Oct. 13, 1936. W. L. CARLSON 2,056,955

SELECTIVITY CONTROL CIRCUIT

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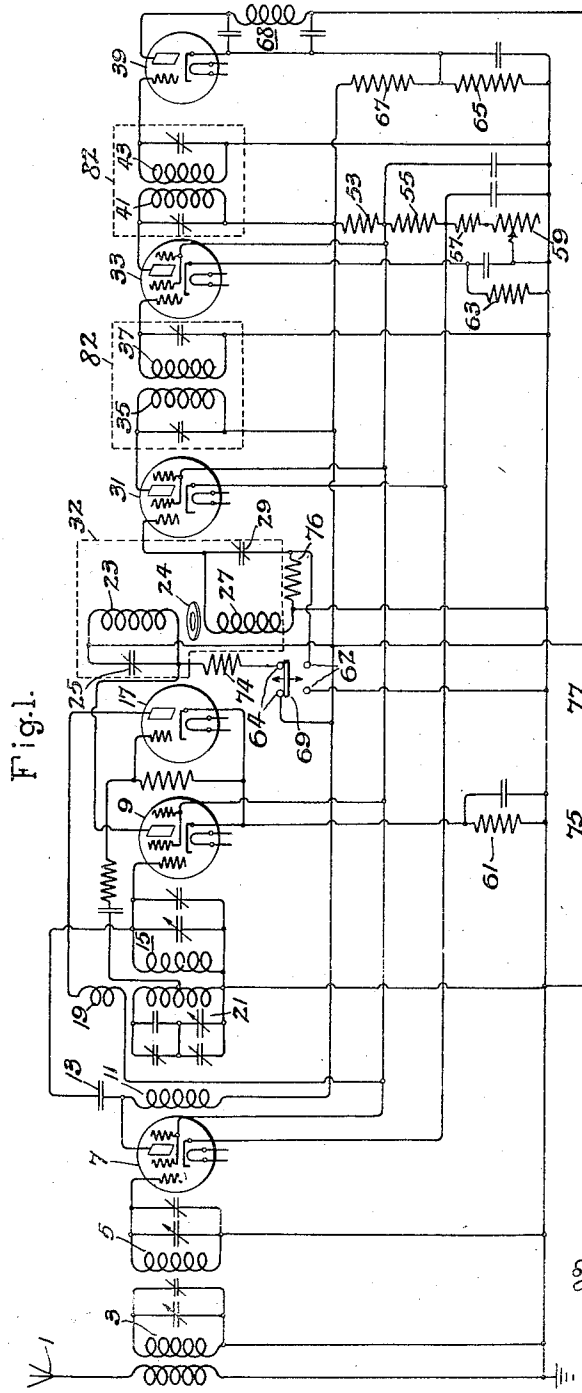


Fig. 1.

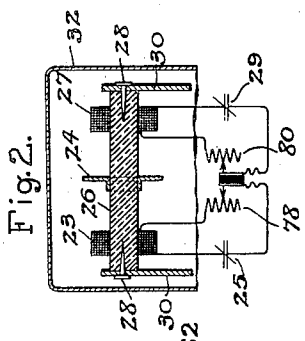


Fig. 2.

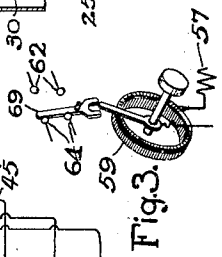


Fig. 3.

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SELECTIVITY CONTROL CIRCUIT

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29 Claims. (Cl. 178—44)

My invention relates to radio receiving circuits and apparatus, and more particularly it relates to a circuit arrangement and apparatus therefor adapted to control the selectivity and fidelity of reproduction under differing conditions of reception, in tuning from one signal channel to another. In the broadcast band of frequencies, for example, a receiving apparatus may be required to receive signals or programs from a powerful local station requiring low gain with a broad tuning response for good fidelity, or from a distant station differing in frequency by only a few kilocycles from an undesired station, requiring a greater and even a maximum amount of both selectivity and gain.

With transmitting stations operating at frequencies differing from each other by only a few kilocycles it is difficult, ordinarily, to obtain good fidelity simultaneously with good selectivity. To obtain a desired degree of selectivity in the one case and the desired degree of fidelity in the other, it is necessary to provide means for changing the receiving circuit constants for local as distinguished from distance reception.

Accordingly, it is an object of my invention to provide an improved and simplified circuit and apparatus therefor adapted for use in a radio receiving system whereby the same may be operated with either high gain and great selectivity or with reduced gain and increased fidelity of reproduction.

A further object of my invention is to provide an improved coupling or transformer unit for use in receiving systems between thermionic tubes which is simple in construction, easily adjusted and which is effective in a selectivity-fidelity control circuit.

My present invention is in the nature of an improvement over the subject matter disclosed in my copending application, Serial No. 193,438 filed May 23, 1927, now Patent 1,871,405. In the said application it is disclosed that fidelity and selectivity may be controlled by a switching arrangement which changes the relation between certain windings of a transformer in one or more points of a receiving system and, at the same time, changes the amount of resistance in the transformer circuit.

In accordance with my present invention, a plurality of loosely coupled tuned circuits, preferably in the intermediate frequency amplifier of a superheterodyne receiving system, are arranged to be changed from a condition of high selectivity and high gain to a condition of reduced selectivity and lower gain by means for readily changing the amount of resistance in one or both of said circuits without disturbing the coupling relation between circuits and without substantially altering the natural reasonant frequency thereof.

Heretofore, it has been customary, in receiving systems including a transformer as a circuit coupling means, and the transformer having relatively close coupling between primary and secondary circuits, to damp the transformer by means of a resistance in either the primary or the secondary circuit. In such a case, as is well known, appreciable resistance is transferred to the opposite side of the transformer circuit, the amount depending upon the degree of coupling and voltage ratio of the transformer.

In my present circuit, however, by reason of the looseness of coupling between circuits, any resistance inserted into one circuit is substantially not transferred into the other circuit. Furthermore, since it is not feasible to obtain the desired reduction in gain by introducing an excessive amount of resistance into only one of the coupled circuits, I have found it desirable to provide means to introduce a limited amount of resistance into one circuit and simultaneously or subsequently to introduce a certain amount into the other circuit.

Other objects of my invention will become evident from the following detailed description, taken in conjunction with the accompanying drawing, in which Fig. 1 is a complete circuit diagram of a superheterodyne receiving system embodying my invention; Fig. 2 is a sectional view of a transformer or coupling unit used in the circuit of Fig. 1, together with a diagrammatic showing of a modified form of my invention, and Fig. 3 is an isometric view, in structural form, of a feature of Fig. 1 showing a modification of my invention.

Referring to Fig. 1, an antenna 1 is coupled to loosely coupled variable tuned circuits 3 and 5 which impress selected radio frequency signals upon a screen grid thermionic amplifier tube 7. The output circuit of the tube 7 is coupled to the first detector 9, of the screen grid type, by suitable means such as a radio frequency choke coil 11, a condenser 13, and a variable tuned circuit 15 providing the input circuit therefor. An oscillation generator, comprising a tube 17, a feedback coil 19 and a variable tuned circuit 21, is coupled to the input circuit of said detector.

The detector output circuit is connected with a coupling unit including a coil 23, tuned by means of a semi-variable condenser 25 to the desired intermediate frequency. A coil 27, tuned

by a condenser 29 in like manner, is loosely coupled to the coil 23 with a coupling no greater than optimum. A disc or annular ring 24, of thin current-conducting material, preferably of low resistance material such as copper, is disposed between the coils 23 and 27, having a common axis therewith, and effects very loose coupling with relatively closer spacing of coils than would otherwise be possible. Such an arrangement may be used to advantage in radio frequency transformers as well.

An intermediate frequency amplifier screen-grid tube 31 is coupled to a similar succeeding intermediate amplifier tube 33 by a plurality of loosely coupled resonant circuits including coupling coils 35 and 37. Similarly, the tube 33 is connected with the second detector 39 by a pair of loosely coupled circuits including coupling coils 41 and 43. The selectivity of each of the latter pairs of coupled circuits is less, and the coupling is greater, than that of the coupled circuits in output of the first detector tube 9. No shielding device is used between the coils of circuits 35 and 37 and the coils of circuits 41 and 43 while the physical spacing between coils is less than in the case of the coils 23 and 27.

Space-current is supplied by a rectified current source 41 through a plurality of filter elements 44, 45, 47, 49, 51, the coil 45 serving, also, as a dynamic speaker field winding hereinafter referred to. The screen grid voltage of the amplifier and detector tubes is supplied by means of a potential divider network including resistors 53 and 55. The control-grid negative bias potentials for the radio frequency tube 7 and the first intermediate frequency tube 31 are supplied by means of a connection from the cathodes to resistors 57 and 59, in circuit with resistors 53 and 55, resistor 59 being variable to control amplification. Individual self-bias resistors 61 and 63 in the cathode leads supply the control grids of tubes 9 and 33 respectively, with bias-potentials, and a combination self-bias resistor and "bleeder" resistor 65 negatively biases the grid of the second detector 39.

The output circuit of the second detector 39 contains a radio frequency filter 68 and is coupled through an audio-frequency transformer 70 to a push-pull output amplifier stage 72. In the output circuit of the latter is connected an electrodynamic loud speaker 71 through a push-pull transformer 73. A variable potentiometer resistor 75, in series with a condenser 79, in combination with the secondary of transformer 70, and in series with a fixed resistor 77, in combination with the primary of transformer 70, constitutes audio frequency control means for adjusting the tone of the output of the receiver. This control means, in the audio frequency amplifier constitutes fidelity control means in addition to the selectivity-fidelity control means in the intermediate frequency amplifier.

For the purpose of varying the gain and band width of transmission in the intermediate frequency amplifier, a double-throw, double-pole switch 69 is provided for throwing resistance into and out of each of a pair of the loosely coupled circuits such as 23, 25 and 27, 29. The circuit arrangement is such that in the switch position shown, resistor 74 of the order of 40,000 ohms is shunted across circuit 23, 25, while resistor 76 of the order of 500 ohms is caused to be in series in the tuned circuit 27, 29. In the lower position of the switch, resistor 74 is open-circuited and resistor 76 is short-circuited. Obviously a high resistance may be arranged to be connected in shunt with both tuned circuits as in the case of resistance 74, or a lower resistance in series in both tuned circuits, as shown in Fig. 2, by means of two simultaneously variable resistors 78 and 80. However, the foregoing arrangement is at present preferred.

Referring particularly to Fig. 2, the physical relation of the coils 23 and 27 and the disc or partial shield 24 is shown, all being mounted coaxially upon a supporting core 26 of insulation material, the copper eddy current shield disc or short circuited ring being disposed between the coils, preferably centrally positioned. However the position of the disc along the support 26 is not critical with regard to coupling between coils 23 and 27. It is desirable that disc 24 be properly spaced from either coil to avoid interfering with the circuit constants. It will be noted that the coils are fixed upon the support whereby the coupling relation is fixed. This is desirable in quantity production. However the shield member provides ready means for adjusting the coupling, it being necessary only to bend down the edge of the member or disc at one or more points to increase the coupling between coils. As above stated, this provides a simple and inexpensive means for adjusting coupling in factory production while permitting the coils to be permanently mounted.

The fittings or pins 28 Fig. 2, used to secure the core to the brackets 30 are preferably of low resistance current-conducting non-magnetic material such as copper or brass, in order to avoid a substantial increase of losses and to permit sharp tuning. Similarly the shielding container 32 is of copper. However, in the succeeding intermediate coupling units the shielding containers indicated at 82 in dotted lines and certain of the fittings corresponding to 28 in Fig. 2 are of iron, a higher loss material, to lessen the sharpness of tuning. Except for the shielding disc 24, the transformer or coupling arrangement shown in Fig. 2 is substantially similar to the transformers 35—37 and 41—43. Alternatively, in transformer 35—37 one of the fittings, corresponding to pin 28 of Fig. 2, used in association with coil 35 may be of iron while that with secondary 37 may be of brass. In the foregoing arrangements the presence of the above metallic elements of the character described tends to effect a small decrease in sharpness of tuning due to the fact that the resistance to inductance ratio of the coils is increased.

The circuit is slightly modified in Fig. 2 to include a resistor in series in each tuned circuit as above suggested. However, in this case the resistors are made continuously variable or variable in a plurality of steps, the movable contacts or switch arms being mechanically connected for simultaneous adjustment. For simplification of operation it would be desirable to mechanically couple these variable resistors 78—80 with a main volume control such as shown at 59 in Fig. 1. As the structural detail of such coupling is not part of the invention, the same is not shown.

Resistance may be inserted in the coupled circuits to control the selectivity and fidelity by opening the circuit connection with either or both of the tuning condensers 25 or 29, for example, in the same manner that the circuit connection with resistor 74 is opened and closed. Removal of the tuning condenser from circuit has the effect of inserting a large resistance in the circuit, in view of the fact that the illustra-

tion of mechanical coupling means in Fig. 3, hereinafter described, will serve to illustrate this phase of my invention.

In a receiver such as that shown in Fig. 1, it may be desirable in some cases to utilize the movable member of the amplification control resistor 59 to operate the gain and selectivity control switch 69, using mechanical arrangements well known in the art. One arrangement of this character is shown in Fig. 3. Operation of the volume control resistor 59 serves to throw switch 69 from one position to the other.

Notwithstanding the fact that I have illustrated my improved gain-selectivity control in its application to a pair of coupled circuits in the signal channel of a radio receiver representing any signal transmission system, it is obvious that three or more coupled circuits may be employed, using means to introduce resistance into all three or into two of the three, as for example the first and third. It should also be obvious that the circuits so controlled may be those in other parts of the system as for example in any of the other intermediate frequency amplifier stages or in any of the radio frequency portions, or in both. For reasons concerning the control of volume it is desirable in reducing amplification for local reception to effect this reduction at a point about midway of the cascade amplifier system. In the circuit shown the first intermediate frequency amplifier stage is preferred for practical reasons.

From the foregoing description it will be seen that in a radio receiving apparatus having a signal transmission channel there is interposed in said channel a coupling unit or transformer having coupling coils arranged to provide electromagnetic coupling between them, such coils being included in successive adjacent circuits and being arranged preferably coaxially.

Furthermore it will be seen that the degree of coupling between said coils and hence, between the circuits in which they are included, is made relatively less, whereby a high degree of selectivity is obtained for signals transmitted through said coupling device. Furthermore, each of said coils, or circuits in which they are included, are tuned to a desired frequency which, in the present example, is the intermediate frequency of the superheterodyne receiver.

The shielding device or copper ring or disc interposed between the coils of the coupled circuits provides a higher degree of selectivity than is possible with a mere physical separation of the coupled coils. In other words, the shielding device serves to electrically isolate or separate the coils to a degree depending upon the size and shape of the device.

It will be appreciated that an arrangement of this character is particularly well adapted for production manufacturing methods since the shielding device may be deformed, for example by being bent at its outer edge, to adjust the degree of coupling without moving or adjusting the positions of the coils. The coils may thus be permanently mounted in position without further adjustment or change.

The coupling device itself is of simple construction including a central mandrel or core of insulating material which forms a support and centering means for the coils and for the shielding device. Furthermore the mounting means supports are utilized to vary the response characteristics of the coupled circuits. Thus the brads or pins pressed through the supports and into the central mandrel may be of differing materials, as hereinbefore described, thereby serving a dual purpose.

As hereinbefore pointed out, in connection with a coupling device of the present example, because of the looseness of the coupling provided to obtain the desired degree of selectivity, it is desirable to insert resistance not only in one of the coupled circuits but in both to obtain the desired degree of high fidelity, and accordingly the resistance control circuit and switching means of the present example may be provided. In this circuit arrangement for which the coupling device is particularly adapted, to obtain reduced selectivity and high fidelity a resistor is connected in shunt to the output circuit of one tube and in series with the tuned input circuit of a succeeding tube in a cascade connected series of tubes.

While the improved circuit arrangement and apparatus of the present invention is relatively simple, it has been found to be very effective as a local-distance control arrangement for a superheterodyne receiver. It serves to control a sensitive receiver when tuned to a strong local signal channel to produce a high degree of fidelity while at the same time it effects the high degree of selectivity and gain necessary for distance reception over other signal channels or stations which are on closely adjacent frequency bands. For example, the control arrangement herein described provides substantially a 20 to 1 reduction in sensitivity when the control switch 69 is moved to the position shown in the drawing (Fig. 1).

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. The combination in a radio receiving system, of a coupling unit including a pair of loosely coupled coils, means for tuning said coils to respond to a narrow band of frequencies, and sensitivity-fidelity control means therefor arranged to insert resistance in circuit with each of said coils independently, thereby to control the signal attenuation effected through said coupling unit.

2. The combination in a radio receiving system, of a coupling unit including a pair of loosely coupled fixed coils, means for tuning said coils to respond to a narrow band of frequencies, and sensitivity-fidelity control means therefor arranged to insert resistance in circuit with each of said coils independently, thereby to control the signal attenuation effected through said coupling unit, and adjustable means interposed between said coils for adjusting the degree of coupling between them.

3. The combination in an electric amplifier system, of a pair of loosely coupled tuned selective circuits responsive to a narrow frequency band, and means for simultaneously reducing the selectivity of said circuits and reducing the amplifier gain, said means including a switch for inserting resistance into each of said circuits while preserving the coupling relation between circuits.

4. In an electric amplifier system, the combination of a pair of tuned selective circuits, fixed means in each of said circuits providing an electrical coupling between them, adjustable means for varying the degree of coupling between said circuits independently of said fixed coupling means, whereby said circuits are rendered highly selective to signals of a predetermined frequency, and means for reducing the selectivity of said cir-

cuits including a resistance element for each of said circuits, and switching means for simultaneously inserting said resistance elements in their respective circuits.

5. The combination in a superheterodyne intermediate frequency amplifier, of a pair of coupled tuned selective circuits responsive to a narrow band of frequencies, said circuits including coaxially mounted coupling coils, shielding means interposed between said coils for loosening the coupling to a degree no greater than optimum, and means for increasing the resistance in said circuits for simultaneously reducing the selectivity of said circuits and the gain of said amplifier.

6. In a superheterodyne intermediate frequency amplifier, the combination of a pair of coupled tuned circuits responsive to a predetermined frequency band, a coupling coil in each of said circuits, said coils being arranged in fixed coupled relation to each other, an adjustable shield device interposed between said coils, and switching means for simultaneously introducing resistance into each of said circuits, whereby the degree of selectivity of said tuned circuits is controlled.

7. The combination in a superheterodyne intermediate frequency amplifier, of a plurality of electrically coupled tuned circuits responsive to a predetermined frequency band, means interposed between at least two of said coupled circuits providing a relatively loose coupling between and a high degree of selectivity in said circuits, means for reducing said selectivity and the gain of said amplifier including a pair of resistors, and switching means arranged to connect one of said resistors into each of said circuits, whereby the selectivity and fidelity characteristic of the amplifier is controlled while preserving the coupling relation between circuits.

8. The combination in a superheterodyne intermediate frequency amplifier, of a pair of coupled tuned circuits responsive to a predetermined frequency, means interposed between two of said coupled circuits providing a relatively loose coupling between and a high degree of selectivity in said circuits, means for reducing said selectivity and the gain of said amplifier including a high resistance element and a relatively low resistance element, a switch arranged to connect said high resistance element in shunt with one of said circuits and said low resistance element in series in the other of said circuits.

9. The combination, in a radio receiving system, of a pair of electrically coupled signal transmission circuits, means including a shield device interposed in the coupling for rendering said circuits selectively responsive to a predetermined narrow band of frequencies, means for readily broadening said frequency band including a high resistance element and a relatively low resistance element, and a switch so arranged that in one position said high resistance element is in shunt with one of said circuits and said low resistance is in series in said other loop circuit, and in another position only said high resistance element is removed from circuit, and in still another position said low resistance element is removed from circuit.

10. The combination in a selective electric amplifier system, of a pair of tuned coupled signal transmission circuits having a coupling no greater than optimum, switching means for introducing resistance into one of said circuits to reduce the selectivity and increase fidelity of reproduction, and eddy current means interposing a partial shielding effect between said circuits for reducing the coupling between them.

11. The combination in a selective electric amplifier system, of a pair of tuned coupled signal transmission circuits having a coupling no greater than optimum, switching means for introducing resistance separately and independently into each of said circuits to reduce the selectivity and to increase the fidelity of reproduction, and means interposed between the coupled portions of said circuits for adjusting the degree of coupling between them.

12. The combination in a tuned thermionic amplifier system having a high degree of selectivity, of volume-control means for adjustably controlling the amplification of said system, means for adjusting the selectivity of said system, and means whereby adjustment of said volume control means is adapted to control said selectivity controlling means.

13. The invention set forth in claim 12, characterized in that said selectivity controlling means comprises a switch for changing the resistance in the tuned circuits of said system.

14. In a high frequency amplifying system, a plurality of coupled tuned circuits selectively responsive to a narrow band of frequencies, each of said circuits including a coupling coil, said coils being relatively closely spaced in substantially coaxial relation, and means comprising an eddy current shield so positioned with respect to the fields of said coils to interpose a partial shielding effect between said coils and to provide looser coupling between said circuits than would be possible in a given space, with said coaxial relation, in the absence of said shielding means, whereby a high degree of selectivity is obtained.

15. In a high frequency amplifying system, a plurality of coupled tuned circuits selectively responsive to a narrow band of frequencies, each of said circuits including a coupling coil, said coils being relatively so positioned as to provide a substantial degree of coupling between said circuits, and means comprising a shield of low resistance material so positioned with respect to said coils as to loosen the coupling between said circuits to a degree substantially no greater than optimum.

16. In an intermediate frequency amplifying system, a plurality of coupled tuned circuits selectively responsive to a narrow band of frequencies, each circuit including a coupling coil, said coils being relatively so positioned in fixed relation to provide a degree of coupling between circuits that is too great for desirable high degree of selectivity, and a low resistance eddy current ring so positioned with respect to said coils as to interpose a partial shielding effect between said coils, thereby to loosen the coupling between said circuits to a degree substantially that of optimum coupling.

17. The combination in a radio receiving system of a highly selective coupling unit including a pair of loosely coupled coils, means for tuning said coils to respond to a narrow band of frequencies, and variable selectivity-fidelity control means for improving fidelity or reproduction arranged to insert resistance in circuit with each of said coils independently, said means being adjustable by the operator to reduce the selectivity to any of several degrees.

18. A superheterodyne receiving system comprising a highly selective intermediate frequency amplifier having coupled circuits, means for tuning said circuits to a predetermined narrow band

of frequencies, means for reducing to any of several degrees the selectivity of said intermediate frequency amplifier, said means being substantially independent of the coupling of said circuits, whereby said system may be adapted to operate with good fidelity of reproduction when tuned to receive certain signal channels or may be adapted to operate with a high degree of selectivity when tuned to receive other signal channels.

19. A superheterodyne receiving system comprising a variable tuned radio frequency amplifier, a highly selective intermediate frequency amplifier, an audio frequency amplifier, means for controlling amplification in said system, selectivity-fidelity control means for adjusting the frequency transmission characteristics of said intermediate frequency amplifier, and additional fidelity control means for adjusting the fidelity of said audio frequency amplifier.

20. The system as set forth in claim 19 characterized by means whereby said selectivity-fidelity control means and one of the other of said control means are simultaneously adjusted.

21. A radio receiving system comprising a highly selective high frequency amplifier, an audio frequency amplifier, means for controlling amplification in said system, selectivity-fidelity control means for reducing the selectivity of said high frequency amplifier to improve the fidelity of said system for the reception of certain signals, and additional fidelity control means in said audio frequency amplifier for variably controling the characteristics thereof, means whereby said selectivity-fidelity control means and one of the other of said control means are simultaneously controlled.

22. In a transmission system, the combination with a pair of tuned circuits, and a substantially fixed reactive coupling between said circuits, of means for simultaneously controlling both the shape and the width of the selectivity curve of said circuits without altering the natural resonant frequency thereof.

23. A carrier wave receiver of the type tunable over a band of frequencies and including a plurality of cascaded amplifier tubes coupled by tuned circuits, and adjustable impedances in certain of said circuits for determining the overall gain and selectivity of said receiver, characterized by the fact that a plurality of said adjustable impedances are simultaneously adjustable to vary at will the overall gain and selectivity throughout the tuning range of said receiver.

24. In a carrier wave receiver, a plurality of cascaded amplifiers and couplings between adjacent amplifiers, the coupling between one pair of adjacent amplifiers comprising a pair of circuits tuned to the frequency of a desired signal, substantially fixed reactance coupling said circuits to each other, means for varying gain of said amplifiers and means for adjusting the width of the selectivity curve of said coupled circuits without change in the natural resonant frequency thereof.

25. In a carrier wave receiver, a plurality of cascaded amplifiers and couplings between adjacent amplifiers, the coupling between one pair of adjacent amplifiers comprising a pair of circuits tuned to the frequency of a desired signal, reactance coupling said circuits to each other, adjustable resistance in each of said circuits, means for adjusting the effective magnitudes of the said resistances and means for adjusting said coupling reactance.

26. In a tunable system for the transmission of signals falling within a band of frequencies, the combination with a tuned amplifier, of means adjustable at will to determine the band width of over-all transmission of the system, said means comprising a second tuned amplifier, and means manually adjustable at will during operation of the system to determine the selectivity of the said second amplifier.

27. The invention as set forth in claim 26, wherein said first amplifier is a radio frequency amplifier tunable over a band frequencies, and said second amplifier is an intermediate frequency amplifier tuned to a fixed frequency.

28. The invention as set forth in claim 26 characterized in that the second mentioned means determines the gain simultaneously with the selectivity of the second amplifier.

29. In a tunable system for the transmission of signals falling within a band of frequencies, the combination with a radio frequency amplifier tunable over a band of frequencies, of a second amplifier tuned to a fixed frequency, of means adjustable at will during the operation of the system to simultaneously determine the gain and selectivity of said second amplifier.

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