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SIGNAL TRANSLATING SYSTEM

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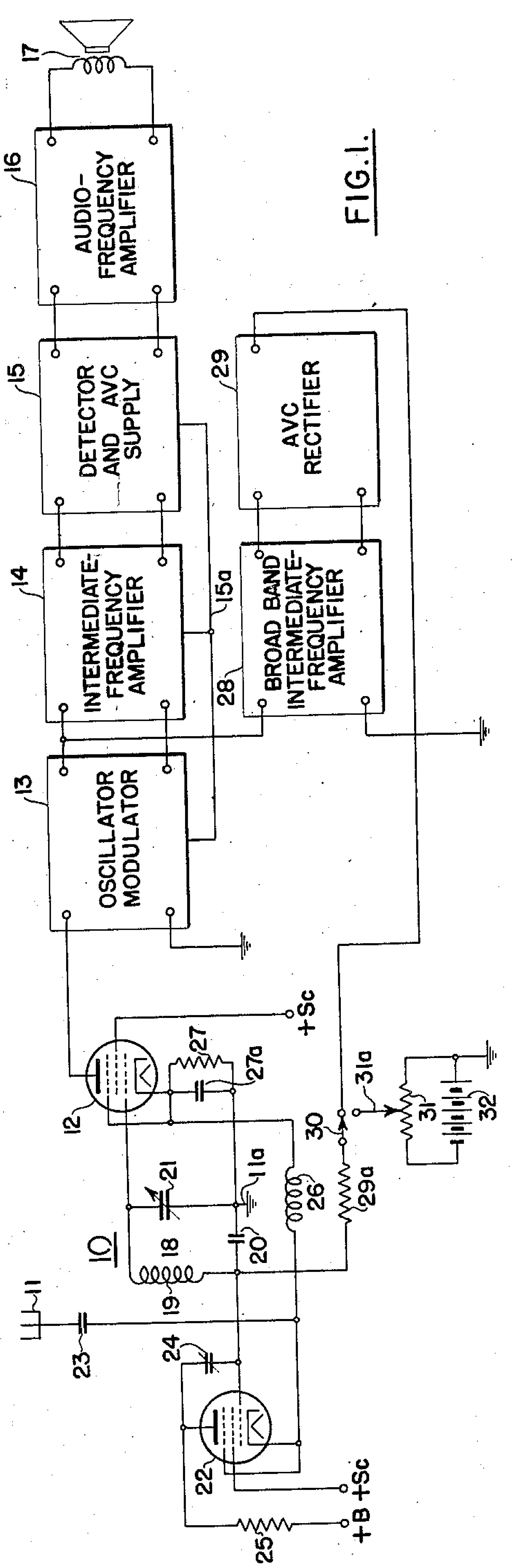

FIG. 1.

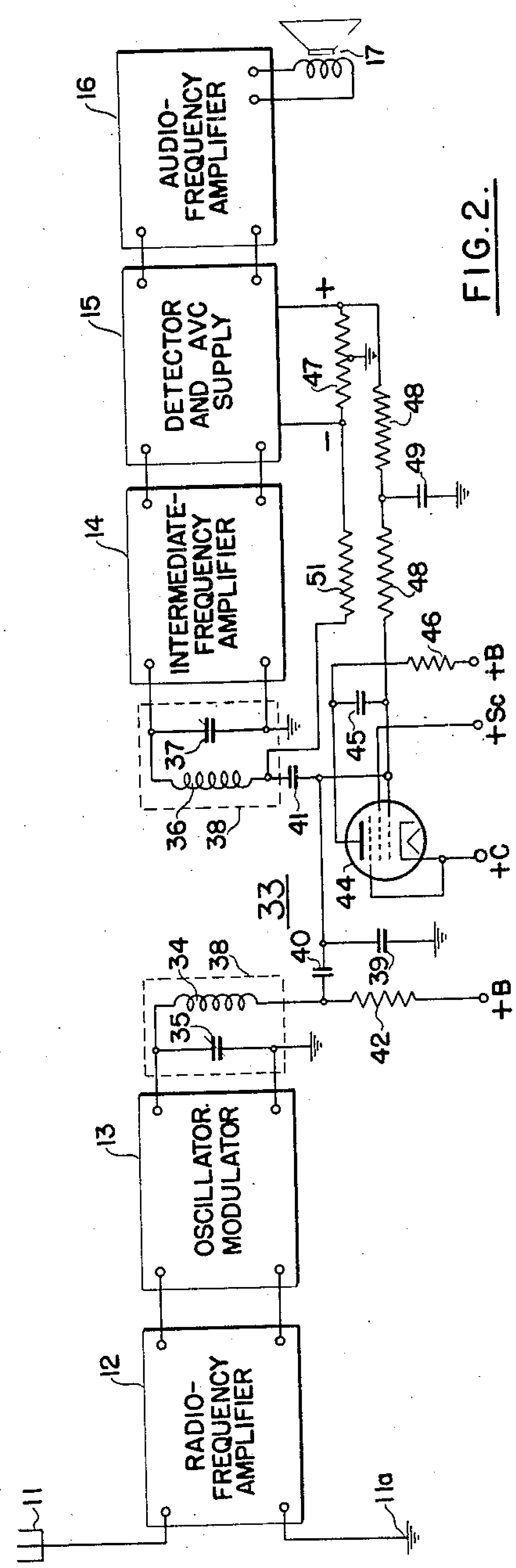

FIG. 2.

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SIGNAL-TRANSLATING SYSTEM

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9 Claims. (Cl. 250—20)

This invention relates to signal-translating systems, and more particularly to adjustable coupling arrangements for use in such systems.

In its broader aspects, the invention is directed to coupling systems generally and to provision of means for adjusting the coupling provided thereby for any desired purpose. The invention is specifically concerned with antenna coupling systems and with the provision of means, rapid and dependable in operation, for automatically controlling the gain of such systems in accordance with the amplitude of signals passed thereby.

In a high-frequency signal-receiving system, in order to obtain satisfactory reproduction of relatively weak received signals, such as signals from distant stations, it is highly desirable that the antenna circuit be coupled to the first vacuum tube amplifier of the signaling system by a coupling system which provides a high gain, so that a maximum signal-to-noise ratio may be obtained at the input circuit of the first amplifier. As is well known, however, if such a system is adjusted to produce a high gain when relatively strong signals, such as signals from nearby stations, are received, such signals will be impressed upon the input circuit of the first amplifier at such high amplitudes as to effect overloading of the amplifier, which causes distortion, whistles, and cross modulation between desired and undesired signals. It is desirable, therefore, that the gain of the antenna coupling system be high for the reception of relatively weak signals and reduced for the reception of relatively strong signals, so that the amplitudes of the signal input to the first amplifier will be maintained at approximately optimum value for received signals of all amplitudes.

Moreover, due to the well-known phenomenon of fading, the amplitude of any particular signal being received may vary over an extremely wide range, that is, from a very low to a relatively high value, at times with great rapidity. Compensation for this condition by adjustment of the antenna gain, therefore, requires an extremely rapid control which is dependent upon, and immediately responsive to, the amplitudes of the signal being received.

While various systems of automatic amplification control or A. V. C. have been devised, which serve to maintain the signal output volume level of systems to which they are applied within a relatively narrow range, or substantially constant, for a wide range of received signal intensities, such arrangements operate to control the vacuum-tube amplifiers of the system and, hence, do not serve to hold the signal at the input circuit of the first amplifier at the optimum amplitude. Certain mechanical arrangements have also been devised heretofore for providing automatic gain control of antenna coupling systems. Such arrangements, however, have proved unsatisfactory in that the control provided thereby was not sufficiently rapid, or was otherwise unstable or undependable.

In general, it is an object of the invention to provide an improved coupling system embodying means for adjusting the coupling provided thereby, which is adapted for use in any desired system to provide any desired change in the characteristics of the system which may be produced by a coupling adjustment.

More particularly, it is an object of the invention to provide an improved adjustable antenna coupling system embodying one or more of the characteristics described above.

It is a further object of the invention to provide an improved antenna coupling system of the character described embodying means, rapid and dependable in operation, for automatically controlling the gain of the system in accordance with the amplitude of the signal passed thereby.

In accordance with the present invention, there is provided, in a signal-translating system, a coupling system which includes input and output circuits and an arrangement for adjusting the coupling. This arrangement preferably comprises a vacuum tube connected to simulate an adjustable reactance element, for example, being so connected that the effective reactance of its input circuit provides a coupling reactance which is adjustable by changing the transconductance of the tube. In certain embodiments of the invention, means are provided for effecting the adjustment of the coupling reactance means automatically and inversely in accordance with the amplitude of signals passed by the system, thereby to control the gain of the coupling system and maintain the amplitude of the signal output therefrom within a relatively narrow range for a wide range of signal input amplitudes.

A preferred embodiment of the invention comprises an antenna coupling system for coupling an antenna circuit to a resonant signal-translating circuit. The gain control means includes a vacuum tube connected so that the effective reactance of its input circuit provides an adjustable coupling capacitance serially included in the antenna circuit. Means are provided for deriving a bias voltage proportional to the amplitude of signals passed by the system and for applying this voltage negatively to a control grid of the tube to adjust the transconductance of the tube, thereby to control the effective reactance of its input circuit and, hence, the gain of the system automatically and directly in accordance with the signal amplitudes. Other embodiments of the invention may be employed to provide coupling systems wherein the coupling is automatically adjusted for various other purposes, as will be hereinafter more fully explained.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing, Fig. 1 is a circuit diagram, partly schematic, of a complete superheterodyne radio receiver including an antenna coupling system embodying the invention; and Fig. 2 is a circuit diagram similar to Fig. 1, but including a modified form of the coupling system of the invention, providing an interstage coupling in the receiver.

Referring now more particularly to Fig. 1 of the drawing, there is shown a radio receiver including a coupling system, indicated generally at 10, interconnecting an antenna circuit comprising an antenna 11 and ground 11*a*, and the input circuit of a radio-frequency amplifier tube 12. Connected in cascade with the radio-frequency amplifier tube 12, in the order named, are an oscillator-modulator 13, an intermediate-frequency amplifier 14, a detector and automatic amplification control or A. V. C. supply 15, an audio-frequency amplifier 16, and a sound reproducer or loud-speaker 17. The coupling system 10 is shown in detail and it, together with the parts of the system associated therewith which embody the present invention, will be hereinafter further described. It will be understood that the several parts which are illustrated in the drawing schematically may be conventional in their construction and operation, the details of which are well understood in the art rendering description thereof unnecessary herein.

Neglecting for the moment the particular construction and operation of the parts of the system embodying the present invention, the system described above includes all of the features of a conventional superheterodyne receiver. The operation of such a receiver being well understood in the art, detailed explanation thereof is deemed unnecessary. In brief, however, a desired modulated-carrier signal intercepted by the antenna is selected and amplified by the antenna coupling system 10 and amplifier tube 12, and converted by the oscillator-modulator to an intermediate-frequency signal. This signal is selected and amplified by the intermediate-frequency amplifier 14 and translated therefrom to the detector 15, wherein the audio frequencies of modulation are derived. The audio frequencies of modulation are amplified in the audio-frequency amplifier 16 and reproduced in the loud-speaker 17 in conventional manner. Biasing potentials developed by the A. V. C. supply 15 are supplied, by way of suitable leads indicated at 15*a*, to control the gain of one or more of the tubes of the intermediate-frequency amplifier and oscillator-modulator, to maintain the amplitude of the signal output of the amplifier 14 within a relatively narrow range for a wide range of received signal amplitudes.

Referring now more particularly to the portion of the system embodying the present invention, the coupling system 10 includes a resonant signal-translating circuit 18, the arms of which comprise, respectively, an inductance 19 and a coupling condenser 20 connected in series with a tuning condenser 21. In order to control the gain of the system, the antenna 11 is connected to ground 11*a* by way of a blocking condenser 23, the input circuit of a vacuum tube 22, and the condenser 20. The condenser 20 is thus a coupling condenser common to both the antenna circuit and the signal-translating circuit 18; the tube 22 is preferably a pentode, as illustrated, although any vacuum tube having three or more electrodes arranged to provide a substantial value of effective input circuit capacitance may be employed. A condenser 24 is connected between the control grid and anode to increase the effective grid-to-cathode capacitance and a high impedance, for example, a resistor 25, is included in the anode circuit of the tube.

Operating voltages are supplied to the anode of the tube by way of the resistor 25 and to the screen from suitable sources, as indicated at +B and +Sc, respectively. The cathode of the tube 22 is preferably maintained at the same average potential as the cathode of the tube 12 and may be connected thereto by way of a radio-frequency choke coil 26, a suitable biasing resistor 27 and by-pass condenser 27*a* being included in the common cathode circuit of the tubes 12 and 22.

As is well understood, the interelectrode capacitances of a vacuum tube include those of the cathode-to-grid, grid-to-plate, and grid-to-plate and cathode connected together. With a high impedance in the anode circuit of the tube, such as the resistor 25, the effective grid-to-cathode capacitance is approximately that represented by the formula:

$$C=C_{G-C}+(\mu+1)C_{G-A}$$

where:

C=the effective grid-to-cathode capacitance.

C_{G-C}=the geometrical grid-to-cathode capacitance.

C_{G-A}=the grid-to-anode capacitance.

μ=the grid-to-plate voltage amplification of the tube and circuit.

The effective grid-to-cathode capacitance, therefore, varies with any factors which affect the transconductance of the tube. Such factors include, for example, the anode circuit load impedance, the screen and anode voltages, and the grid-bias voltage. This effective capacitance is, therefore, admirably adapted for providing an adjustable coupling capacitance in a coupling system, and in accordance with the present invention it is so utilized.

In order to vary the transconductance of the tube 22 and, hence, the effective grid-to-cathode capacitance of the tube, in the present instance a control-bias voltage is applied to its control grid. For the purpose of developing this voltage, a broad band intermediate-frequency amplifier 28 and an automatic amplification control or A. V. C. rectifier 29 are connected in cascade, in the order named, to the output circuit of the oscillator-modulator 13. The amplifier 28 is designed to pass a band of frequencies which is substantially as wide as that passed by the coupling system 10; that is, it passes and amplifies not only the desired signal to which the system is tuned, but also undesired signals which are passed by the antenna coupling system and which may have sufficient amplitude to be capable of overloading the amplifier 12, causing distortion, cross modulation, or interference. The construction of an amplifier having the desired broad band-pass characteristic is well understood in the art and a detailed description thereof is deemed unnecessary. The A. V. C. rectifier is designed and operates in a conventional manner to develop a bias voltage proportional to the carrier amplitude of the signals supplied thereto, and this bias voltage is applied negatively by way of a suitable resistor 29a to the control grid of the tube 22. This bias voltage is also applied to the control grid of the amplifier tube 12 to provide a supplemental amplification control.

In order to provide a manual gain control of the antenna coupling system and radio-frequency amplifier, a switch 30 may be included in the control-bias voltage lead, by means of which the control grid returns of the tubes 22 and 12 may be disconnected from the output circuit of the rectifier 29 and connected to an adjustable tap 31a on a voltage divider resistor 31, connected to a suitable source of biasing potential, such as a battery 32.

For the usual automatic operation of the system, the switch 30 is positioned, as illustrated. The operating potentials applied to the tube 22 including the initial fixed grid-bias voltage supplied by resistor 27, the value of the condenser 24, and the constants of the other circuit elements associated with the tube 22 are adjusted, so that, in the absence of a signal or for relatively weak signals, the effective grid-to-cathode capacitance of the tube is a maximum, giving the maximum gain for the coupling system. A satisfactory maximum value of effective capacitance has been found to be one which is between one and ten times the value of the antenna capacitance. Hence, when relatively weak signals are received, the gain of the coupling system is high, and a relatively strong signal and a high signal-to-noise ratio are obtained at the input circuit of the tube 12.

When, however, there are received signals, including either the desired signal to which the system is tuned or undesired signals on carriers adjacent the desired signal carrier, which would be of sufficiently great amplitude at the input circuit of the tube 12 to overload this tube if maximum gain were maintained for the antenna coupling system, these signals are amplified by the amplifier 28 and rectified by the rectifier 29. The unidirectional voltage derived therefrom is applied negatively to the control grids of the tube 22 and 12. The transconductance of the tube 22 and, hence, its effective grid-to-cathode capacitance are thus varied inversely in accordance with the received signal amplitudes; that is, the capacitance in series in the antenna circuit is reduced, preferably to an amount substantially less than the antenna capacitance. The gain of the antenna coupling system is thereby automatically controlled inversely in accordance with the ampliture of the signals passed thereby. By this arrangement, therefore, the gain of the antenna coupling system is so controlled as to provide automatically the maximum gain permissible for all received signals of a wide range of amplitudes without overloading the radio-frequency amplifier tube 12. A supplemental amplification control is effected in the tube 12 by the application of the negative bias voltage to the grid of the tube, variable directly in accordance with the received signal amplitudes.

In Fig. 2 there is illustrated a superheterodyne receiver which embodies the present invention in a modified form. The system of Fig. 2 is, in general, similar to the receiver of Fig. 1, and like parts are indicated by the same reference numerals in the two figures. The description of the general construction and operation of the receiver of Fig. 1, set forth above, is equally applicable to the receiver of Fig. 2 and, therefore, need not be repeated While an automatically controlled antenna coupling system, such as is shown in Fig. 1, may be embodied in the receiver of Fig. 2 if desired, for the sake of brevity this has not been illustrated.

In Fig. 2 an improved coupling system according to the present invention is indicated generally at 33. This system is utilized as an interstage coupling between the oscillator-modulator 13 and the intermediate-frequency amplifier 14. The output circuit of the oscillator-modulator 13 includes an inductance 34 tuned to the intermediate-frequency carrier by a condenser 35, and the input circuit of the intermediate-frequency amplifier 14 includes an inductance 36 tuned to the intermediate-frequency by a condenser 37. The two tuned circuits 34, 35 and 36, 37 are electromagnetically isolated from each other by suitable shields indicated at 38. The lower terminals of the condensers 35 and 37 are connected directly to ground, while the lower terminals of the inductances 34 and 36 are grounded by way of direct current blocking condensers 40 and 41, respectively, and common coupling condenser 39. Operating potential is supplied to the oscillator-modulator from a suitable source, indicated as +B, by way of an isolating resistor 42 and the inductance 34.

A vacuum tube 44, similar in its connections and operation to the tube 22 of Fig. 1, is provided for the coupling system 33. A condenser 45 is connected between the control grid and anode of the tube 44, and its input circuit is connected effectively in parallel with the coupling condenser 39. Operating potentials are applied to its anode, by way of a resistor 46, to its screen, and to its cathode, from suitable sources, as indicated at +B, +Sc, and +C, respectively. The effective capacitance of the input circuit of the tube 44 is thus included in parallel with the condenser 39 and serves as an adjustment on the coupling capacitance between the circuits 34, 35 and 36, 37. In this embodiment, the unidirectional control-bias voltage is developed by the A. V. C. supply 15 across a resistor 47, which is grounded at an intermediate point. A portion of this voltage is applied positively to the control grid of the tube 44 by way of suitable isolation resistors 48, the junction of which is by-passed to ground by condenser 49. The constants of the circuit elements associated with the tube 44, including the initial voltages applied thereto, are so proportioned as to bias the tube beyond cutoff in the absence of a signal of sufficient strength to effect the application of substantial bias voltage to its control grid, so that the input circuit capacitance of the tube 44 is inappreciable under this condition. The condenser 39 is of such size that the coupling provided thereby between the two tuned circuits is such as to provide a single-peaked resonance characteristic for the system which corresponds to the maximum gain thereof. When a relatively strong signal is received, resulting in an increased bias voltage being developed across the resistor 47 and applied positively to the control grid of the tube 44, the effective capacitance of the input circuit of the tube is increased and the coupling between the two circuits 34, 35 and 36, 37 is, therefore, decreased. Such decrease in coupling reduces the gain of the system and, by virtue of this effect, the amplitude of the signal output from the coupling system is maintained within a relatively narrow range for a wide range of signal amplitudes.

Supplementing the gain control provided by the coupling adjustment, the unidirectional bias voltage developed across the resistor 47 may be applied negatively to the control grids of one or more of the amplifier tubes of the system in accordance with conventional A. V. C. practice. For example, this voltage may be applied as shown by way of an isolating resistor 51 and the inductance 36 to the control grid of the first tube of the intermediate-frequency amplifier 14.

From the above description it will be apparent that the present invention provides a novel, practical, and efficient arrangement whereby the coupling between a pair of circuits may be readily adjusted for various desired purposes, and more particularly it provides a highly satisfactory arrangement whereby the gain of an antenna coupling system may be controlled to obtain the optimum value for all received signal conditions.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a signal-translating system, a coupling system comprising an input circuit, an output circuit, means for coupling said circuits, and means for controlling the coefficient of coupling between said input and output circuits comprising a vacuum tube having electrodes connected with said circuits and means coupling said electrodes whereby said tube simulates a reactance element connected in circuit with said circuits for modifying the coefficient of coupling therebetween and adjustable with the transconductance of said tube and means for adjusting said transconductance of said tube.

2. In a signal-translating system, a coupling system comprising an input circuit, an output circuit, means for coupling said circuits, a vacuum tube having electrodes connected with said circuits and means coupling said electrodes whereby the input circuit of said tube provides an effective reactance connected in circuit with said input and output circuits for modifying the coefficient of coupling therebetween and adjustable with the transconductance of said tube, and means for controlling the gain of said coupling system thereby to maintain the amplitude of the signal output therefrom within a relatively narrow range for a wide range of signal input amplitudes comprising means for adjusting the transconductance of said tube in accordance with the amplitude of signals passed by said system.

3. In a signal-translating system, a coupling system comprising an input circuit, an output circuit, means for coupling said circuits, a vacuum tube having anode, cathode, and grid electrodes, means for applying operating potentials to said electrodes, said tube having a high impedance included in its anode circuit and a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said tube, and means for controlling the coefficient of coupling between said input and output circuits of said coupling system including the input circuit of said tube and means for adjusting the transconductance of said tube.

4. In a signal-translating system, a coupling system comprising an input circuit, an output circuit, means for coupling said circuits, a vacuum tube having anode, cathode, and control grid electrodes, means for applying operating potentials to said electrodes, said tube having a high impedance included in its anode circuit and a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said tube, means for controlling the coefficient of coupling between said input and output circuits of said coupling system for varying the gain of said system including the input circuit of said tube, and means for applying a controllable bias voltage to said control grid.

5. In a signal-translating system, an antenna coupling system comprising an antenna circuit, a resonant signal-translating circuit, means for coupling said circuits, and means for controlling the gain of said coupling system comprising a vacuum tube having electrodes connected with said antenna circuit and means coupling said electrodes whereby the input circuit of said tube provides an effective coupling reactance included in said antenna circuit and adjustable with the transconductance of said tube and means for adjusting said transconductance to vary said coupling provided by said effective reactance.

6. In a signal-translating system, an antenna coupling system comprising an antenna circuit, a resonant signal-translating circuit, means for coupling said circuits, a vacuum tube having anode, cathode, and control grid electrodes, means for applying operating potentials to said electrodes, said tube having a high impedance in its anode circuit, and a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said tube, and means including the input circuit of said tube for controlling the coupling between said antenna and signal-translating circuits and means for adjusting the transconductance of said tube.

7. In a signal-translating system, an antenna coupling system comprising an antenna circuit, a resonant signal-translating circuit, means for coupling said circuits, a vacuum tube having anode, cathode, and control grid electrodes, means for applying operating potentials to said electrodes, said tube having a high impedance in its anode circuit and a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said tube, and means for controlling the gain of the system including the input circuit of said tube controlling the coupling between said antenna and signal-translating circuits and means for applying a controllable bias voltage to said control grid.

8. In a signal-translating system, an antenna coupling system comprising an antenna circuit, a resonant signal-translating circuit, means for coupling said circuits, a vacuum tube having anode, cathode, and control grid electrodes, means for supplying operating potentials to said

electrodes, said tube having a high impedance in its anode circuit and a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said tube, means including the input circuit of said tube for controlling the coupling between said antenna and signal-tranlating circuits, means for developing a bias voltabe proportional to the amplitude of signals passed by said coupling system, and means for maintaining the signal output of the system within a relatively narrow range for a wide range of received signal amplitudes comprising means for applying said voltage to said control grid.

9. In a signal-translating system, an antenna coupling system including an antenna circuit and a resonant signal-translating circuit, a vacuum tube amplifier having a grid electrode, coupled to said signal-translating circuit, a second vacuum tube having anode, cathode, and control grid electrodes, means for applying operating potentials to the electrodes of said tubes, said second vacuum tube having a high impedance in its anode circuit and having a substantial reactive coupling between its grid and anode, whereby its input circuit provides an effective reactance adjustable with the transconductance of said second tube, the input circuit of said second tube being included in said antenna circuit, a conductive connection between the grids of said tubes, means for developing a control bias voltage, and a connection from the last said means to said conductive connection, whereby said bias voltage is simultaneously applied negatively to the control grids of both said tubes to control the gain of the system.

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