Sept. 29, 1936. R. A. BRADEN 2,055,996

BAND-PASS AMPLIFIER

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Fig. 1

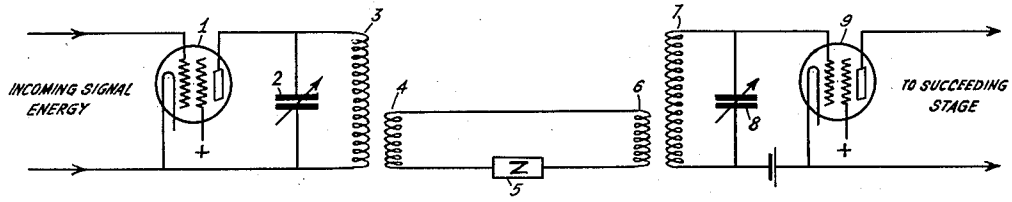


Fig. 2

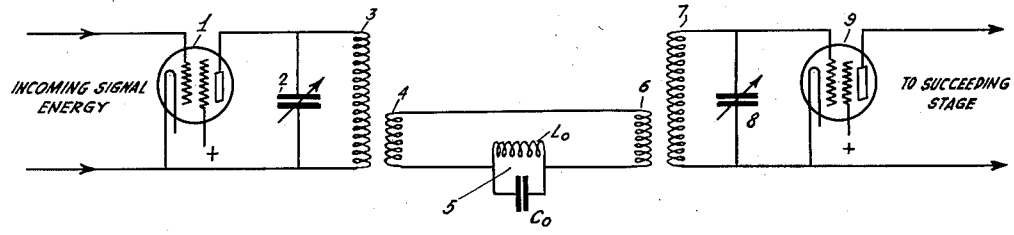


Fig. 3

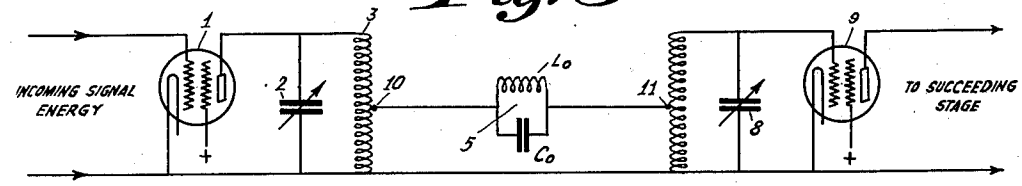
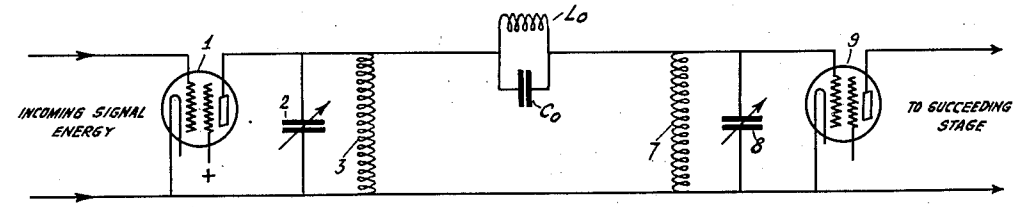


Fig. 4



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Fig. 5

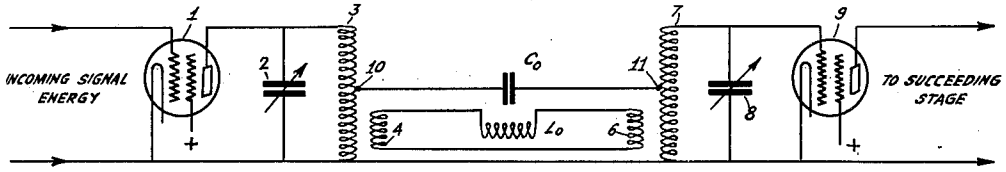


Fig. 6

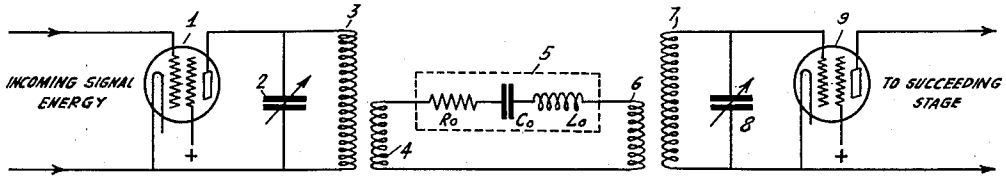


Fig. 7

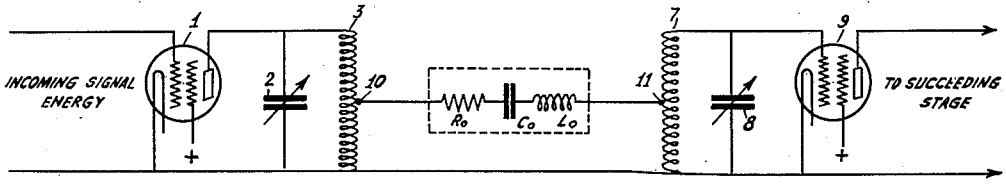
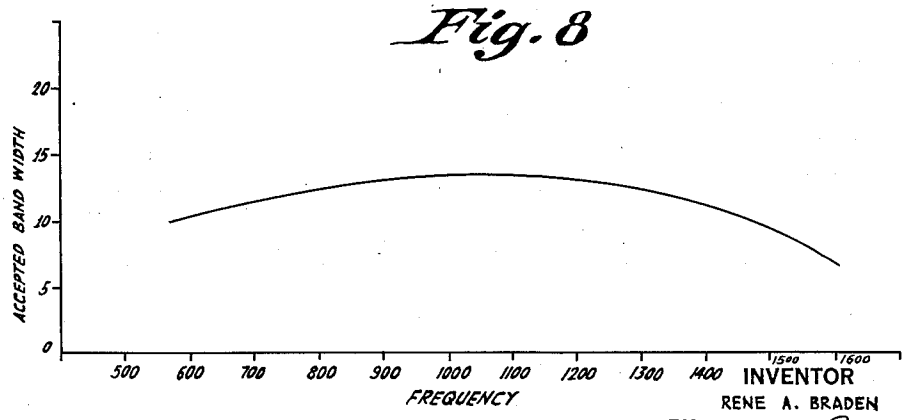


Fig. 8



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UNITED STATES PATENT OFFICE

2,055,996

BAND-PASS AMPLIFIER

Rene A. Braden, New York, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application September 5, 1929, Serial No. 390,468

3 Claims. (Cl. 178—44)

My present invention relates to amplifiers, and more particularly, to band-pass amplifiers, in which the accepted band width is maintained constant as the amplifier is tuned to various wave frequencies.

The operation of a band-pass amplifier circuit is well understood, it being known that the band-pass characteristic is secured by tuning the primary and secondary circuits to the mid-band frequency, and coupling them to a degree of closeness in the neighborhood of that value which is commonly termed "critical coupling". Constant band width is secured by causing the coupling between the tuned circuits of the amplifier to vary in a certain manner with wave frequency, and circuits for securing this result have already been disclosed, described and claimed in my copending application Serial No. 278,105 filed May 16, 1928. In the present application are disclosed, described and claimed novel amplifier circuits for securing results similar to those disclosed in my said co-pending application.

Accordingly, it is one of the main objects of my present invention to provide coupling means for band-pass amplifiers such that the accepted band width is maintained constant as the amplifier is tuned to various wave frequencies.

Another important object of the invention is to provide a coupling means for band-pass amplifiers, embodied in radio receivers employing two or more tuned coupled circuits in association with screen grid amplifying tubes in the radio frequency amplifier stages, the coupling means being also applicable to receivers employing three electrode tubes, to intermediate frequency amplifiers for superheterodyne receivers, and to the power amplifier stages of the antenna coupling of radio telephone transmitters.

Another important object of the invention is to provide an interstage amplifier coupling system producing a band-pass characteristic, consisting of the combination of a primary tuned circuit and a secondary tuned circuit, with an interposing linking circuit which couples the primary to the secondary circuit, the link circuit having a coil coupled to the primary circuit, a coil coupled to the secondary circuit, and a series net-work composed of resistance, inductance and capacity.

Still another object of the invention is to provide an interstage amplifier coupling system producing a band-pass characteristic, consisting of the combination of a primary tuned circuit, a secondary tuned circuit, and a coupling impedance connected from a point on the primary coil to a point on the secondary coil.

Other objects of the invention are to improve generally the simplicity and efficiency of band-pass amplifier coupling devices, and to provide a coupling device for this type of amplifier which is not only durable and reliable in operation, but economical to manufacture.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows schematically an amplifier circuit embodying the broad principle of the invention,

Figs. 2 to 7 inclusive, show specific modifications of the invention as disclosed in Fig. 1,

Fig. 8 is a graphic representation of the operation of a circuit of the type shown in Fig. 4.

Referring to the accompanying drawings in which like characters of reference indicate the same parts in the different figures, the circuit in Fig. 1 illustrates the principle of the coupling method herein disclosed, constant band width being obtained by coupling the tuned circuits in such a way that the coupling is proportional to the wave length, or approximately inversely proportional to the wave frequency. Referring more specifically to Fig. 1 the incoming signal energy is impressed across the input terminals of the vacuum tube 1, the tube preferably being of the screen grid type, the output circuit of the tube being tuned by the variable condenser 2 and the inductance 3.

A second vacuum tube 9, also of the screen grid type, has its input circuit tuned by means of a variable capacity 8 and inductance 7, the tuned output circuit of tube 1 and the tuned input circuit of tube 9 being coupled by means of a circuit consisting of an inductance coil 4 coupled to coil 3 and an inductance coil 6 coupled to coil 7. An

impedance 5, the electrical value of which is represented as Z, is shown connected in series with the coils 4 and 6 in Fig. 1, and possesses certain characteristics to be described in greater detail at a later point.

The two tuned circuits in Fig. 1, may not appear to be efficiently coupled, but actually this form of coupling is as efficient as the more usual inductive coupling methods, such as are described in the aforementioned co-pending application. I prefer to regard the tuned circuits as being coupled through the medium of two transformers, the coils 3 and 4 constituting a step-down transformer; the coils 6 and 7 a step-up transformer.

The output circuit of the first transformer 3, 4 would then be coupled to the input circuit of the second transformer 6, 7, with the impedance 5 in series to regulate the closeness of coupling. Should the electrical value of the impedance Z be made equal to zero, and the mutual inductance between coils 3 and 4 be assumed the same as that between coils 6 and 7, then the mutual inductance between coils 3 and 7 would be equal to one-half of the mutual inductance between coils 3 and 4, or between coils 6 and 7. With the impedance 5 in the coupling link, the coupling between coils 3 and 7 is reduced in proportion to the magnitude of the electrical value Z. The variable coupling required for constant band width, is secured, therefore, by causing the electrical value Z of the impedance 5 to vary with frequency in the required manner.

One way by which the principle illustrated in Fig. 1 may be applied, is shown in Fig. 2. In this latter figure, the parallel inductance and capacity, L_0 and C_0, are resonant at a frequency somewhat higher than the highest wave frequency to which the tuned circuits 2, 3 and 7, 8 are to be tuned. At this frequency the impedance of L_0, C_0, is very high, and the coupling between the primary and secondary tuned circuits is very low.

As the tuned circuits are tuned to lower wave frequencies the impedance of the net-work 5 diminishes, and the coupling increases. It is to be understood that the coupling can be made to vary with wave frequency at the proper rate to keep the band width substantially constant by properly choosing the component parts of coupling circuit 4, 5, and 6.

In the amplifier circuit shown in Fig. 2, as in Fig. 1, the incoming signal energy is impressed across the input circuit of the screen grid tube 1, the amplified output of the screen grid tube 9 being impressed across the input circuit of the succeeding stage and utilized in any manner well known to those skilled in the art.

Fig. 3 shows a modification of the circuit of Fig. 2, in which the coils 4 and 6 of the coupling link circuit are omitted, and the impedance 5 is connected to the taps 10 and 11 on the inductance coils 3 and 7, respectively. The output circuit of the screen grid tube 1, in this figure, is tuned as in the case of Figs. 1 and 2 by the variable capacity 2, the input circuit of the screen grid tube 9 being tuned by the variable capacity 8. The impedance network 5 comprises the same elements as the impedance net-work in Fig. 2, but as stated above, the terminals of the impedance are connected directly to the coils 3 and 7 of the two tuned circuits.

A further modification of the circuits shown in Figs. 2 and 3 is illustrated in Fig. 4, the circuit being the same as the circuit in Fig. 3, except for the fact that the terminals of the coupling impedance 5, consisting of the inductance L_0 in shunt with the capacity C_0, are connected to the high potential ends of the coils 3 and 7 of the two tuned circuits.

In Fig. 5, I have shown a combination of the circuits of Figs. 2 and 3, the inductance L_0 being connected in a coupling link including the coils 4 and 6, as in Fig. 2, while the capacity C_0 is connected to taps 10 and 11 on the coils 3 and 7, as in Fig. 3. Thus, coils 3 and 4 are inductively coupled and coils 6 and 7 are likewise coupled, it being noted that the inductance L_0 is in series with the coils 4 and 6. The amplifier circuit in Fig. 5 is otherwise the same as the circuit shown in Figs. 2 or 3.

An application of the principle illustrated in Fig. 1, in which the impedance 5 consists of a series connection of a resistance R_0, a capacity C_0 and inductance L_0 is shown in Fig. 6. As in Fig. 1 the coupling circuit includes the coils 4 and 6, the impedance 5 consisting of the resistance, capacity and inductance in series as shown in Fig. 6. The impedance 5 is so adjusted that the whole coupling link 4, 5, and 6 is resonant at a frequency below the lowest frequency to which the primary and secondary tuned circuits are adapted to be tuned. The coupling is then a maximum at the low frequency limit of the receiver, and decreases with increasing frequency, keeping the accepted band width substantially constant.

A modification of the amplifier circuit of the Fig. 6, is shown in Fig. 7, the terminals of the coupling circuit impedance net-work 5, being connected directly to points 10 and 11 on the two inductance coils 3 and 7. As in Fig. 6, the impedance network consists of resistance R_0, capacity C_0 and inductance L_0 in series. It will be observed that the manner of connecting the impedance net-work between the coils 3 and 7 is similar to the manner in which the impedance 5 is connected in Fig. 3.

It is not to be inferred that the resistance R_0 is essential to the operation of the circuit. In some cases it is necessary to reduce the resistance of the link circuit to the lowest possible value, and then R_0 represents the resistances of the coils 4 and 6, and the connecting wires.

I have graphically shown in Fig. 8 the variation of accepted band width at various wave frequencies for a circuit of the type shown in Fig. 4. The curve was derived by employing the following circuit constants:

Coils 3 and $7 = 2 \times 10^{-4}$ henries
Inductance coil $L_0 = .01$ henry
Capacity $C_0 = .77 \times 10^{-12}$ farads

It will be observed from the curve that constant band width is substantially secured by coupling the tuned circuits in such a manner that the coupling is proportional to the wave length or approximately inversely proportional to the wave frequency.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications in the circuit arrangements, as well as in the apparatus employed, may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. A band selective transmission network comprising a pair of syntonous tuned circuits, each including an inductance, means for varying the tuning of said circuits, a connection between the

low potential points of said inductances, a coupling impedance connected between high potential points on each of said inductances, and a link circuit consisting of the series combination of two coils coupled respectively to the tuned circuit inductances and an additional coil.

2. An interstage amplifier coupling system adapted to produce a band-pass characteristic consisting of a first tube, a primary tuned circuit connected to said tube output, a second tube, a secondary tuned circuit connected to the input of said second tube, a condenser connected between intermediate points on the primary and secondary coils, and a link circuit consisting of the series combination of two coils coupled respectively to the primary and secondary circuits, and an additional inductance coil.

3. A band selective transmission network comprising a pair of syntonous tuned circuits, each including an inductance, means for varying the tuning of said circuits, a coupling capacity connected between intermediate points on said circuit inductances, a pair of coils, each inductively coupled to one of the tuned circuit inductances, and a third coil serially connected to said pair of coils.

RENE A. BRADEN.