Feb. 3, 1942. F. K. VREELAND 2,272,075

RECEIVING SYSTEM FOR MODULATED WAVES

Filed Aug. 17, 1928 2 Sheets-Sheet 1

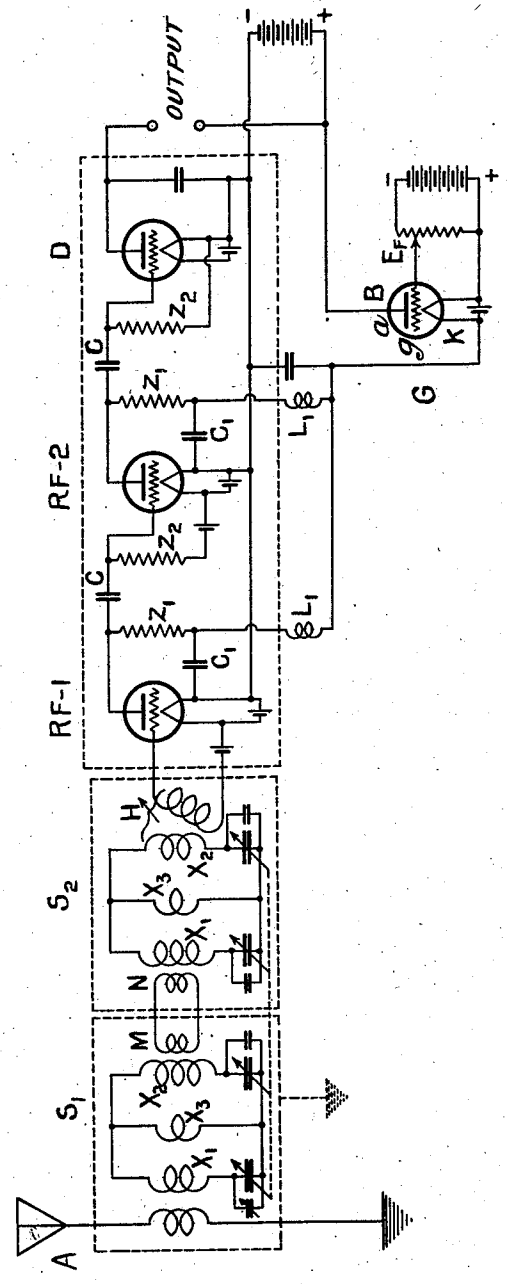


Fig. 1.

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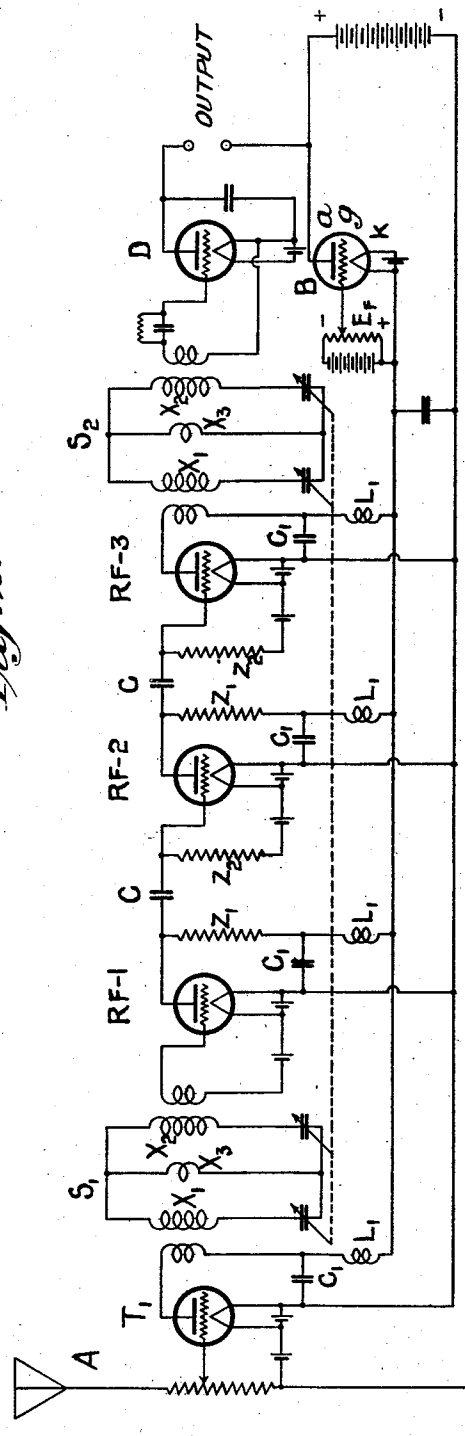


Fig. 2.

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RECEIVING SYSTEM FOR MODULATED WAVES

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Application August 17, 1928, Serial No. 300,172

4 Claims. (Cl. 179—171)

The invention herein described relates to receiving systems for radiant energy.

The particular object of the invention is to secure distortionless reception and amplification of the band of transmitted frequencies included in a modulated signal wave and to permit ready adjustment of the position of the band of reception in the frequency scale to include the band of transmission frequencies of a desired signal and to exclude undesired frequencies.

One means of accomplishing this is disclosed in my U. S. Patent No. 1,666,518 which includes a band receiving system comprising an amplifier whose gain is substantially uniform over a band of frequencies together with means for shifting of the band of effective amplification in the frequency scale. In my Patent No. 1,682,874 I have described an improved band amplifier including means for continuously varying the position of the band in the frequency scale for the purpose of selecting desired and rejecting undesired frequencies.

Another type of band receiving system is described in my Patent No. 1,725,433 including a band selector which receives with substantial uniformity a band of frequencies and excludes undesired frequencies and in an embodiment of that invention shown the frequency selection of the band selector operates independently of the amplifier. Specifically I have shown and claimed in that patent the use of such a band selector in cooperation with an aperiodic amplifying and detecting system.

The present invention is an improvement on the last named arrangement. It contemplates primarily the distortionless reception of a modulated signal wave by first selecting with substantially equal efficiency all the frequencies included in the transmission band, then amplifying these frequencies equally by a radio frequency amplifier which is substantially aperiodic and has a response curve which is substantially flat or uniform over any band of frequencies included in any modulated signal wave within the range of adjustment of the band selector and whose response curve is preferably substantially uniform over the entire range of frequencies to be received.

The present invention has important advantages. In the first place, in order to take full advantage of the property of the band selector of receiving with substantial uniformity all of the frequencies included in the band of the modulated signal wave, it is necessary that the amplification of such frequencies shall be uniform. When the position of the band of selected frequencies is shifted in the frequency scale it is important that the band of amplification shall be uniform also in each position of the band of response of the selector. One means of accomplishing this was set forth in my application last named and included the use of a radio frequency amplifier having also a uniform band characteristic, and shifting the positions of the bands of reception of the band selector and the band amplifier simultaneously in the frequency scale. This requires co-ordination of adjustment between the band selector and the band amplifier.

Such co-ordination is avoided in another arrangement shown in the same application in which the band selector is combined with an aperiodic amplifying and detecting system. Such a system meets the requirements above explained of amplifying without distortion any band of selected frequencies and permitting the adjustment of this band in the frequency scale, without requiring adjustment of the amplifying and detecting system.

The specific improvement of the present invention resides in the inclusion in an aperiodic amplifying and detecting system of an aperiodic radio frequency amplifier and also in the use of other features that increase the effectiveness of this combination as will appear hereinafter.

I have found that it is feasible to construct an amplifier of this type which is highly efficient and whose response curve is substantially uniform over the full range of adjustment of the band selector.

The use of such an amplifier makes possible a high sensitivity in the receiving system, particularly when a large number of stages are employed with a relatively small gain per stage. In fact a sensitivity has been obtained fully equal to that accomplished by tuned radio frequency amplifiers.

In order to take advantage of the highest sensitivity of the aperiodic amplifier it is usually desirable to increase the selectivity of the band selector by employing a plurality of band selector units. In one embodiment of the present invention the plurality of band selector units are coupled in cascade in advance of the aperiodic radio frequency amplifier. In another arrangement one or more of the units is placed in advance of the aperiodic amplifier and another one or more units inserted behind the amplifier or a part thereof. Other possible modifications will be readily understood.

In the drawings Figure 1 represents a simple embodiment of the invention.

Figure 2 represents another embodiment including a second band selector following the aperiodic amplifier.

In Figure 1 S_1S_2 represent two band selector units. These units as shown are of the type set forth in my Patent No. 1,725,433 which includes two reactive couples X_1X_2 combined with a band forming reactance X_3 common to both couples, whereby the system is made responsive with substantial uniformity over a definite and limited band of frequencies. These two band selector units are coupled by a coupling means which is sufficiently loose not to impair their band selective quality. In the arrangement shown the coupling means comprises a loop circuit including coils MN coupled to both band selectors. This arrangement is desirable since it permits individual shielding of the two selector units as indicated by the broken lines, and also reduces the transmission of shock pulses producing ground noise, but any suitable form of coupling may be substituted. The value of the coupling reactances is so related to the reactances of the couples as to effect highly uniform and selective transfer of the modulated energy through a frequency range corresponding substantially to the range of audio frequencies as fully explained in my Patent No. 1,725,433.

The first band selector, which is double tuned, is employed as a pre-selector in advance of the first amplifier tube and is operatively associated with a suitable signal collecting means which is here shown as an antenna A coupled with the band selector in the manner explained in my co-pending application last referred to. The second band selector is operatively associated with an aperiodic radio frequency amplifier. In the arrangement shown the selector is coupled to the amplifier by an aperiodic coupling coil H, as fully explained in my said co-pending application.

The aperiodic amplifier shown comprises amplifier tubes RF—1, RF—2 and a detector tube D. The mode of coupling of the tubes here shown is that employing impedances z_1, z_2, located respectively in the output circuit of one tube and the input circuit of the next tube, with a bridging capacity C which passes the radio frequency impulses from one tube to the next. Bypass condenser C_1 and choke coils L_1 are desirable to prevent interaction between the stages.

If the impedances z_1z_2 are large, as they are preferably, or if they have large resistance, the amplifier is substantially aperiodic.

The operation of the apparatus is as follows:

Signal impulses whose frequencies lie within a definite band of frequencies are passed with substantial uniformity by the first band selector S_1, and frequencies outside the band are to a large extent excluded. The same band of frequencies is received and passed with substantial uniformity by the second band selector S_2, and any remnant of interfering frequencies outside the band is still further reduced by the selective action of the selector. The band of frequencies thus selected is applied to the radio frequency amplifier, which amplifies them without distortion.

When it is desired to select a different band of transmitted frequencies, the band of response of the selector or selectors S_1 and S_2 is shifted in the frequency scale by simultaneous and similar adjustment of their reactances, and the system is then responsive to another band of frequencies. Because of the aperiodic character of the radio frequency amplifier any band of frequencies so selected is amplified with substantial uniformity, so that the selected signal is received without distortion.

The variable elements of the band selector units, here shown as condensers, are mechanically coupled so that they may be adjusted simultaneously and similarly by a single movement. Means for compensating the collector reactance are included, when required, as shown and as explained in my application.

The simultaneous adjustment of the variable elements involves no mechanical difficulties, such as are found when synchronously tuned circuits are employed in cascade, since any lack of uniformity of the circuits will merely cause a slight mutual displacement and over-lap of the reception bands. The only effect of this will be to narrow slightly the overall band of reception. It causes no loss of signal strength, as occurs with tuned resonant circuits. This is an important practical feature of the present invention.

In order to utilize the particular features of this invention that give distortionless selection and amplification of a modulated wave, and still permit the reception of signal waves ranging from feeble distant signals to the most powerful ones, it is important to have means for controlling the responsiveness of the system without impairing the uniformity of its response. The preferred mode of accomplishing this is to regulate the gain of the radio frequency amplifier by controlling the space current in the tubes. This arrangement takes full advantage of the unusual capabilities of this invention of securing high selectivity for a band of frequencies together with extreme sensitivity in the amplifier. The specific arrangement shown includes a variable impedance inserted in series with the anode supply whereby the current or voltage or both supplied to the tubes is controlled. The preferred form of variable impedance is a ballast tube shown at B in the drawings, preferably of the thermionic type having an anode a, cathode k, and a control electrode g. The effective impedance of the ballast tube is controlled by impressing an adjustable electromotive force on the control electrode g of the tube, as for example by means of the battery and potentiometer E_F shown. This mode of controlling the output of the system enables the gain of the amplifier to be varied over very wide limits from the highest amplification obtainable to a point where the signals are not amplified but are in fact reduced in strength, and this wide variation of gain is accomplished without sensible distortion of the signals, that is, without material variation in the uniformity of amplification of all frequencies included in the modulation band. When a considerable number of stages are so controlled the range of sensitivity that may be obtained without distortion is enormous.

This means of controlling the gain of the amplifier is set forth at length in my Patent No. 1,926,129, issued September 12, 1933, which shows in addition automatic governing means whereby the amplifier is controlled automatically through the agency of the regulating tube B. It will be understood that the automatic features of the last named application may be employed to supply the electromotive force E_F, in place of the battery and potentiometer shown.

In the arrangement shown in Figure 2 the

aperiodic radio frequency amplifier, including the stages RF—1, RF—2, RF—3, is inserted between the two band selector units S_1S_2 as shown. In this arrangement the first band selector is shown associated with the collector by a coupling tube T_1. Since this coupling tube prevents the introduction of an indeterminate reactance by the collector into the band selector system, means for compensating the antenna reactance are not required and hence are omitted.

The arrangements shown in the drawings are chosen for illustration as typical embodiments of the invention but it will be understood that the invention is not limited to these specific arrangements but is susceptible of a variety of applications.

I claim as my invention:

1. In a receiving system for modulated signal waves, an amplifier comprising a plurality of amplifier tubes arranged in cascade relation, a pre-selector with collecting means in operative relation therewith in advance of the first tube with respect to received waves and comprising two reactive couples each having variable reactances, coupling means between two of said amplifier tubes comprising two reactive couples each having variable reactances, and substantially aperiodic coupling means between others of said amplifier tubes.

2. In a receiving system for modulated radio frequency energy the combination of two reactive couples tuned to a frequency of said energy, means for impressing said energy on one of said couples, a coupling reactance common to both couples whose value is so related to the reactances of the couples as to effect highly uniform and selective transfer of the modulated energy through a frequency range corresponding substantially to the range of audio frequencies, means for shifting the position of the frequency range of the energy transfer in the frequency scale, and an amplifier aperiodically coupled with the other of said reactive couples and adapted to be responsive with substantial uniformity to all frequencies included in any selected frequency range.

3. In a receiving system for modulated radio frequency energy the combination of a plurality of band selector units, each comprising two reactive couples tuned to a frequency of the said energy and a coupling reactance common to both couples whose value is so related to the reactances of the couples as to effect highly uniform and selective transfer of the modulated signal energy through a frequency range corresponding substantially to the range of audio frequencies, means for coupling the selector units in cascade, means for simultaneously adjusting their reactances whereby the position of the band of response is shifted in the frequency scale, and an amplifier aperiodically coupled in cascade with one of said selector units and adapted to amplify with substantial uniformity all frequencies included in any band passed by the band selectors.

4. In a receiving system for modulated radio frequency energy the combination of a collector, a preselector comprising two reactive couples tuned to a frequency of said energy, means for impressing the energy received by the collector on one of said couples, a coupling reactance common to both couples whose value is so related to the reactances of the couples as to effect highly uniform and selective transfer of the modulated energy through a frequency range corresponding substantially to the range of audio frequencies, means for adjusting the reactances of the two couples simultaneously and similarly thus shifting the range of the selectively transferred energy in the frequency scale, and an amplifier including a plurality of amplifier tubes aperiodically coupled to the other of said reactive couples for receiving signal impulses from the preselector and responsive with substantial uniformity to all frequencies in any frequency range selected by the preselector.

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