March 22, 1932. F. K. VREELAND 1,850,973

BAND RECEIVING SYSTEM

Original Filed Aug. 1, 1927 2 Sheets-Sheet 1

Fig. 1.

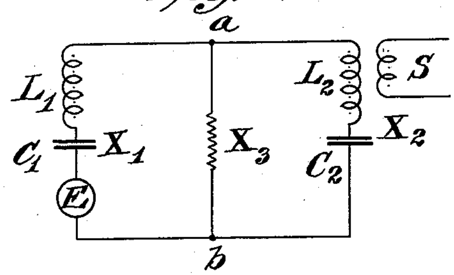


Fig. 2.

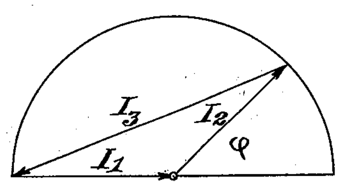


Fig. 3.

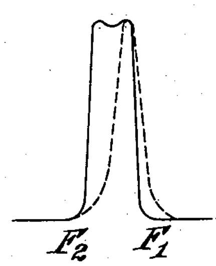
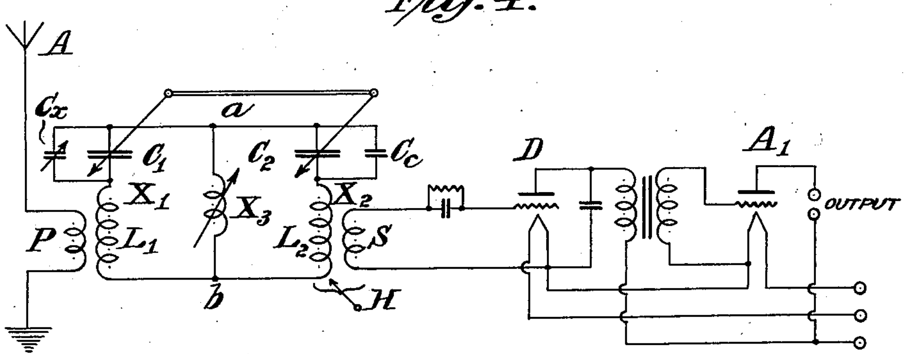


Fig. 4.



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Original Filed Aug. 1, 1927 2 Sheets-Sheet 2

Fig. 5.

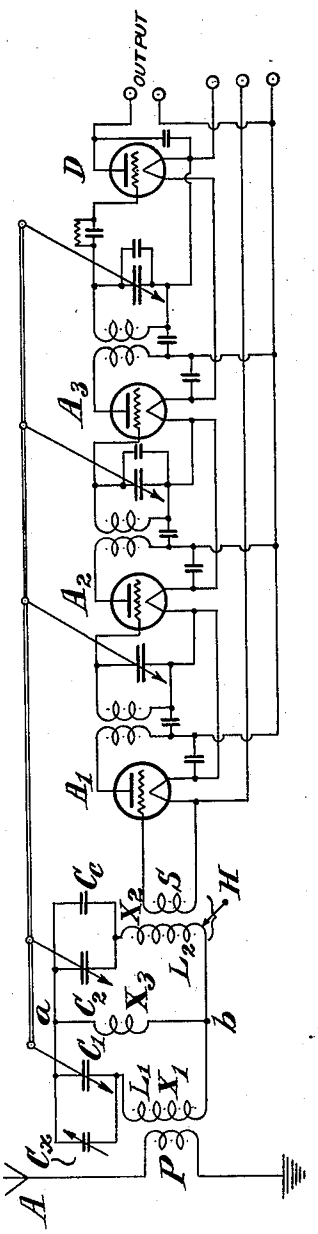
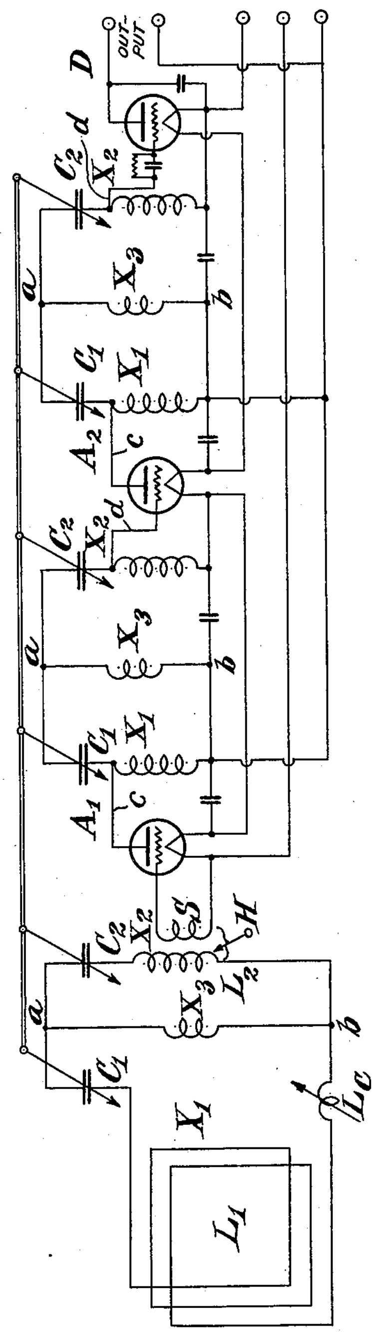


Fig. 6.



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Patented Mar. 22, 1932 **1,850,973**

UNITED STATES PATENT OFFICE

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BAND RECEIVING SYSTEM

Original application filed August 1, 1927, Serial No. 209,650. Patent No. 1,725,433, dated August 20, 1929. Divided and this application filed July 11, 1929. Serial No. 377,409.

This application is a division of application Serial No. 209,650, filed August 1, 1927, on which Letters Patent No. 1,725,433 issued August 20, 1929.

The invention herein described relates to a system of receiving alternating currents including a band of frequencies, particularly such a band of frequencies as comprise the transmission band of a modulated signal wave.

The general purpose of the invention is to receive the component frequencies of such a band with such uniformity as to avoid material distortion of the modulated wave, and to exclude frequencies outside of the band which the system is designed to receive. Another purpose of the invention is to provide means for shifting the position of the band in the frequency scale at will, by a simple adjustment, so that the system may be readily adapted to receive modulated waves of any desired carrier frequency, including the side bands of such modulated waves. Still another purpose is to secure the band characteristic in a single unit of a receiving or amplifying system, such unit giving substantially uniform reception for all frequencies within the band for which it is designed, with a sharp cut-off for frequencies outside the desired band, thereby securing in a single unit of the system a high degree of selectivity without distortion of the modulated signal wave. In one embodiment of the invention the band selector unit is combined with an antenna or other collector, and a compensating reactance is employed to compensate the indeterminate reactance introduced by the collector and preserve the necessary symmetry of the system. Other features of the invention relate to the combination of a plurality of such units, each having a band characteristic, in a receiving and amplifying system, giving a high degree of amplification over a band of frequencies with a high selectivity or power of excluding frequencies outside the desired band. Other desirable features of the invention are explained at length. The application of which this application is a division has been restricted to the band selector as a unit while the claims of this divisional application are directed to the combination of such a band selector with other elements of a receiving system.

When selectivity, or the power of separating a signal wave of one carrier frequency from undesired waves of different carrier frequencies, is accomplished by the usual method employing a tuned circuit or circuits, the frequency characteristic of the receiver is essentially peaked, since there is only one frequency at which the capacity and inductance reactances of the circuits are balanced. At any other frequency there will be an unbalanced reactance in the system which cuts down the response to such frequency. In receiving a modulated wave, comprising a band of frequencies, such a system will receive one frequency of the band effectively, and the other frequencies of the band less effectively or not at all, with resulting signal distortion.

In the case where a plurality of synchronously tuned circuits are employed in cascade, selectivity is increased since the amplification at peak frequency is increased in geometric ratio and the amplification at any other frequency is increased in a much smaller ratio, but this selectivity is necessarily secured at the expense of tone quality, since the side bands are relatively reduced according to the same law. It has been proposed to improve the reception of side bands by introducing damping into the synchronously tuned circuits, but this only results in partial mitigation of the distortion and this mitigation is gained at the expense of selectivity.

In my Patents Nos. 1,666,518, April 17, 1928, 1,682,874, September 4, 1928, and 1,730,987, October 8, 1929, I have described means whereby substantially uniform reception is obtained at all frequencies included in the band of a modulated wave the means specifically claimed in these patents being the use of successive stages of amplification having different frequency characteristics, and in combination producing a band characteristic.

By means of the present invention I am able to secure a similar uniform band characteristic in a single selector unit comprising a system of reactances so related to each other that they are mutually balanced, not merely at a single frequency, as in the case of the ordinary tuned circuit, but at a plurality of frequencies included in a limited band. At any frequency outside of this band the reactances are not balanced. As a result of this property, the selector unit responds with substantial equality to all the frequencies within its characteristic band, and is non-responsive to frequencies outside this band. When the system is suitably constructed, as hereinafter described, the cut-off at the limits of the band is exceedingly sharp. By the use of such a selector unit I am able to secure distortionless reception of the entire band of frequencies included in a modulated wave, and effectively eliminate the frequencies of interfering waves. Because of the sharp cut-off this uniform band reception is accomplished without any loss of selectivity. Comparing the frequency characteristic of my selector unit with that of a pair of selective circuits tuned by resonance it is found that the broadening of the band over the effective frequency range is accomplished without any increase of the width of the curve at its base, which determines the selectivity of the system.

Any number of my band selector units may be employed in cascade. In one arrangement that is especially effective they may be used for example as coupling units in a multi-stage amplifier, thus securing increased signal strength and increased selectivity without impairing the uniformity of the band reception and hence without the increased distortion by trimming the side bands which necessarily occurs when geometric tuning is employed.

The construction of my band selector is so simple, and the means for compensating indeterminate reactances so effective, that complete symmetry or similarity may be readily secured in the several component circuit elements, so that common control means may be effectively applied to the frequency adjustment.

These features are illustrated and the apparatus employed is fully explained in the accompanying drawings and in the following description. In the drawings:

Figure 1 represents schematically one of my band selector units, in generalized form.

Figure 2 is a vector diagram showing the relation of the currents in the various parts of the system of Figure 1.

Figure 3 is a typical curve representing the frequency characteristic of one of my band selector units. It shows also for comparison a frequency characteristic of an ordinary tuned circuit.

Figure 4 shows a radio receiving system embodying one of my band selector units associated with an antenna or collecting circuit on the one hand and an aperiodic amplifying and detecting system on the other.

Figure 5 shows a band selector unit employed as a preliminary selector or pre-selector with a band amplifier.

Figure 6 shows a radio receiving system embodying a plurality of my band selector units, one being associated with a collector as in Figure 4 and the others being employed as coupling units in a multi-stage radio frequency amplifier.

Figure 1 shows one of my band selector units in generalized form. It employs two reactive couples X_1 X_2, each comprising capacity and inductance reactances C_1 L_1 and C_2 L_2 which are preferably balanced at the same frequency and partially balanced at all the frequencies included in the band, combined with a third reactance X_3, which is shared in common by the two reactive couples and completes the balance of the reactances. This third reactance is small in relation to the reactances of the two reactive couples. It serves as a band forming reactance tending to balance the unbalanced portions of the two reactive units and renders the system responsive with substantial equality to all frequencies within a band whose width depends upon the relative values of the band forming reactance and the other reactances. For frequencies outside of this band, whether higher or lower than the frequencies included within the band, the unbalanced portions of the reactances of the two reactive couples become greater or less than the effective reactance of X_3, which is hence unable to balance them so that the system as a whole has an over-all reactance which prevents its transmission of currents of such frequencies outside the band. The reactance X_3 may be untuned and either an inductance, a capacitance, or a mutual inductance, Figure 1 showing the reactance in generalized symbolic form.

In using my band selector unit as a frequency selector the impressed electro-motive force may be applied in any suitable way, shown schematically by the electro-motive element E in the diagram, and the output of the unit may be taken off in any suitable way, as, for example, by means of a pick-up coil S coupled to the inductance L_2 as shown. Other specific means of applying and taking off the signal energy are shown in Figures 4, 5 and 6.

The operation of the band selector unit may be more readily understood by reference to the vector diagram Figure 2. Let the currents set up by the impressed electro-motive force E in the three branches X_1, X_2 and X_3 be I_1, I_2 and I_3 respectively. These three currents are considered positive when they flow in the direction from the common point *a* of the branches to the common point *b*. Since the total current flowing into or out of points

a and b must be zero, the current I_3 in the common reactance X_3 must be equal and opposite to the vector sum of currents I_1 and I_2 in the other two branches. This relation is shown by the vector diagram Fig. 2, φ being the phase angle between the currents I_1 and I_2.

This phase angle varies from zero to 180 degrees in the following manner, depending upon the frequency of the impressed electromotive force E.

For any given band selector there is a critical frequency F_1, at which the inductance and capacity reactances L_1, C_1 and L_2 and C_2 of the branches X_1 and X_2 are balanced in themselves. The overall reactance of the circuit C_1, L_1, L_2 and C_2 will then be zero, the current will be in phase with the electromotive force and its magnitude will depend upon the effective resistance of the system. The currents I_1 and I_2 will then be in substantially opposite phase relation, considered from the junction points a and b, the angle φ will be approximately 180 degrees, and the current I_3 will be approximately zero, the resistance of the system being considered small.

There is another critical frequency, F_2, at which the unbalanced reactance of the branches X_1, X_2 in parallel is equal and opposite to the reactance of the branch X_3. The reactances of the system as a whole are thus balanced if the currents I_1 and I_2 are in phase, the phase angle φ being zero, in which case I_3 will be approximately equal to the arithmetical sum of I_1 and I_2, the effect of resistance being considered small.

At any frequency between these limits F_1 and F_2 the unbalanced reactance of the branches X_1 and X_2 will have a value intermediate between zero and X_3, the phase angle φ will lie between the limits 180 degrees and zero, and the current I_3 will adjust itself between the limits zero and $2I_1$. If the resistance of the system is low and the value of X_3 is sufficiently small in relation to the other reactances, the current I_2 will be substantially constant at all frequencies between these limits.

At frequencies above or below these limits, the combined reactance of the branches X_1 and X_2 will be greater than X_3 or of opposite sign to X_3, as the case may be, so that X_3 cannot balance the unbalanced reactances of X_1 and X_2 and the over-all reactance of the system as a whole is large, and this unbalanced reactance will reduce the current in I_2 to a small value. The band selector thus is responsive to and transmits with substantial equality all frequencies included in the band lying between the limiting frequencies F_1 and F_2, and effectively excludes all frequencies outside this band.

If the resistance and other losses of the system are low, as they are preferably, the cut-off at the limiting frequencies is very sharp, and the frequency characteristic of the band selector unit has the form shown in Figure 3.

The width of the band depends upon the relation of the reactance X_3 to the other reactances of the system. Thus if X_3 is an inductance, as shown in Figures 4, 5 and 6, the band width depends upon the relation of this inductance to the inductances L_1 and L_2. If the reactance X_3 is a capacity, the band width is determined by the relation of the capacity reactance of X_3 to the capacity reactance of C_1 or C_2. In the case where the common reactance is a mutual inductance, the relation is similar to that existing in the case of a simple inductance.

In general the width of the band, expressed as a fraction of the mean or carrier frequency, is equal to the ratio of the reactance X_3 to the balanced reactances of the branches X_1 and X_2, very approximately. Thus when X_1 and X_2 are equal and X_3 is an inductance having its value L_3, the band width is equal to

$$\frac{L_3.}{L_1}$$

When X_3 is a capacity having the value C_3, the band width is

$$\frac{C_1}{C_3}$$

When X_3 is a mutual inductance having the value M_3, the band width is

$$\frac{M_3.}{L_1}$$

To cite a specific example in the case of broadcast reception at a carrier frequency of 1,000 kilocycles with a band width of 20 kilocycles, the limiting frequencies are 1,010 and 990 kilocycles and the ratio of L_3 to L_1 (or C_1 to C_3, as the case may be) becomes 2 to 100. That is, L_3 is equal to 2% of L_1. It will be understood that this example is merely illustrative, and that the quantities employed may be varied over wide limits to suit the particular case in hand.

The band width may be determined within reasonable limits by choice of the relation of the common reactance X_3 to the other reactances. If X_3 is made too large the band loses some of its uniformity, and shows a depression or valley at the middle. In practice, however, the band is substantially uniform when designed for the frequency range represented by a modulated radio signal wave, for example if the system is designed to transmit a band 20 kilocycles wide, which includes substantially all the side band frequencies of a modulated wave. By making X_3 variable the band width may be adjusted at will, to be broad or narrow as conditions or the convenience or pleasure of the operator may require.

It is of interest to note the relation of the band characteristic of the band selector unit to the characteristic of a tuned selective circuit. Thus if the common reactance X_3 is omitted, the two branches X_1 and X_2 together constitute a resonant circuit tuned to a certain frequency F_1, this being one of the limiting frequencies of the band of the selector unit. The resonance characteristic curve of such a tuned circuit is shown by the dotted lines in Fig. 3 in its characteristic sharply peaked form.

When the common reactance X_3 is added to the system the curve takes the band form shown in full lines, the limiting frequency F_1 corresponding to the natural frequency of the tuned circuit, and the limiting frequency F_2 being below or above this frequency, depending upon whether the reactance X_3 is inductive or capacitive.

When the reactance X_3 has a suitable small value in reference to the other reactances, the widths of the two curves at the base are substantially the same, showing that the uniform band reception is achieved without any loss of selectivity, but rather with a noteworthy gain.

It will be noted that the gradient of the cut-off in the band characteristic is much sharper than the slope of the resonance curve, since at any frequency outside the band X_3 becomes a shunt or bypass of small reactance across the then large unbalanced reactance of X_1 and X_2, and so effectively prevents transfer of energy from one to the other. This sharp cut-off is a notworthy feature of the selectivity of the band selector.

The curves shown in Figure 3 are reproduced from records made by an oscillograph of the performance of an actual apparatus at a frequency of 600 kilocycles.

The band of reception may be readily adjusted in the frequency scale by varying the capacities C_1 C_2 or the inductances L_1 L_2 or both. Usually X_3 may remain constant. For example the capacities C_1 C_2 may be variable condensers of the usual type, preferably equal, and operated by a single or common control. The band frequency of the system may thus be adjusted to any point in the frequency scale within the limits determined by the ratio of the maximum and minimum capacities of the condensers. In this case if the reactance X_3 is an inductance of constant value, the band width, considered as a fraction of the mean frequency, is constant, being determined by the ratio of the constant inductances.

Similarly if the frequency is adjusted by varying the inductances, as it may readily be, for example, by inserting similar short circuiting rings or tubes in the inductance coils, the frequency of the band may be adjusted at any point within the limits determined by the greatest and least value of these inductances. In such case if the reactance X_3 is a capacity, the band width, expressed as a fraction, will be constant, whatever the position of the band in the frequency scale.

While the inductances and capacities may both be made variable it is usually preferable to make one pair of reactances, for example the inductances, constant and similar. The other pair of reactances which are of opposite sign, e. g. capacitive, in the case assumed, are also preferably made similar and similarly variable. It is usually desirable to make the band forming reactance X_3 of the same sign as the fixed reactances, thus, if the fixed reactances are inductive, X_3 will be as inductance; if the fixed reactances are capacitances, X_3 will be a capacitance. In this case, if X_3 is constant, the band width, expressed as a fraction, would be constant as above explained.

By making X_3 variable as heretofore noted any desired relation of band width to the frequency may be secured. In general the reactive coupling, due to the reactance X_3, between the component resonant circuits or reactive couples should be of sufficient magnitude to make the frequency response of the system broader than that of the individual circuits, as illustrated in Figure 3, though the variation of the coupling may be used to narrow the response to any desired degree permitted by the other constants of the system.

In Figure 4 I have shown one of my band selector units employed as a frequency selector in a radio receiving system. The reactive couples X_1 and X_2 and the common reactance X_3 are indicated by the same symbols as in the generalized schematic diagram Figure 1. The band selector unit is associated with the antenna or collector A by a primary coil P coupled with the inductance L_1 of the reactive couple X_1. The band selector unit may be associated with an aperiodic amplifying and detecting system, such as the detector D and audio frequency amplifier A_1 in any suitable way. I prefer to form this association by an adjustable aperiodic coupling which will give control of the strength of signal impulses applied to the system. A convenient arrangement for this purpose is an aperiodic pick-up coil S which is in variable inductive relation with the inductance L_2 of the band selector. Since the purpose of this coil is to derive from the current in L_2 an electro-motive force which is applied to the detector, tuning or frequency adjustment is not necessary. It is sufficient to have the magnetic circuits of the two coils interlinked. By varying the degree of interlinkage the electro-motive force applied to the detector may be varied from zero to a maximum. The maximum occurs when the coils are closely coupled, and the minimum when their fields are not interlinked at all.

The antenna coil P is preferably closely coupled to the inductance L_1. Usually I prefer a step-up ratio of turns, i. e. the number of turns of the antenna coils P is less than the number of turns of the inductance L_1. In the case of such a step-up ratio the effective capacity introduced into the reactive element X_1 by the antenna is less than the antenna capacity, in proportion to the ratio of turns. For this reason, and for other reasons that will be understood, this inductive coupling is usually preferable to connecting the antenna and ground directly across the capacity C.

The effective capacitance introduced by the antenna, or in general the effective reactance introduced by the collector, into the reactive element X_1 is an indeterminate factor which if not compensated, would unbalance the symmetry of the system, and, if large enough, would distort the band characteristic. A feature of the present invention which avoids such unbalance and distortion is the introduction of a compensating reactance in one of the reactive couples corresponding to the indeterminate reactance introduced into the other reactive couple. For example, in the case where the element that introduces the indeterminate reactance is a collector and the reactance introduced by the collector is capacitive, as shown in Figure 4, symmetry may be restored by introducing a compensating capacity C_c, which is shown in parallel with the capacity C_2. This capacity may be adjustable to compensate for any desired value of the capacity of the collector, but I prefer to make it a fixed capacity larger than the largest value of the effective capacity that will be introduced into the element X_1 by the collector. I then employ an adjusting capacity C_x in parallel with the capacity C_1, to make up the difference between the compensating capacity C_c and the effective capacity introduced into the system by the collector.

In this respect the compensation of the collector reactance to make the system symmetrical is similar to the means of compensation of two tuned receiving circuits shown in my applications Serial Nos. 582,603, 582,604, 680,061 and 680,062, in which I set forth in general terms the means for securing symmetry or similarity in two parts of a system, one of which contains an indeterminate reactance such as an antenna or other collector. In my applications above mentioned, a broad system of compensation was described, and specifically, its application to a receiving system comprising two tuned circuits tuned to the same frequency, by the method of geometric tuning common in the art. In the case of the present invention similar means for producing symmetry or similarity in two circuit elements, one of which contains an indeterminate reactance, is applied to another specific case, in which similarity is desired in the two reactive elements X_1 X_2 of my band receiving system.

It will be readily understood that any of the specific devices shown in the above mentioned applications for producing similarity in two circuit elements will be applicable to the specific case of the two circuit elements, one of which includes a collector, in the band selector unit of the present invention.

In the arrangement shown in Figure 4, the position of the band of reception in the frequency scale is determined by adjusting the capacities or condensers C_1 C_2 simultaneously by a common control movement, whereby the frequency of the band of reception may be changed at will without altering its uniform band character.

In Figure 5 I show one of my band selector units employed as a preliminary selector or pre-selector, with a coupled collector, in conjunction with a band amplifier of the type set forth in Patents Nos. 1,666,518, April 17, 1928, 1,682,874, September 4, 1928 and 1,730,987, October 8, 1929. This is a very desirable improvement over the combination including a tuner, set forth in my Patent No. 1,730,987.

By a suitable choice of the inductances and capacities of the band selector unit and the band amplifier, the frequency characteristics may be made to coincide so that they may be adjusted in the frequency scale by a single or common control means, as shown and fully explained in my former application.

A very important characteristic of the described band selector system is that any number of band selector units may be employed in cascade, thus greatly increasing the selectivity of the system, without narrowing the response curve. When the conventional system of tuning by resonance is employed the use of synchronously tuned circuits in cascade inevitably sharpens the response curve, thus trimming the side bands and destroying the fidelity. When band selector units are used in cascade any desired degree of selectivity may be obtained without narrowing the effective band of response. There is no diminution of signal strength at any part of the useful reception band, but the use of successive units serves to steepen greatly the gradient of the cut-off, thus improving selectivity.

The use of a selector unit of the type described as a pre-selector in advance of the first amplifier tube, is also important. When a single tuned circuit is used, as is customary at the present day, a powerful signal of foreign frequency introduces forced oscillations which are impressed on the grid of the first amplifier tube and modulate the desired signal oscillations, producing cross modulation or "cross talk", so that when the desired signal is tuned in the interfering signal is heard superimposed upon it.

Such cross modulation is prevented by the use of a pre-selector unit of the type described, which is double tuned by means of the two reactive couples X_1 X_2 and reduces the grid swing of the first tube due to forced oscillations to a point that is not sufficient to modulate perceptibly the desired signal wave.

Both of these features are of great practical value and both are embodied in the arrangement shown in Figure 6 which includes a plurality of double tuned selector units, one being employed as a pre-selector coupling the collector, here shown as a loop collector, with the amplifier, the others being employed as interstage coupling elements of a radio frequency amplifier.

This arrangement includes a plurality of amplifier tubes A_1, A_2, D, which are coupled in cascade, but the interstage coupling means in this case is not a single tuned transformer unit as in Figure 5, but a double tuned selector unit. The coupling means in each case comprises two reactive couples X_1 and X_2, each of which includes an inductance and a capacitance. The inductances or the capacitances or both are variable for the purpose of frequency selection. In the preferred arrangement shown the inductances are fixed and the capacitances C_1 and C_2 are variable. These two reactive couples are associated with each other by means which permits the transfer of oscillatory energy between them, which means, in the arrangement shown, comprises the reactive element X_3 whose reactance is common to both couples. Preferably the reactance X_3 is so related to the other reactances in the system as to balance the reactances of the complete selector unit at a plurality of frequencies so that the system is responsive to all the frequencies included in the transmission band, as above explained.

The output of the first tube, such as A_1, is impressed on a selector unit X_1, X_2, X_3, which serves as the coupling means connecting the tubes in cascade and the selector unit is also operatively connected to the second tube such as A_2. The means shown for impressing the output of the first tube on the selector unit is the connection *c* between the anode of the first tube and the reactive couple X_1 and the connection *d* serves to connect the second couple X_2 to the grid or input circuit of the second tube, impressing signal oscillations thereon.

In the arrangement of this figure, three of these selector units are shown, operating in cascade and coupled by the amplifier tubes A_1 and A_2, the first being employed as a pre-selector in advance of the first tube A_1, and being associated with collecting means, here shown as a loop connector L_1, the second being employed as an interstage coupling unit, coupling the tubes A_1 and A_2 in cascade, and the third coupling the amplifier tube A_2 to the detector D.

It will be noted that each of the selector units is double tuned by means of the variable condensers C_1, and C_2.

It has been stated above that the means shown for impressing the output of the first tube on the selector unit is the connection *c* and that the connection *d* serves to connect the second couple to the input circuit of the second tube, but it will be obvious that instead of the direct electrical connection shown, a transformer or other suitable coupling may be employed, as is well known in the art. It is characteristic of the selector unit described that the impedance between the points *c* and *b* and the points *d* and *b* is high at all frequencies within the band of effective response of the system and relatively low at frequencies outside of this band, and these high impedances are adapted to cooperate with the impedances of the tubes A_1, A_2, D. It will be understood that a similar cooperative relation of effective impedances should be maintained in whatever means is employed for coupling the selector units to the tubes.

The two or more band selector units are preferably made alike, for convenience in mechanical construction. The inductance L of the loop is made approximately equal to that of the inductor L_2, and a small compensating inductor L_2 added, so that all the units are made symmetrical and all may be similarly adjusted by a single control means.

It will be understood however that complete symmetry is not essential, provided there is such similarity as will give the various band selector units similar frequency characteristics, the variable reactances being similarly variable, so that they may be all operated by single control means as shown, which serves to adjust the pre-selector and the interstage coupling unit simultaneously by a single operation, so that the frequency response of the several selectors is simultaneously and similarly adjusted and the system as a whole is made responsive to any desired signal frequency or band of frequencies.

It will be understood that other modifications and applications of the system may be made without departing from the essential principles of the invention.

I claim as my invention:

1. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, and a selector unit coupling such tubes in cascade, such unit comprising two reactive couples, whose effective impedances are adapted to cooperate with the impedances of the tubes, means for the transfer of oscillatory energy between these couples, and

single control means for simultaneously and similarly adjusting the reactances of the couples whereby the frequency response of the system is adjusted.

2. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, and a selector unit coupling such tubes in cascade, such unit comprising two reactive couples each having a variable reactance and a reactance common to both of such couples, the effective impedances of the selector unit being adapted to cooperate with the impedances of the tubes, and single control means for simultaneously and similarly adjusting the variable reactances of the couples whereby the frequency response of the system is adjusted.

3. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, coupling means connecting two such tubes in cascade and comprising a reactive couple having a fixed inductance and a variable capacitance receiving signal energy from the first tube, a second reactive couple having a fixed inductance and a variable capacitance impressing signal oscillations on the second tube, means for the transfer of signal energy between the two reactive couples, and single control means for simultaneously and similarly adjusting the two variable capacitances whereby the frequency response of the system is adjusted, said means for the transfer of signal energy not being subject to adjustment by said single control means.

4. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, a pre-selector with associated collecting means in advance of the first tube and comprising two reactive couples each having a variable reactance, coupling means between two of said amplifier tubes comprising two reactive couples each having a variable reactance, and single control means for simultaneously and similarly adjusting the variable reactance of the pre-selector and the coupling means whereby the frequency response of the system is adjusted.

5. In a system for receiving a signal wave, a plurality of double tuned selector units each comprising two reactive couples having variable reactances with means for the transfer of oscillatory energy between these couples, means for coupling the selector units in cascade, and single control means for simultaneously and similarly adjusting the reactances of the several reactive couples whereby the frequency response of the several selector units is simultaneously and similarly adjusted, said means for the transfer of oscillatory energy not being subject to adjustment by said single control means.

6. In a system for receiving a signal wave, a plurality of double tuned selector units each comprising two reactive couples having variable reactances with means for the transfer of oscillatory energy between these couples, an amplifier tube coupling the selector units in cascade, the effective impedances of the couples being adapted to cooperate with the impedances of the tube, and single control means for simultaneously and similarly adjusting the reactances of the several reactive couples whereby the frequency response of the several selector units is simultaneously and similarly adjusted.

7. In a system for receiving the transmission band of a modulated signal wave, a plurality of selector units each responsive with substantial uniformity to a band of frequencies with a sharp cut-off at the extremities of the band, means for coupling the selector units in cascade, said coupling being sufficiently close to avoid material loss in transmission and of such a nature that it does not modify materially the band response of the selector units, and single control means for simultaneously and similarly adjusting the position of the bands of response of the several selector units in the frequency scale.

8. In a system for receiving the transmission band of a modulated signal wave, a plurality of selector units each responsive with substantial uniformity to a band of frequencies with a sharp cut-off at the extremities of the band, an amplifier tube for coupling these units in cascade, thereby performing an effective transfer of energy between the selector units without modifying their band response, and single control means for simultaneously and similarly adjusting the position of the bands of response of the several selector units in the frequency scale.

9. In a system for receiving a signal wave, the combination of a radio frequency amplifier comprising a plurality of amplifier tubes, a double tuned pre-selector with associated collecting means in advance of the first amplifier tube, a second double tuned selector unit coupling two of the amplifier tubes and single control means for simultaneously and similarly adjusting the two double tuned selector units whereby the frequency response of the system is adjusted.

10. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, coupling means between the tubes, a plurality of double tuned selector units connected in cascade, at least one of said double tuned selector units being located in advance of the first amplifier tube, and signal collecting means operatively associated with the last named selector unit.

11. In a system for receiving a signal wave, an amplifier comprising a plurality of amplifier tubes, coupling means connecting two such tubes in cascade and comprising two reactive couples, means for the transfer of oscillatory signal energy between the two couples, means for impressing the output of the

first tube on one couple, the connection between the output circuit and said means being at points between which the effective impedance is high within the operating frequency range and low at frequencies outside this range, means operatively connecting the other couple to the input circuit of the second tube, and means for simultaneously and similarly adjusting the reactances of the couples whereby the frequency response of the system is adjusted.

12. In a system for receiving the transmission band of a modulated signal wave, a collector, a double tuned band pre-selector comprising two variable reactive couples and means for the transfer of oscillatory energy between these couples, said means having such relation to the reactances of the couples as to make the band of effective frequency response of the selector substantially broader than the effective response of the component couples, an amplifier receiving signal energy from the collector through the band pre-selector said amplifier including means for performing a selection supplementary to the selection performed by the pre-selector, and single control means for simultaneously varying the variable reactive couples of the band pre-selector in such relation to the other reactances of the system as to shift the band of response of the system in the frequency scale.

13. In a system for receiving the transmission band of a modulated signal wave, a collector, a double tuned band pre-selector comprising two variable reactive couples and means for the transfer of oscillatory energy between these couples, said means having such relation to the reactances of the couples as to make the band of effective frequency response of the selector substantially broader than the effective response of the component couples, an amplifier receiving signal energy from the collector through the band pre-selector and having a band characteristic including the reception band passed by the band pre-selector and comprising variable reactive couples determining the position of the band characteristic in the frequency scale, and single control means for simultaneously varying the variable reactive couples of the amplifier and the band pre-selector in such relation of the other reactances of the system as to shift the band of response of the amplifier and the band pre-selector in the frequency scale.

14. In a system for receiving the transmission band of a modulated signal wave, a collector, a double tuned band selector comprising two variable reactive couples and means for the transfer of oscillatory energy between these couples, said means having such relation to the reactances of the couples as to make the band of effective frequency response of the selector substantially broader than the effective response of the component couples, an amplifier having a band characteristic substantially co-extensive and co-incident with the characteristic of the band selector and comprising variable reactive couples determining the position of the band characteristic in the frequency scale, and single control means for simultaneously varying the variable reactive couples of the amplifier and the band selector in such relation to the other reactances of the system as to shift the band of response of the amplifier and the band selector in the frequency scale.

15. In a system for receiving the transmission band of a modulated signal wave, an amplifier comprising a plurality of amplifier tubes, a coupling between two of these tubes comprising two resonant circuits each having a capacitance and an inductance whereby they are tuned, and a coupling reactance shared in common by these circuits, the effective impedances of the coupling being adapted to cooperate with the impedances of the tubes.

16. In a system for receiving the transmission band of a modulated signal wave, an amplifier comprising a plurality of amplifier tubes, a coupling between two of these tubes comprising two resonant circuits each having a capacitance and an inductance, and a coupling reactance shared in common by these circuits of sufficient magnitude to make the frequency response of the system broader than that of the individual circuits, the effective impedances of the coupling being adapted to cooperate with the impedances of the tubes.

17. In a system for receiving the transmission band of a modulated signal wave, an amplifier comprising a plurality of amplifier tubes, a coupling between two of these tubes comprising two resonant circuits each having a capacitance and an inductance, a coupling reactance shared in common by these circuits, the effective impedances of the coupling being adapted to cooperate with the impedances of the tubes and a pre-selector in advance of the first amplifier tube.

18. In a system for receiving the transmission band of a modulated signal wave, an amplifier comprising a plurality of amplifier tubes, a resonant circuit comprising an inductance and capacitance receiving signal energy from one tube, and a second resonant circuit comprising an inductance and capacitance impressing signal impulses on the control electrode of a second tube and a coupling reactance shared in common by these circuits, the effective impedances of the resonant circuits being adapted to coöperate with the impedances of the tubes.

19. In a system for selectively receiving any desired transmission band of modulated signal waves, the combination with means for collecting and means for detecting said

waves, of a double tuned system of reactances operatively connected with the collecting means to receive the collected energy therefrom and operatively connected with the detecting means to impress the selected signal band on the detecting means, means for varying said reactances for selecting at will any desired transmission band, and means for amplifying the entire transmission band of the selected signal to a substantially constant degree and performing a selection supplementary to the selection performed by the double tuned system of reactances.

20. In a system for selectively receiving any desired transmission band of modulated signal waves, the combination with means for collecting and means for detecting said waves, of a double tuned system of reactances operatively connected with the collecting means to receive the collected energy therefrom and operatively connected with the detecting means to impress the selected signal band on the detecting means, means for varying said reactances for selecting at will any desired transmission band, and means for selectively amplifying the transmission band of the selected signal, said last named means cooperating with the double tuned system of reactances to increase the selectivity of the system without imparting distortion thereto.

21. In an amplifier for selectively amplifying the transmission band of a modulated signal wave, the combination with two high frequency vacuum tubes arranged in cascade, of means for coupling the output of one vacuum tube with the input of the other, said means including a system of reactances cooperating with said tubes to select the band of frequencies of the modulated signal wave and simultaneously amplify with substantial uniformity all the frequencies of the said band.

22. In an amplifier for selectively amplifying the transmission band of a modulated signal wave, the combination with two high frequency vacuum tubes arranged in cascade, of double tuned means for coupling the output of one vacuum tube with the input of the other, said means including a system of reactances cooperating with said tubes to select the band of frequencies of the modulated signal wave and simultaneously amplify with substantial uniformity all the frequencies of said band.

23. In a system for receiving the transmission band of a modulated signal wave, a plurality of tuned circuits, coupling means uniting these circuits in pairs, said coupling means being so related to the other reactances of the circuits that the effective frequency response of each pair is broader than that of the component tuned circuits, and amplifier tubes connecting these pairs in cascade, thereby increasing the selectivity of the system without diminishing the range of effective frequency response.

This specification signed this 3rd day of July, A. D. 1929.

FREDERICK K. VREELAND.