant frequency of the first tuned circuit thereof.

It is a further object of the invention to provide a coupling arrangement for coupling alternatively a capacitive antenna or a resistive antenna to the first tuned circuit of a radio receiver so that each antenna, when effectively coupled to such tuned circuit, is coupled in the manner preferred for that type of antenna; so that the change from one antenna to the other does not substantially affect the resonant frequency of the first tuned circuit; and so that, when the first tuned circuit is tunable, the alignment thereof with respect to other tuned circuits tunable conjointly therewith is not substantially altered.

Other objects of the invention will become apparent upon consideration of the following specification taken in conjunction with the accompanying drawing and the appended claims.

The illustrated embodiment of the invention contemplates a radio receiver having two different coupling circuits associated with the first tunable circuit thereof, one for coupling a capaci-

tive antenna and the other for coupling a resistive antenna to this circuit. The impedance characteristics of these two coupling circuits are so proportioned that the connection of either antenna to its respective coupling circuit causes substantially the same change of the resonant frequency of the first tunable circuit. In the preferred embodiment of the invention, the capacitive-antenna coupling circuit includes capacitance in common with the first tunable circuit while the resistive-antenna coupling circuit includes at least a portion of the reactance of the coupling capacitance for the capacitive antenna and also other impedances individual thereto. Such other impedances may include an inductance inductively coupled to the inductance of the first tunable circuit and capacitance serially connected with such inductance, the several impedances of the resistive-antenna coupling circuit being proportioned to provide optimum coupling between such antenna system and the first tunable circuit, over the tuning range thereof.

The single figure of the drawing is a circuit diagram, partly schematic, illustrating an embodiment of the invention as incorporated in a tunable radio receiver especially adapted to operate either from a simple capacitive antenna or from a doublet antenna with antenna filter, transmission line and receiver filter.

The radio receiver **12** comprises a tunable radio-frequency portion **13** and succeeding tunable signal-translating portions of conventional character indicated in block form at **14**. The receiver is adapted to be used with either a mainly capacitive antenna **16**, such as an ordinary single-wire antenna, or with a mainly resistive antenna system **18** comprising a doublet antenna **20**, an impedance matching antenna filter **21**, a transmission line **22** and an impedance matching receiver filter **23** connected in the order named. Illustrative of one such resistive antenna system is that disclosed in the previously mentioned application Serial No. 25,735.

Antenna system **18** is referred to as a resistive antenna system because the impedance presented to the receiver has a mean value which approximates a pure resistance. This is to be distinguished from the ordinary single-wire antenna in that the latter has an impedance characteristic approximating that of a condenser. For reference, resistance **24** is indicated in dotted lines across the output terminals A, G of receiver filter **23** to represent the mean impedance of antenna system **18** as measured across its output terminals. Likewise, capacitance **25** is indicated in dotted lines between ground and the terminal of antenna **16** to represent the mainly capacitive impedance characteristic of antenna **16**.

Receiver **12** is provided with three input terminals **26**, **27**, and **28**, terminals **26** and **28** being for connection respectively to the A and G terminals of the receiver filter **23**, terminal **28** being for connection to ground as indicated at **30**, and terminal **27** being for connection to the lead-in terminal of antenna **16**. To indicate that the receiver is to be used alternatively with either antenna **16** or **18** but not with both at the same time, a switch **31** is illustrated, antennas **16** and **18** being individually effectively connected with the receiver when switch **31** is in the upper and lower positions, respectively. If only one type of antenna is to be used in a given installation, it may be preferable to omit the switch **31**, providing only the terminals **26**, **27**, and **28** for appropriate connection in that installation. The tunable radio-frequency portion **13** includes the first tuned circuit **34** connected to the input terminals of the first vacuum tube **35** of the radio receiver **12**.

The first tuned circuit **34** includes a fixed inductance **36** across which are connected in series fixed condensers **37**, **38** and the variable condenser **40**. The latter is indicated as tunable by unicontrol means **41** which also operates a variable condenser **42**, representative of the succeeding tunable circuits of the receiver.

The coupling circuit for coupling the capacitive antenna **16** to the tuned circuit **34** is essentially of the form described in the previously mentioned Patent 1,943,405 and includes the condensers **37**, **38** included in the tuned circuit **34**.

The bias for the grid of vacuum tube **35** is provided in the usual manner by means (not shown) connected to the terminal **45**, the bias being applied through a resistor **44** having high impedance at radio frequencies.

A condenser **46** and resistor **47** interposed between terminals **27**, **28** and the tuned circuit **34** form a high-pass filter having negligible effect at radio frequencies but serving to attenuate audio-frequency disturbances which are picked up by the antenna **16** and otherwise would be impressed on the grid of the vacuum tube. Condenser **46** has negligible impedance, and resistor **47** has high impedance, at radio frequencies.

The effective capacitance of condensers **37** and **38** in series is preferably much greater than (on the order of 5 to 20 times) the maximum capacitance of tuning condenser **40**. This arrangement assures that the antenna **16**, within a reasonable range of dimensions, will not have excessive effect on the resonant frequency of the tuned circuit.

The coupling circuit for coupling the resistive antenna system **18** to the tuned circuit **34** includes in series a coupling condenser **50**, inductance **51** inductively coupled to the inductance **36** of the tuned circuit, and the condenser **38** of the tuned circuit **34**. The polarity of coupling between inductances **36** and **51** is chosen so that this coupling aids the capacitive coupling of condenser **38**. The inductance **51** and condenser **50** resonate at a frequency substantially above the tuning range of tuned circuit **34** so that the coupling circuit for the resistive antenna system has substantial net capacitive reactance at all frequencies in the tuning range.

The relative proportions of the elements of the coupling circuits for the antenna **16** and the antenna system **18**, respectively, in conjunction with the characteristic impedances of such antennas, are such that the connection of either antenna to the receiver **12** causes substantially the same effect on the resonant frequency of tuned circuit **34**, and further are such that the antenna system **18** is coupled to the tuned circuit **34** with optimum coupling.

The actual proportioning of the elements of the coupling circuits, particularly those of the coupling circuit for the resistive antenna, can be determined by the aid of the following rules. In applying these rules, the major considerations are the effect of each element on the coupling between the antennas and the tuned circuit on one hand, and, on the other hand, the effect on the resonant frequency of the tuned circuit caused by either antenna when coupled thereto.

The amount of coupling between the resistive antenna system **18** and the tuned circuit **34** is determined primarily by the capacitance C_{38} of condenser **38** and the mutual inductance M_{51-36} between coils **51** and **36**. Decreasing C_{38} or in-

creasing M_{51-36} has the effect of increasing the coupling and also the change of resonant frequency of the tuned circuit 34 when the antenna system 18 is connected thereto. Changing C_{36} has relatively more effect at lower frequencies, while changing M_{51-36} has relatively more effect at higher frequencies. The capacitance C_{50} of condenser 50 and the self-inductance L_{51} of coil 51 have a secondary effect on the amount of coupling and the change of the resonant frequency of the tuned circuit 34 when the antenna system 18 is connected thereto. Decreasing C_{50} has the effect of decreasing the amount of coupling and also the change of the resonant frequency. Increasing L_{51} (without increasing M_{51-36}) has the effect of increasing the amount of coupling and the change of the resonant frequency. Changing C_{50} has relatively more effect at lower frequencies while changing L_{51} has relatively more effect at higher frequencies.

There are thus four degrees of freedom in the design of the coupling system for the resistive antenna system 18. This is a sufficient number to permit proportioning the circuit to secure the following two results. Firstly, two degrees of freedom are required to proportion the effect on the resonant frequency of the circuit 34 caused by coupling the resistive antenna system 18 thereto to equal that caused by coupling the capacitive antenna 16 thereto at both the higher and the lower frequencies of the tuning range. Secondly, two more degrees of freedom are required to secure optimum coupling to the resistive antenna system 18 at both the higher and lower frequencies. There is no particular order of procedure which is suggested for properly determining the four values relating to the coupling circuit for the resistive antenna system 18. It is not generally required to adjust these values very precisely because both the coupling and the effect on the resonant frequency are relatively noncritical, the latter usually being a very small fraction of the resonant frequency. It is an essential requirement, however, that the above four factors have different effects on the response of the system.

The amount of coupling between the capacitive antenna 16 and the tuned circuit 34 is determined by the capacitance of condensers 37 and 38 in series. In general, it is desired to maintain this capacitance substantially at a predetermined value regardless of the value that may be selected for the capacitance of condenser 38 in accordance with the considerations discussed above. As a consequence, when C_{38} is changed in one sense in determining the amount of the coupling between the resistive antenna system 18 and the tuned circuit 34, C_{37} is usually changed in the opposite sense, to an extent necessary to maintain constant the series capacitance of the two condensers.

It is to be noted that an antenna system including a doublet, filters and connecting transmission line, such as herein described and shown, is not the only type of resistive antenna. A simple single-wire antenna much longer than one quarter of the wavelength of the received signal wave has an impedance characteristic whose mean value over a range of frequencies is mainly resistive.

The means herein disclosed and claimed for coupling a tuned circuit to either a capacitive or a resistive source with substantially the same effect on the resonant frequency of the tuned circuit, is not limited to coupling the first tuned circuit of a radio receiver to different types of antennas, but is equally applicable to coupling the radio frequency system of a radio transmitter to different types of antennas, and in fact is of general application to any tuned circuit having associated circuits of different impedance characteristics alternatively coupled thereto, and whether or not such associated circuits are sources of excitation thereof.

In order to illustrate the relative magnitudes of the various circuit elements of a typical radio receiver having means in accordance with this invention for adapting it for use with either a capacitive or a resistive antenna, the following approximate values for the tuned and coupling circuits, and other pertinent information, are given for an arrangement of the type herein shown and described.

Tuning range, 550 to 1500 kilocycles.

Capacitance of capacitive antenna, C_{16}=200 micro-microfarads.

Mean resistance of resistive antenna system, R_{18}=400 ohms.

L_{51}=4.5 microhenries.

L_{36}=220 microhenries.

M_{51-36}=9 microhenries.

C_{38}=4800 micro-microfarads.

C_{37}=4800 micro-microfarads.

C_{50}=820 micro-microfarads.

C_{40}=50—450 micro-microfarads (including inherent capacitance of the circuits connected thereto).

R_{44}=100,000 ohms.

C_{46}=.02 microfarad.

R_{47}=10,000 ohms.

While we have described what we at present consider the preferred embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from our invention, and we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What is claimed is:

1. An electric circuit arrangement for coupling to a resonant circuit any one of a plurality of circuits having predetermined impedance characteristics of substantially different kinds, comprising a plurality of coupling circuits corresponding, respectively, to said first-named plurality of circuits, each of said coupling circuits being coupled to said resonant circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the connection of any of said first-named circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said resonant circuit.

2. An electric circuit arrangement adapted for alternatively coupling to a resonant circuit a circuit having a predetermined mainly resistive impedance or a circuit having a predetermined mainly capacitive impedance, comprising two different coupling circuits corresponding, respectively, to said first-named circuits, each of said coupling circuits being coupled to said resonant circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the connection of either of said first-named circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said resonant circuit.

3. An electric circuit arrangement for alternatively coupling to a tuned radio-frequency circuit a mainly resistive antenna circuit or a mainly capacitive antenna circuit, comprising two different coupling circuits coupled to said tuned circuit and including provisions for connection respectively to said antenna circuits, the impedance characteristics of said coupling circuits being so proportioned that the connection of either of said antenna circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said tuned circuit.

4. In combination, a tuned circuit adapted to be coupled to any one of a plurality of circuits having impedance characteristics of different kinds, and a plurality of coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the connection of any of said first-named circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said tuned circuit.

5. In combination, a tuned circuit adapted to be alternatively coupled to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the resistive first-named circuit, when effective, is optimum coupled to said tuned circuit and that either coupling circuit in connection with its respective first-named circuit causes substantially the same effect on the resonant frequency of said tuned circuit.

6. In combination, a tuned circuit adapted to be alternatively coupled to either of two circuits having impedance characteristics of different kinds, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that either first-named circuit in connection with its respective coupling circuit reflects into said tuned circuit reactance of substantially the same kind and magnitude.

7. In combination, a tuned circuit adapted to be alternatively coupled to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that either first-named circuit in connection with its respective coupling circuit reflects into said tuned circuit reactance of the same kind and of substantially the same magnitude.

8. In combination, a tuned circuit adapted to be alternatively coupled to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection to its respective first-named circuit, the coupling circuit for the reactive first-named circuit including reactance in common with said tuned circuit, and the coupling circuit for the resistive first-named circuit including at least a part of said common reactance and also other reactance individual thereto, the impedances of said coupling circuit reactances for the resistive first-named circuit being so proportioned that the connection of either of said first-named circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said resonant circuit.

9. In combination, a tuned circuit adapted to be alternatively coupled to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said resistive and reactive circuits, each of said circuits being coupled to said tuned circuit and including provisions for connection individually to its respective resistive or reactive circuit, the coupling circuit for said resistive circuit being coupled to said tuned circuit by two reactive couplings of opposite kind and also including therein two self-reactances of opposite kind, the coupling circuit for said reactive circuit being coupled to said tuned circuit by reactive coupling which includes one of the reactive couplings of said first named coupling circuit, the values of the reactive couplings and of the self-reactances of said first named coupling circuit being so proportioned relative to the impedance characteristic of said other coupling circuit that said resistive and reactive circuits produce substantially the same change in the resonant frequency of said tuned circuit when individually effectively connected to their respective coupling circuits, and that said first-named coupling circuit provides substantially optimum coupling between said resistive circuit and said tuned circuit.

10. In combination, a tunable circuit adapted to be coupled alternatively to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tunable circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the connection of either of said first-named circuits to its respective coupling circuit causes substantially the same effect on the resonant frequency of said tunable circuit for any adjustment of the resonant frequency of said tunable circuit within the tuning range thereof.

11. In combination, two tunable circuits having conjointly actuated tuning elements, one of said circuits being adapted to be alternatively coupled to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said second-named circuits, each of said coupling circuits being coupled to said one tunable circuit and including provisions for connection to its respective second-named circuit, the impedance characteristics of said coupling circuits being so proportioned that the connection of either second-named circuit to its respective coupling circuit causes such an effect on the resonant frequency

of said one tunable circuit as to maintain it substantially in a predetermined relation with the resonant frequency of the other of said tunable circuits for any adjustment of the resonant frequency thereof within its tuning range.

12. In combination, a tunable circuit adapted to be coupled alternatively to either of two circuits having respectively a mainly resistive and a mainly reactive impedance characteristic, and two coupling circuits corresponding, respectively, to said first-named circuits, each of said circuits being coupled to said tunable circuit and including provisions for connection to its respective first-named circuit, the impedance characteristics of said coupling circuits being so proportioned that either, in connection with its respective first-named circuit, causes substantially the same effect on the resonant frequency of said tunable circuit and causes substantially optimum coupling of said resistive circuit to said tunable circuit when effective, for any adjustment of the resonant frequency of said tunable circuit within the tuning range thereof.

13. In combination, a resonant circuit, including in series fixed inductance, fixed capacitance and variable capacitance, tunable over a wide range of frequency and adapted to be alternatively coupled to either a predetermined mainly resistive antenna or a predetermined mainly capacitive antenna; and two different fixed coupling circuits coupled to said resonant circuit and including provisions for connection respectively to said antennas, each coupling circuit including in series at least part of the reactance of said fixed capacitance, the coupling circuit for the resistive antenna including additionally in series individual fixed capacitance and individual fixed inductance inductively coupled to the fixed inductance of said resonant circuit, the values of capacitance and of self and mutual inductance in said coupling circuits being so proportioned that the resistive antenna coupling circuit has substantial capacitive reactance at all frequencies in said range, and that the connection of either of said antennas to its respective coupling circuit causes substantially the same effect on the resonant frequency of said resonant circuit for any value of said variable capacitance.

14. In combination, a resonant circuit, including in series fixed inductance, fixed capacitance and variable capacitance, tunable over a wide range of frequency and adapted to be alternatively coupled to either a predetermined mainly resistive antenna or a predetermined mainly capacitive antenna; and two different fixed coupling circuits coupled to said resonant circuit and including provisions for connection respectively to said antennas, each coupling circuit including in series at least part of the reactance of said fixed capacitance, the coupling circuit for the resistive antenna including additionally in series individual fixed capacitance and individual fixed inductance inductively coupled to the fixed inductance of said resonant circuit, the values of capacitance and of self and mutual inductance in said coupling circuits being so proportioned that the resistive antenna coupling circuit has substantial capacitive reactance at all frequencies in said range, that the connection of either of said antennas to its respective coupling circuit causes substantially the same effect on the resonant frequency of said resonant circuit for any value of said variable capacitance, and that approximately optimum coupling is secured between said resistive antenna and said resonant circuit for any value of said variable capacitance.

15. In a radio receiver having a plurality of tunable circuits with conjointly operated tuning elements, means for adapting said receiver for substantially optimum operation with either a mainly capacitive antenna or a mainly resistive antenna without readjustment of the receiver, said means comprising two different coupling circuits permanently coupled to the first tunable circuit of the receiver and adapted for connection respectively to said antennas, the coupling circuit for the capacitive antenna consisting of a capacitive reactance in common with said first tunable circuit, and the coupling circuit for the resistive antenna including at least a portion of said capacitive reactance and including also other reactances individual thereto including an inductive reactance inductively coupled to said first tunable circuit, the impedance characteristics of said resistive antenna coupling circuit being so proportioned that said resistive antenna is optimum coupled to said first tunable circuit over the tunable range thereof, and that the connection of either antenna to its respective coupling circuit causes substantially the same effect on the resonant frequency of said first tunable circuit and on its relation to the resonant frequency of the other or others of said tunable circuits, for any adjustment of the tuning element of said first tunable circuit.

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