April 26, 1938. T. J. WEYERS 2,115,377

INTERMEDIATE FREQUENCY AMPLIFIER

Filed June 15, 1935

Fig. 1

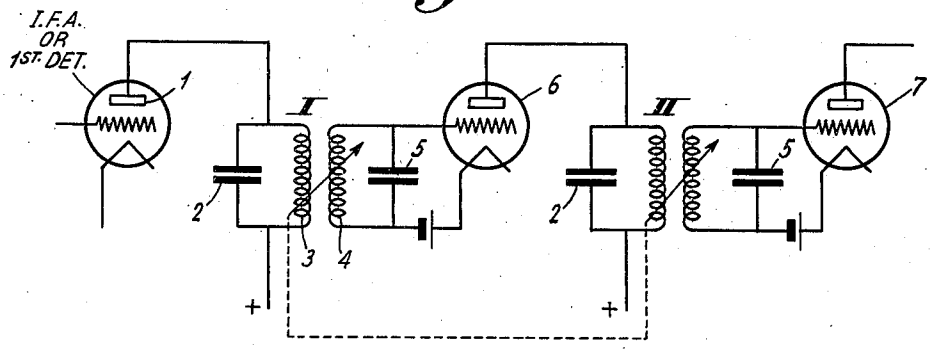


Fig. 2

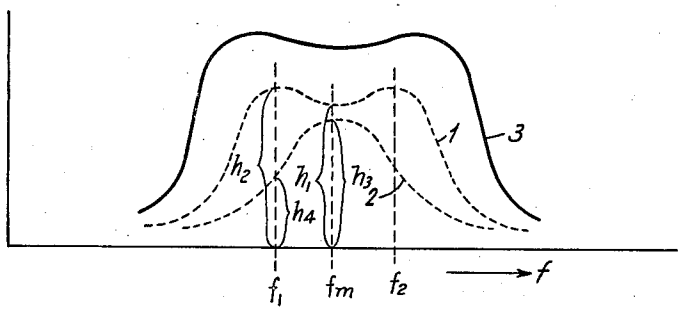
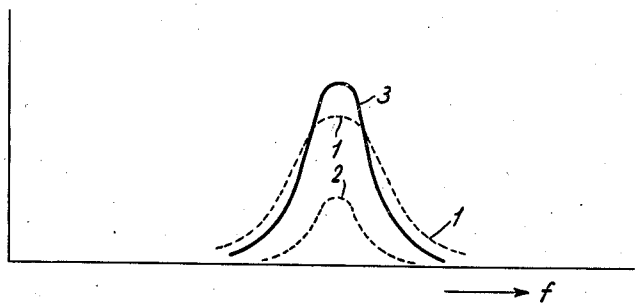


Fig. 3



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Patented Apr. 26, 1938 2,115,377

UNITED STATES PATENT OFFICE

2,115,377

INTERMEDIATE-FREQUENCY AMPLIFIER

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Application June 15, 1935, Serial No. 26,772
In Germany June 18, 1934

4 Claims. (Cl. 179—171)

The invention relates to a circuit arrangement for intermediate-frequency amplifiers such as they are employed in superheterodyne receiving apparatus.

In such amplifiers the successive amplification stages are usually coupled to one another by means of band filters which have such frequency characteristic curves that, dependent upon the side-band frequencies of the intermediate-frequency carrier wave, a determined band of frequencies is almost uniformly transmitted and that all the frequencies located above and below said band are suppressed. As, however, the damping of the usual band filters does not increase rapidly enough at the limits of the transmitted band the selectivity of the intermediate-frequency amplifier is often insufficient which results in disturbances in the reception of a weak transmitter due to neighboring strong transmitters. In order to remove these drawbacks it has previously been proposed to render the width of the band of the band-filter adjustable in such manner that in the reception of a weak transmitter the width of the band of frequencies which are almost uniformly transmitted, is reduced.

According to the invention an improved intermediate-frequency amplifier with which the width of the band of frequencies is transmitted with almost uniform amplification may be obtained by coupling two or more amplification stages by means of transformers tuned on both the primary and the secondary side. In this case the coupling between the windings may be adjusted in such manner that with the tightest adjustment of the coupling the windings of one transformer are over-critically coupled and are slightly damped and the windings of another transformer are critically coupled and are strongly damped, whereas with the loosest adjustment of the coupling the first-mentioned transformer windings are critically and the last-mentioned transformer windings are less than critically coupled.

The invention will be explained more fully with reference to the accompanying drawing in which Figure 1 represents, by way of example, a circuit arrangement according to the invention, and Figures 2 and 3 represent resonance curves to help explain the circuit of Figure 1.

In Fig. 1 of the drawing, the anode 1 of an intermediate-frequency amplifying tube or of the first detector is connected to the primary winding 3 of an intermediate-frequency transformer I whose secondary winding 4 is located in the control grid circuit of an intermediate-frequency amplifying tube 6. Both windings are tuned by means of condensers 2 and 5. The tube 6 is connected in a similar manner by means of a transformer II having tuned primary and secondary to a following intermediate-frequency amplifying tube or to a rectifier or second detector 7.

The coupling between the windings of both transformers is adjustable in unison as indicated by the arrows and the dotted line joining them and, in accordance with the invention, it is so chosen that with the tightest adjustment of the coupling the windings of transformer I are over-critically coupled and are slightly damped whereas the windings of transformer II are critically coupled and are strongly damped. By "critical coupling" it is to be understood to mean any coupling with which the resonance curve just does not yet show a sag. Under these conditions the course of the resonance curves of the tuned transformers I and II may be represented by the curves 1 and 2 respectively in Figure 2, so that the resonance curve of the amplifier takes the shape of curve 3. Furthermore, according to the invention, with the loosest adjustment of the coupling of the windings of transformers I and II the former transformer windings are critically coupled and the latter are less than critically coupled. The resonance curves have in this case the shape shown in Figure 3.

When the coupling is altered from the state in which it is tightest into the state in which it is loosest, the resonance curve 3 of Figure 2 gradually changes into the resonance curve 3 of Figure 3, which is attended with an increase of the selectivity of the amplifier.

In the case of disturbances in the reception of a weak transmitter due to interference by neighboring transmitters, these disturbances can be suppressed by loosening the coupling between the windings of the transformers I and II.

As the windings of transformer I are only slightly damped and are over-critically coupled, the ratio between the voltage across the secondary winding and the voltage across the primary winding increases the more, the looser the coupling is made. On the other hand, the windings of transformer II are strongly damped and are less than critically coupled so that with a loosening of the coupling the ratio of the voltage across the secondary winding to the voltage across the primary winding decreases. The adequate choice of the dampings and couplings allows of obtaining in this case a mutual neutralization of the variations of the voltage transmission of both transformers so that when the coupling varies the

total amplification of the intermediate-frequency amplifier remains substantially constant. In other words, the coupling of the transformer I changes between over-critical and critical coupling, so that this coupling is over-critical over the whole control range except for the loosest coupling obtainable. The coupling of the transformer II changes between critical and under-critical coupling, so that this transformer is under-critically coupled over the whole control range except for the tightest coupling obtainable. Therefore the voltage ratio between the secondary and the primary windings increases for transformer I, and decreases for transformer II as the coupling is loosened, so that a constant amplification over the whole control range may be obtained. It is to be understood that the expression "damping of the tuned circuits" as it is used herein is defined as the ratio of

$$\frac{r}{wL}$$

r being the total resistance; w, the resonant frequency; and L the inductance of the tuned circuit under consideration. By total resistance r is not only meant the resistance of the tuned circuit itself but also the parallel resistance formed by the internal resistance of the tube to which the circuit is connected. As to the tuned circuits forming the over-critically coupled band filter indicated by I in Fig. 1, the ratio

$$\alpha=\frac{r}{wL}$$

is made as small as can be realized in practice with the usual coils, condensers and amplifier tubes, so that a humped resonance curve is obtained as shown at 1 in Fig. 2. From this resonance curve the amplitude h_1 at the mid-frequency f_m and the amplitude h_2 at the peak frequencies f_1 and f_2 can be derived.

The tuned circuits forming the band filter II are critically coupled so that the resonance curve of this band filter will have the form shown by the curve 2 in Fig. 2. (It is to be understood that the several resonance curves illustrate merely their shape and are not drawn to scale.) The damping of the circuits should be so chosen that the amplitudes h_3 and h_4 at the frequencies f_m and f_1, f_2 fulfill the condition $h_1 h_3=h_2 h_4$ or

$$\frac{h_3}{h_4}=\frac{h_2}{h_1}$$

As

$$\frac{h_2}{h_1}$$

can be derived from the resonance curve 1 in Fig. 2, the ratio

$$\frac{h_3}{h_4}$$

and therefrom the damping of the tuned circuits can be determined. In a practical example good results were obtained with the following values

$$f_m=115Kc,\ f_1=106Kc,\ f_2=124Kc$$

$$\alpha_1=0.03\ \alpha_2=0.025\ \alpha_3=\alpha_4=0.065$$

The damping necessary in the second pair of tuned circuits can easily be obtained by proper choice of the wire of which the coils are wound or by means of additional resistances in series or parallel to the circuits.

What I claim is:

1. An intermediate-frequency amplifier comprising a plurality of tubes, a first pair of adjustably-coupled tuned circuits connected between successive tubes, a second pair of adjustably-coupled tuned circuits connected between successive tubes, characterized in that with the tightest adjustment of the coupling, one pair of tuned circuits is over-critically coupled and is slightly damped and the other pair of tuned circuits is critically coupled and is strongly damped, whereas, with the loosest adjustment of the coupling, the first-mentioned pair of tuned circuits is critically coupled and the last-mentioned pair is less than critically coupled, and further characterized in that means are provided for effecting the coupling adjustments of the two pairs of coupled circuits in unison whereby constant amplification over the whole control range is obtained.

2. A circuit arrangement comprising a pair of fixedly tuned but variably coupled circuits interconnected between a pair of vacuum tube amplifiers, a second pair of fixedly tuned but variably coupled circuits interconnected between a pair of vacuum tube amplifiers, and means for varying the coupling between the respective pairs of tuned circuits in unison such that for one adjustment one of said pair of tuned circuits is over-critically coupled and the other is critically coupled and for another adjustment the former pair of circuits is critically coupled and the latter pair is less than critically coupled.

3. A system for the transmission of a band of frequencies with substantially uniform amplification comprising a first pair of tuned coupled circuits, means for varying the coupling between said circuits through a range from over-critical coupling to critical coupling, a second pair of similarly tuned coupled circuits, means for varying the coupling between said second pair of circuits through a range from critical coupling to less than critical coupling, and means to simultaneously vary said coupling means through their respective ranges.

4. The method of controlling the selectivity of an amplifier provided with two pairs of similarly-tuned coupled circuits which consists in over-critically coupling one pair of said circuits and simultaneously critically coupling the other pair whereby the net result of the amplifier is to transmit a comparatively wide band of frequencies, and then critically coupling the first pair of circuits and simultaneously coupling the second pair to less than critical whereby the net result of the amplifier is to transmit a comparatively narrow band of frequencies.

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