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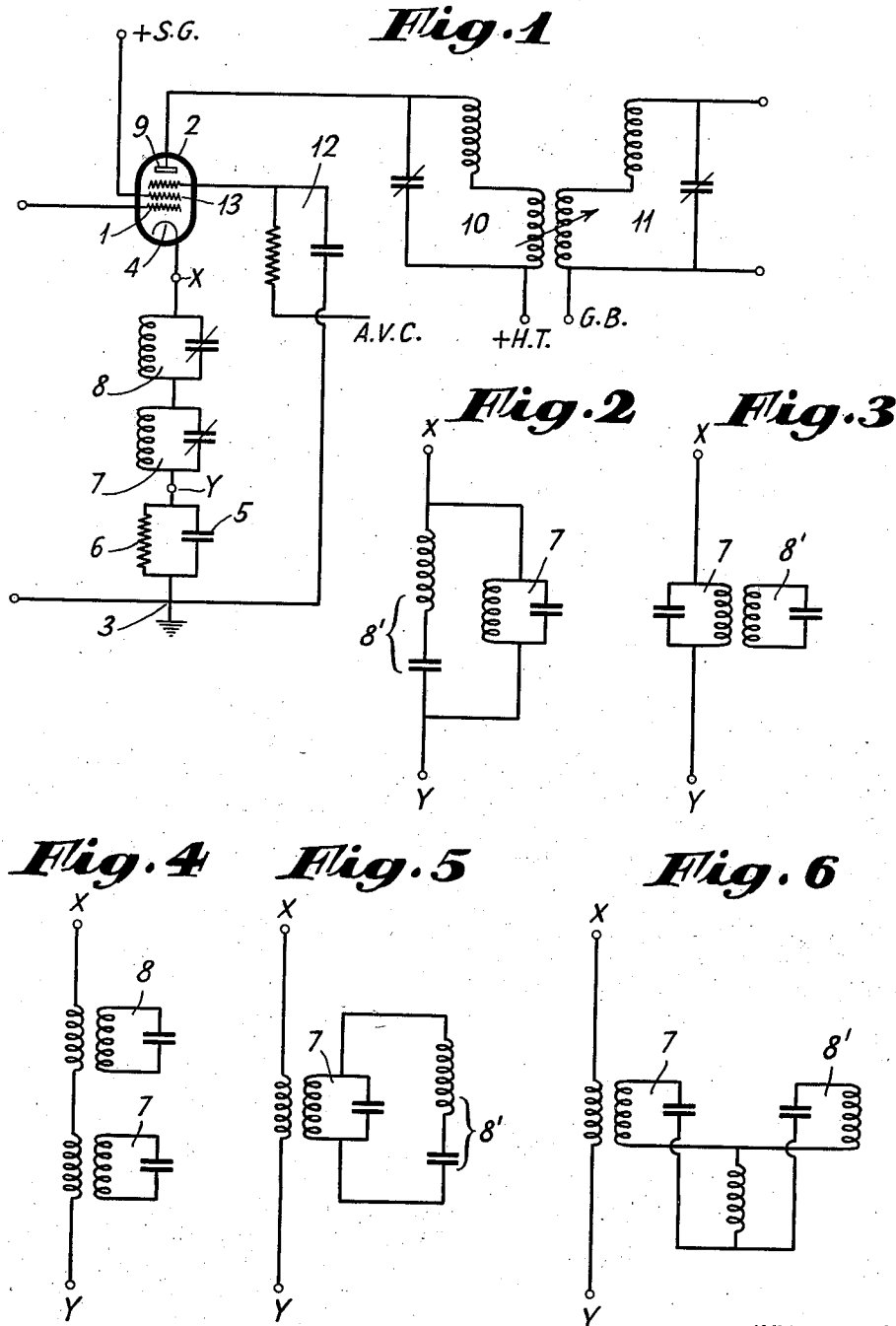
N. M. RUST ET AL

2,210,384

ELECTRICAL FILTER ARRANGEMENT

Filed Feb. 19, 1938

2 Sheets-Sheet 1



INVENTORS
NOEL M. RUST
JOSEPH D. BRAILSFORD
BY *H. S. Swer*
ATTORNEY

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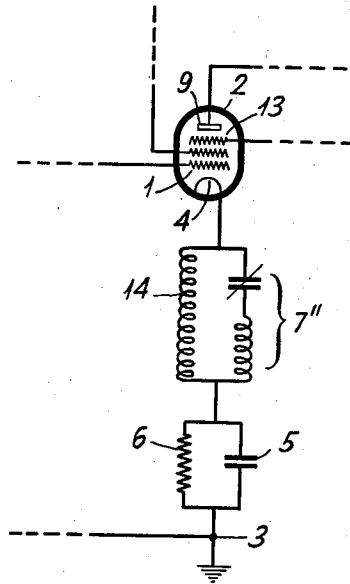


Fig. 7

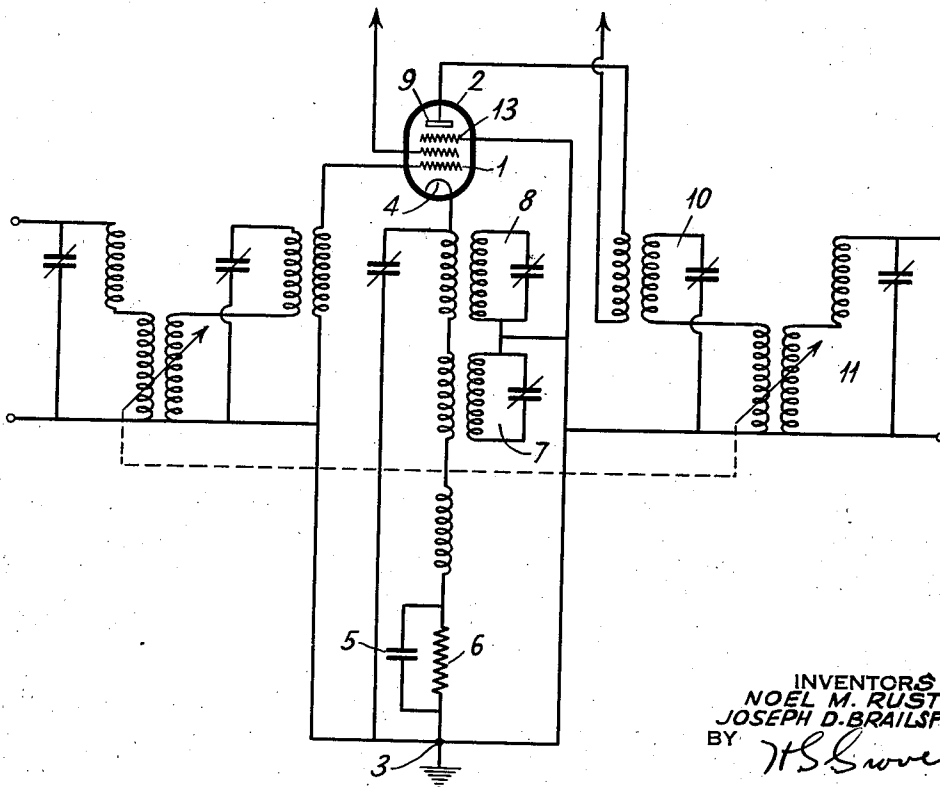


Fig. 8

INVENTORS
NOEL M. RUST
JOSEPH D. BRAILSFORD
BY *J. H. S. over*
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRICAL FILTER ARRANGEMENT

Noël Meyer Rust, Chelmsford, and Joseph Douglas Brailsford, London, England, assignors to Radio Corporation of America, a corporation of Delaware

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2 Claims. (Cl. 179-171)

This invention relates to electrical filter arrangements and has for its object to provide improved filter arrangements of the band pass type adapted to give band pass characteristics with good flat "tops" and steep sharp "cut off" sides.

An important though not exclusive application of the invention is to radio receivers and more particularly to the intermediate frequency stages of superheterodyne receivers for broadcast reception where, as is known, band pass characteristics of "flat tops" and sharp "cut offs" are required.

It is common practice to use, for example in an intermediate frequency stage of a superheterodyne receiver, a band pass filter consisting essentially of two tuned circuits closely coupled together (constituting an over-coupled tuned transformer) one being connected in the anode circuit of one valve and the other in the grid circuit of the next, these circuits (which are intermediate frequency circuits) being arranged in well known manner to produce a band response. If in a known commonly employed band pass circuit of this type, it is sought to increase the sharpness of cut off by reducing damping in the whole circuit by using coils of very low ohmic resistance and high inductance, there is the difficulty that the characteristic curve becomes more and more of the familiar "double humped" type, and this is undesirable for obvious reasons.

According to this invention an improved band pass filter effect is obtained by employing in combination with a band pass filter, a valve which is subjected to frequency selective negative feed back in such manner that the amount of said feed back is small or approximates to zero at or near the middle of the desired pass range, but increases at and near the ends of the said pass range so as to reduce the over-all gain at these parts of the frequency spectrum. Preferably the band pass filter is of the type including a variable coupling between two parts thereof, so that by varying this coupling the width of band passed can be adjusted to obtain variable selectivity. Preferably also the valve which is subjected to negative feed back is the valve which feeds into and immediately precedes the band pass filter and the negative feed back is obtained by means of tuned circuits in the cathode leg of said valve or by means of tuned transformers connected in series.

An important feature of this invention is that the application of negative feed back can be utilized both to secure very sharp cut off effects and

also to level the response within the pass range, thus enabling coils of low loss (high "Q") which can incidentally be of high inductance and low capacity (thus improving efficiency) to be used in the filter without producing the "double humped" characteristic effects which would result from the use of such coils, were negative feed back not applied. It is possible so to arrange matters that the rate of change of response due to the cathode circuit considered as acting alone is (in the pass band) substantially equal and opposite to the rate of change of response due to an overcoupled transformer in the band pass filter (considered as acting alone) with the result that a substantially perfectly level overall response is obtained within the pass band.

The invention is illustrated in the accompanying diagrammatic drawings, wherein Fig. 1 is an intermediate frequency stage of a superheterodyne receiver embodying the present invention, Figs. 2 to 7 are alternative forms of cathode circuits capable of being substituted for the circuit between the points X-Y of Fig. 1 and Fig. 8 is a further modification of the invention.

Referring to Figure 1, intermediate frequency input is applied between the control grid 1 of a normally provided intermediate frequency valve, for example a pentode 2, and an earthed point 3 which is connected to the cathode 4 of said valve through the normally provided capacity shunted self-bias resistance 5, 6, in series with two parallel tuned circuits 7, 8, which are in series with one another. For example, if the predetermined mid-frequency of the intermediate frequency pass range is to be 450 k. c. one of these parallel tuned circuits (7 say), may be resonant at 461 k. c. and the other may be resonant at 439 k. c. The anode 9 of the valve feeds into a parallel tuned circuit 10 the whole or a portion (usually a relatively small portion) of the inductance in which is coupled to a similar portion of the inductance in a further parallel tuned circuit 11 in the input circuit of the next valve (not shown) of the receiver. The two tuned circuits 10, 11, which are thus coupled together, constitute a band pass filter as known per se, and these two circuits may be "over-coupled" and include coils of high inductance and low resistance and capacity so that, were the present invention not applied, a band pass characteristic having pronounced humps in the neighbourhood of 456 k. c. and 444 k. c. would be obtained. By reason of the fact, however, that in accordance with this invention the two series connect-

ed parallel tuned circuits 7, 8, are included in the cathode lead of the valve which feeds into the band pass filter, the double humped effect is avoided and also the sharpness of cut off increased. This is because the said tuned circuits 7, 8, introduce negative feed back to an extent which is quite low at the middle of the intermediate frequency pass band, which increases sufficiently to "pull down" the "humps" at the ends of said pass band, increasing to maxima just outside the pass band at the frequencies to which the cathode circuits are resonant (in the example given 461 k. c. and 439 k. c.) thus producing rapid cut off.

Preferably the coupling between the two tuned circuits 10, 11, forming part of the band pass filter proper, is variable, and it is found that by varying this coupling the width of band pass may be adjustable while still retaining a substantially flat top and steep sides to the characteristic. The tighter the coupling the greater the width of band passed. As the coupling is made looser the heights of the sides of the band pass characteristic curve increases, but the steepness remains approximately constant. The variable coupling, therefore, provides a very satisfactory form of variable selectivity. At maximum coupling "high fidelity" conditions are fulfilled, while at looser couplings, the negative feed back action increases the attenuation in the cut off region relative to the mid-band frequency.

Automatic volume control can, if desired, readily be applied to the valve 2, as shown in Figure 1, by applying automatic gain control bias through resistance 12 to the suppressor grid 13 of the said valve 2. With the A. V. C. circuit shown in Figure 1 the anode current is controlled but the cathode current remains substantially constant. This method of A. V. C. should, however, be used with discretion where the valve 2 is a pentode for with the at present commercially available pentodes the anode-cathode impedance of the valve drops as the suppressor grid is biased back. Therefore, as will be seen, as soon as the valve impedance drops to some value comparable to the external anode circuit impedance the valve provides a direct conducting path coupling the anode circuit to the cathode circuit and therefore the voltage across the cathode circuit is applied via the valve impedance to the anode circuit. For this reason, therefore, the A. V. C. circuit of Figure 1 should be employed only when this type of coupling can be regarded as negligible.

In Figure 1 what may be termed the negative feed-back impedance in the cathode leg of the valve 2 consists of the two tuned circuits 7, 8, in series. The invention is, however, not limited to this for other forms of negative feed back impedance can be substituted, if desired, for the impedance consisting of circuits 7, 8. Thus the networks of Figure 2 and 3 may be used between the terminals marked XY in Figure 1 in place of the circuits 7, 8. Figures 2 and 3 are practically self-explanatory it being necessary only to state that in Figure 2 a series tuned circuit 8' in parallel with circuit 7 is substituted for a parallel tuned circuit in series therewith. The negative feed back impedance need not be directly in the cathode leg but may be transformer coupled thereto. Thus Figures 4, 5, and 6 show transformer coupled arrangements respectively equivalent to the impedance arrangements of Figures 1, 2 and 3 respectively.

Again, it is not necessary to use multiple tuned negative feed back impedances. Thus, for exam-

ple, Figure 7 shows a cathode-(4)-earth circuit which can be substituted for that shown in Figure 1, the series tuned circuit 7' being resonant at or very close to the intermediate frequency. 14 is a choke for preserving the continuity of the cathode leg as respects direct current.

With a circuit as shown in Figure 4 the mutual couplings may throw undesirable reactance components into the cathode circuit but, if desired, these may be balanced out by providing an additional series inductance in the lead between X and Y and/or by providing a suitable shunt condenser between these points. The series inductance is for the purpose of ensuring that the series resonance of the whole cathode circuit comes mid-way between the two parallel resonances while the shunt condenser affects the symmetry of the two parallel resonant conditions.

Figure 8 shows a complete circuit for variable selectivity. In view of the description already given this figure will, it is thought, be found self-explanatory. The gang control of the selectivity of the input and output band pass filters for valve 2 will be noted.

It may be shown that if the internal impedance of the valve 2 is high in comparison with its external anode impedance—as is certainly the case when the valve 2 is a pentode—and if the negative feed back impedance is of the type shown in Figures 1, 3, 4, 6, or 8 (i. e., including two tuned circuits which offer high impedance at resonance and are resonant respectively on opposite sides of the carrier at about the limits of the modulation band desired, which, for the intermediate frequency portion of a broadcast receiver may be taken as the intermediate frequency ± 9 k. c.), the effect of altering the mutual conductance of valve 2 (e. g., for automatic gain control) will not only be to alter the gain but also to alter the selectivity, for it may be shown that the frequency-attenuation characteristics of the tuned circuits in the cathode leg depend, in the circumstances above stated, on the mutual conductance of the valve. Thus, if the gain of the valve 2 of Figure 1 is increased the selectivity of the circuit is also increased and by suitably selecting the circuit constants an excellent combined automatic gain—automatic selectivity control can be obtained by deriving a uni-directional potential proportional to received signal strength and applying it as gain control to valve 2, the result being simultaneously to increase (or decrease) gain and selectivity.

The invention is applicable not only to broadcast receivers but also to receivers for commercial purposes and which are required to receive radio telephony and telegraphy under varying conditions of reception. For such commercial receivers the provision of variable coupling in the band pass filter is a great advantage since the characteristic obtainable with a loose coupling should greatly facilitate telegraphy reception whilst by tightening the coupling, the band width can readily be increased to give the maximum quality of telephony which reception conditions will, at any given time, permit.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed we declare that what we claim is:

1. In a superheterodyne receiving circuit, an intermediate frequency amplifier comprising a vacuum tube and a band pass filter coupled thereto, said filter comprising a pair of variably coupled tuned circuits resonant to the intermediate

frequency and resulting when closely coupled in a double humped characteristic curve, and means for compensating for said uneven response whereby a substantially level resultant response is produced, said means comprising a pair of tuned circuits effectively serially connected to the cathode and included in both the input and output circuits of said tube, said pair of tuned circuits being resonant respectively at or near the lower and upper hump frequencies and providing a negative feed back at those frequencies which is more pronounced at those frequencies than at the other frequencies of the range passed by the filter.

2. In a superheterodyne receiving circuit, an intermediate frequency amplifier comprising a vacuum tube, a first band pass filter coupled to the input of said tube, a second band pass filter coupled to the output of said tube, each filter

comprising a pair of variably coupled tuned circuits resonant to the intermediate frequency and resulting when closely coupled in a double humped characteristic curve, and means for compensating for said uneven response whereby a substantially level resultant response is produced, said means comprising a pair of tuned circuits effectively serially connected to the cathode and included in both the input and output circuits of said tube, said pair of tuned circuits being resonant respectively at or near the lower and upper hump frequencies and providing a negative feed back at those frequencies which is more pronounced at those frequencies than at the other frequencies of the range passed by the filter, and common means for varying the coupling of the first and second band pass filters.

NOËL MEYER RUST.

JOSEPH DOUGLAS BRAILSFORD.