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O. B. BLACKWELL ET AL

MULTIPLE CHANNEL RADIORECEIVER

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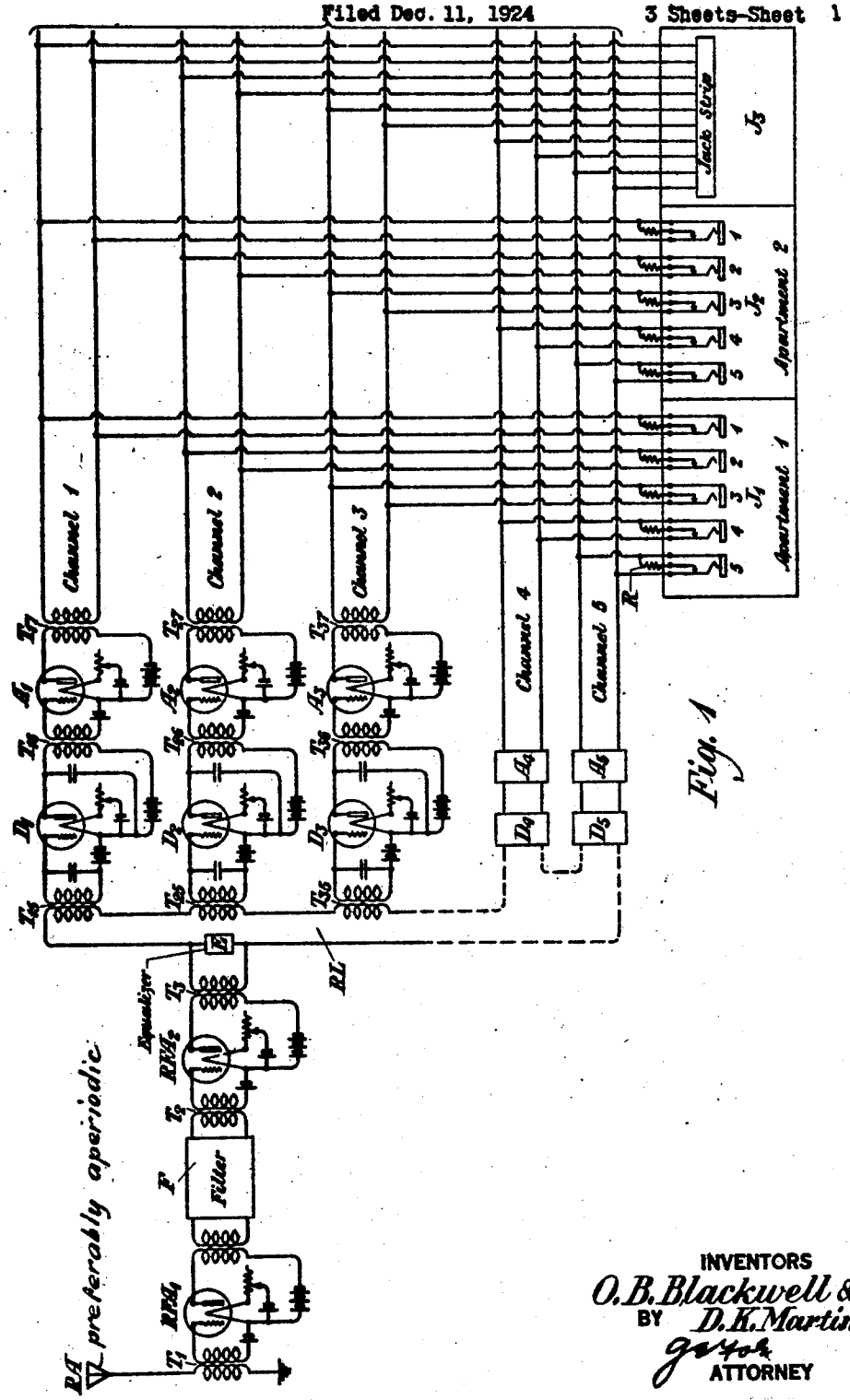


Fig. 1

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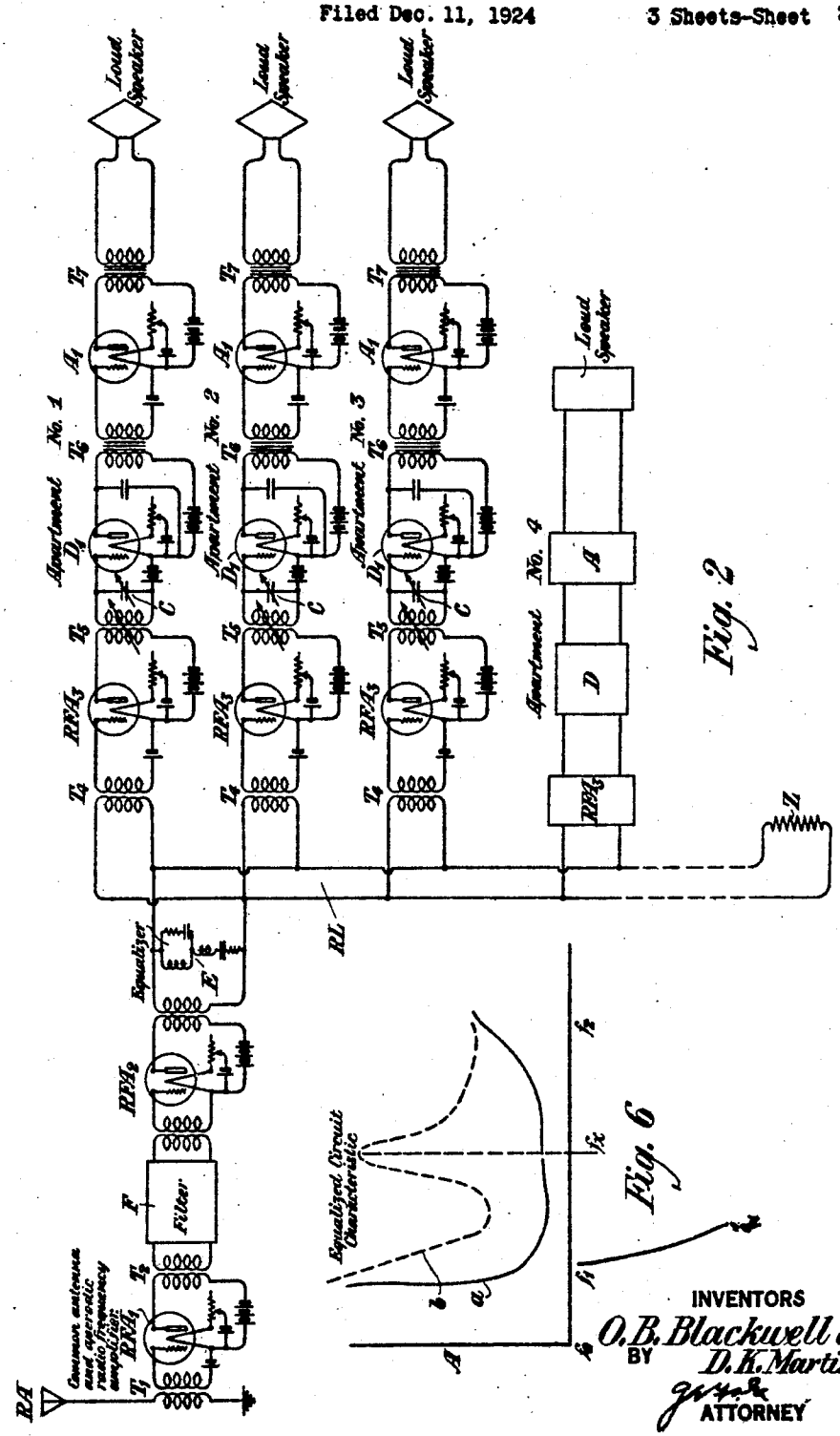


Fig. 2

Fig. 6

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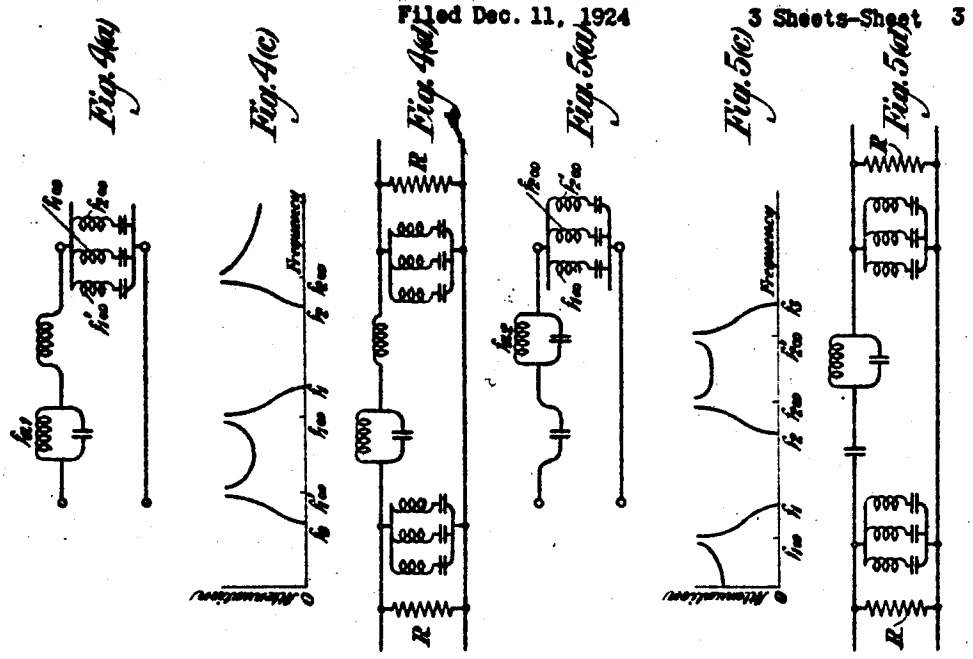
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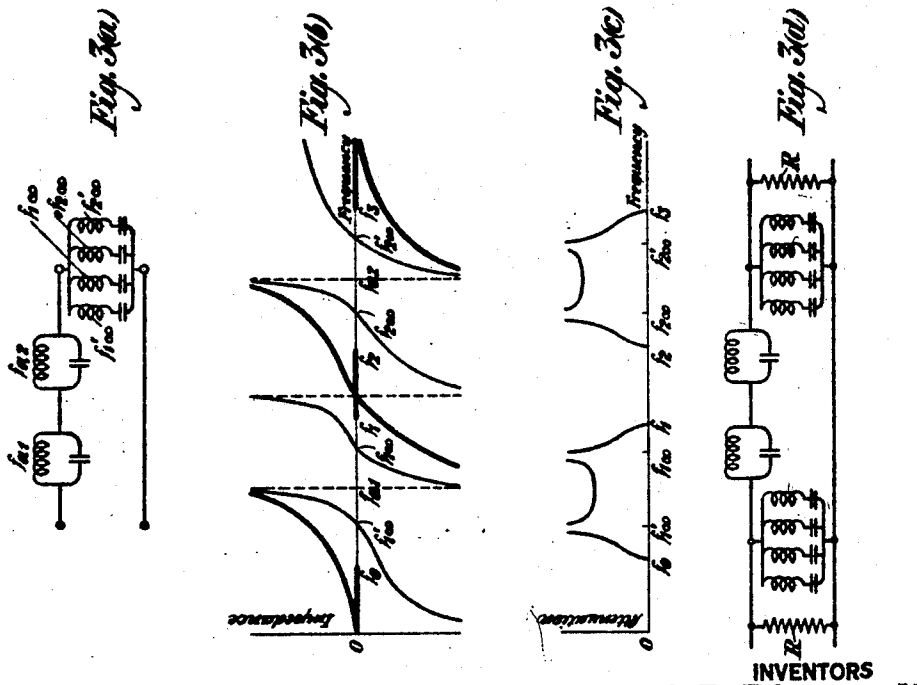
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MULTIPLE CHANNEL RADIORECEIVER

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UNITED STATES PATENT OFFICE.

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MULTIPLE-CHANNEL RADIORECEIVER.

Application filed December 11, 1924. Serial No. 755,278.

This invention relates to multiple channel radio receivers and more particularly to receiving circuits of this type for use in apartment houses or other places where a number of different broadcast listeners desire to simultaneously receive different programs.

In a large city where great numbers of people dwell in apartment houses, it is impractical and often impossible for each broadcast listener in the apartment house to operate a radio receiving set with an individual antenna. It has been proposed to overcome this difficulty by providing an antenna for the apartment house, which is common to all of the broadcast listeners and is made aperiodic over the range of frequencies employed in radio broadcasting. A radio frequency amplifier adapted to efficiently amplify frequencies within the broadcasting range may be associated with the antenna for amplifying all program channels which the system is to receive. Multiple connections are established from the amplifier to the individual broadcast listeners' stations and suitable detecting and selecting equipment may be provided, either individual to each listener or common to the listeners but individual to the channels.

In either of these cases, it is desirable that some arrangement be provided to eliminate undesired frequencies either above or below or within the broadcasting range. For this purpose suitable networks such as filters and attenuation equalizers may be employed in connection with the high frequency part of the circuit, these being so designed as to accomplish the desired result.

The invention will be more fully understood from the following detailed description thereof when read in connection with the accompanying drawing, in which Figures 1 and 2 illustrate two forms of receiving circuit arrangements embodying the principles of the invention, and Figs. 3^a, 4^a and 5^a illustrate fundamental forms of filter sections which may be employed in connection with the filters schematically illustrated in Figs. 1 and 2. Fig. 3^b is a curve showing the impedance characteristics of the various elements of the filter, Figs. 3^c, 4^c and 5^c are curves illustrating the attenuation characteristics of the several types of filters, Figs. 3^d, 4^d and 5^d show complete filters of one section together with suitable terminations based on the type forms illustrated in Figs. 3^a, 4^a and 5^a, while Fig. 6 is a curve illustrating the action of the attenuation equalizer illustrated in Figs. 1 and 2.

Referring to Fig. 1, RA designates a receiving antenna which is substantially aperiodic over the range used for radio broadcasting, said antenna being coupled through a transformer T_1 to high frequency amplifying equipment RFA_1 and RFA_2. The output circuit of the amplifier RFA_2 is coupled through a transformer T_3 with a common receiving circuit RL through which a plurality of radio broadcast listeners in an apartment house or other area may obtain service. A plurality of receiving channels, one corresponding to each broadcasting station whose programs are to be received, are provided. Each channel is connected with the common circuit RL through transformers such as T_{15}, T_{25}, etc., and includes detectors such as D_1, D_2, etc., coupled to low frequency amplifiers such as A_1, A_2, etc., through low frequency transformers T_{16}, T_{26}, etc. The output sides of the low frequency amplifiers of the channels are connected through multiple connections to jack strips such as J_1, J_2, etc., at the various apartments or other radio listeners' locations so that the radio listener at any point may hear a desired program by plugging his receiver into the jack leading to the proper channel.

In connection with the high frequency equipment common to all of the channels and all of the listeners' sets, a filter F is provided. As will be described later, this filter may have any suitable characteristic whereby it will suppress all frequencies above the radio broadcasting range or below said range or both. As will appear later, it may also be given a characteristic such as to discriminate against frequencies within the broadcasting range as well. The filter F may be located at any point in the common high frequency part of the circuit. For example, as illustrated in Fig. 1, this filter is interposed between the amplifiers RFA, and RFA_2.

The filter F may assume a large number of forms and its design will depend upon

the particular conditions to be met in connection with each installation.

Fig. 3[a] illustrates a fundamental section of the general type of filter which will satisfy the requirements of the filter F of Fig. 1. The general characteristics of filters of this type are described in an article published in the Bell system Technical Journal of January, 1923, vol. II, No. 1, in an article by Otto J. Zobel, extending from pages 1 to 46 inclusive. The fundamental section and its characteristics are illustrated particularly on page 14 of said article. As the methods of design and the general characteristics of these filters do not constitute a part of the present invention it will only be necessary here to refer in detail to those features necessary to an understanding of their application to the particular circuit arrangement herein disclosed. For further details of the filters per se, reference may be had to the article in the Bell system Technical Journal, already referred to.

In general, the type of filter section shown in Fig. 3[a] comprises series and shunt impedance elements, the series elements including two anti-resonant circuits in series with each other and the shunt element including four resonant circuits in parallel with each other. Such an arrangement will, in general, have three ranges of free transmission and two suppression ranges.

The impedance characteristics of the filter elements of Fig. 3[a] are illustrated by the curves of Fig. 3[b]. In this figure the heavy line curves show the impedance characteristics of the series element of the filter section, and the light line curves show the impedance characteristics of the shunt element of the section. The horizontal heavy lines indicate the free transmission range of the filter, these ranges extending, as will be clear from the figure, as follows: The first range extends from zero to an upper limiting frequency f_0. A suppression range then extends from f_0 to f_1. A second range of free transmission extends from f_1 to f_2, followed by a suppression range from f_2 to f_3. Finally another range of free transmission extends from f_3 to infinity.

An examination of the curves of Fig. 3[b] shows that the series element is anti-resonant at two frequencies, fa_1 and fa_2 so that the two anti-resonant circuits of the series element are designed to be anti-resonant at these two frequencies, as indicated in Fig. 3[a]. Fig. 3[b] also shows that there are four frequencies at which the impedance of the shunt element is zero or, in other words, there are four frequencies at which the shunt element resonates. These frequencies are as shown by Fig. 3[b], frequencies $f_1'\infty$, $f_1\infty$, $f_2\infty$ and $f_2'\infty$.

The attenuation characteristics of the filter constructed from a fundamental section of the type shown in Fig. 3[a] are illustrated by the curves of Fig. 3[c]. These curves indicate that if a filter is constructed of a sufficient number of sections of the general type shown in Fig. 3[a] the filter will transmit with zero attenuation frequencies from zero to f_0, from f_1 to f_2, and from f_3 to infinity, while so greatly attenuating as to practically extinguish all other frequencies.

In practice, a filter can be constructed employing very few sections and in the limiting case even a single section which will approximate the conditions illustrated by the curve of Fig. 3[c], providing the filter is properly terminated. Such a filter is shown in Fig. 3[d]. In order to make the impedance looking into the filter from either end substantially equal, the shunt element of the filter is divided into two parts, each part being so designed that the two parts in parallel are equivalent to the single shunt element of Fig. 3[a]. The two shunt elements are arranged one on either side of the series element so that the filter is terminated in "mid-shunt".

At either side of the filter the circuit to which it is connected should have the same impedance as the characteristic impedance of the filter. This may be done by arranging the transformers, through which the filter F of Fig. 1 is connected to the output circuit of the amplifier RFA_1 and to the input circuit of the amplifier RFA_2, so that said transformers step the impedances of the repeater circuits to a proper value to match the characteristic impedance of the filter. It is sometimes simpler to accomplish the same result by connecting the filter terminals to bridge resistances R, as shown in Fig. 3[d]. The impedances of the amplifier circuits will be very large so that when shunted by resistances such as R the impedance looking into the combination consisting of the tube impedance shunted by the resistance R will not be greatly different from the resistance R itself. R should therefore be made equal to k, the characteristic impedance of the filter (see formula 6, page 7 of the article in the Bell System Technical Journal already referred to).

It will be observed that the filter above referred to has free transmission ranges extending from zero to a certain cut-off frequency, then from a higher cut-off frequency through a band to a still higher cut-off frequency, and finally from a still higher cut-off frequency to infinity. In other words, the filter has a low pass range, a band range, and a high pass range of free transmission, and for this reason it is known as a general low band and high pass filter. It is sometimes desirable, however, to have the filter arranged to transmit a band from zero up to a cut-off point and then transmit a band between two other frequencies above this point

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without transmitting any high pass band; in other words, it is desirable to have a low and band pass filter.

The fundamental section of such a filter is illustrated in Fig. 4[a], and such a filter may be readily obtained from the general type of filter shown in Fig. 3[a] in a very simple manner. Referring to the impedance diagram of Fig. 3[b], it will be seen that the problem is to eliminate the band of free transmission extending from f_3 to infinity or, to state it in a different way, the suppression band extending upward from the frequency f_2 is to be continued to infinity. This means that the frequency f_3 must be made infinite and as the frequencies fa_2 and $f_2'\infty$ are functions of the frequency f_3 these two frequencies will also be infinite. The series resonance point at $f_2'\infty$ of Fig. 3 will not now exist and consequently the part of the shunt element which is resonant at $f_2'\infty$ will be eliminated from the physical structure. The shunt element as illustrated in Fig. 4 therefore includes only three series resonant circuits instead of four. It also follows that if anti-resonance is to occur at $fa_2=\infty$ this condition will be satisfied by making the second anti-resonant circuit a simple inductance instead of an inductance shunted by a capacity, as shown in Fig. 4[a].

A filter constructed of sections such as those illustrated in Fig. 4[a] will have the attenuation characteristics shown in Fig. 4[c], that is, it will have a low pass band of free transmission from zero to frequency f_0 and a band of free transmission from a lower cut-off frequency f_1 to a lower cut-off frequency f_2. A complete filter of one section with proper terminations is shown in Fig. 4[d]. As in the case of Fig. 3[d], the shunt element is made of two parts so that the two parts in parallel are equivalent to the shunt element of Fig. 4, and the two parts are arranged on either side of the series element. In other words, the filter is given a mid-shunt termination and is connected to the repeater circuit at either end through resistances R which are equal to the characteristic impedance k of the filter. The design formulæ for a filter of this type are given on page 44 of the article in the Bell System Technical Journal, previously referred to.

In a similar manner, if it is desired that the filter F of Fig. 1 shall have ranges of free transmission corresponding to a band extending from a lower cut-off frequency to an upper cut-off frequency and a high pass band extending from a third frequency to infinity, a filter answering these requirements may be obtained from the fundamental type illustrated in Fig. 3[a]. The fundamental section of the desired band and high pass filter is illustrated in Fig. 5[a]. Referring to Fig. 3[b], it will be seen that the filter of Fig. 3[a] will have the desired characteristics if it be so designed that frequency f_0 is made equal to zero. The dependent frequencies $f_1\infty$ and fa_1 will also become zero. The series resonance point at frequency $f_1'\infty$ is eliminated and consequently the left-hand resonant circuit of the shunt element of Fig. 3[a] is omitted. Furthermore, the series element is to be anti-resonant at zero frequency and this condition calls for a simple capacity instead of a capacity in parallel with an inductance at frequency fa_1. The attenuation characteristics of a filter of this type are shown in Fig. 5[c]. Fig. 5[d] shows how the complete filter of one section terminated in mid-shunt and connected to suitable resistances R equal to its characteristic impedance k, may be constructed.

Fig. 2 shows the invention as applied to a slightly different type of receiving circuit. Here, as in the case of Fig. 1, high frequency amplifiers common to all of the channels and all of the listeners are interposed between the receiving antenna RA and the common receiving circuit RL, as indicated by RFA_1 and RFA_2. The filter F is likewise interposed between the two high frequency amplifiers. Instead of having detecting and amplifying apparatus common to all of the listeners but individual to each station, in this instance each listener is provided with his own detecting and amplifying equipment and also with adjustable selecting means for selecting the program which he wishes to receive. Thus, as illustrated, each channel has a high frequency receiving amplifier RFA_3, a detector D_1, and a low frequency amplifier A_1 connected to a loud speaker or other receiving device. A transformer T_5 between the high frequency amplifier RFA_3 and the detector D_1 is tuned by means of an adjustable condenser C to the desired frequency. The high frequency amplifier RFA_3, which is a one-way device, is interposed between the adjustable tuned circuit and the common point to which the apparatus of other listeners is connected so that the tuning of one listener's set does not affect the tuning of any other listener's set. The volume of the signaling may be controlled by varying the coupling of the transformer T_5.

The filter F may be of any of the types previously described, and in fact, may be of any known type of filter having the desired characteristics for the particular situation to be met. The effect of a filter is, in general, to restrict the transmission to a certain range or ranges, while suppressing frequencies lying outside such range or ranges. It sometimes happens, however, that in the range of free transmission of a filter, or in other words, within the broadcasting range which is to be received, there is some channel that is not desired or there

is some interfering frequency which is persistent at this point. Such a narrow range of frequencies may be discriminated against by the use of an equalizer such as illustrated at E in Figs. 1 and 2. This equalizer is of a well known type and by proper proportioning of its component elements may be made to have a wide variety of transmission characteristics. For example, it may be so designed as to shunt or by-pass a certain frequency or a certain narrow range of frequencies. The resultant effect is illustrated by the curves of Fig. 6 where the curve *a* may be taken to represent the transmission characteristic of the filter F in one of its ranges of free transmission. As indicated by the curve, the filter roughly transmits without substantial attenuation frequencies between f_1 and f_2 and attenuates frequencies lying outside this range. If the attenuation equalizer E is arranged to readily by-pass frequencies in the neighborhood of frequency f_x the effect will be one of great attenuation in the neighborhood of the frequency f_x, the attenuation falling off rapidly on either side of said frequency. The resultant effect of the filter and the attenuation equalizer combined is illustrated by the curve *b* of Fig. 6.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A multiple channel radio receiver comprising an antenna common to the channels and substantially aperiodic over the frequency range employed by the channels, a radio frequency amplifier common to the channels, apparatus for selecting the channels and detecting signals from the channels for transmission to listeners, and means for restricting the range of frequencies to be selected by said apparatus comprising a filter common to all of the channels designed to substantially suppress all frequencies above a preassigned upper limit.

2. A multiple channel radio receiver comprising an antenna common to the channels and substantially aperiodic over the frequency range employed by the channels, a radio frequency amplifier common to the channels, apparatus for selecting the channels and detecting signals from the channels for transmission to listeners, and means for restricting the range of frequencies to be selected by said apparatus comprising a filter common to all of the channels designed to substantially suppress all frequencies below a preassigned lower limit.

3. A multiple channel radio receiver comprising an antenna common to the channels and substantially aperiodic over the frequency range employed by the channels, a radio frequency amplifier common to the channels, apparatus for selecting the channels and detecting signals from the channels for transmission to listeners, and means for restricting the range of frequencies to be selected by said apparatus comprising a filter common to all of the channels designed to substantially suppress all frequencies above a preassigned upper limit and below a preassigned lower limit.

4. A multiple channel radio receiver comprising an antenna common to the channels and substantially aperiodic over the frequency range employed by the channels, a radio frequency amplifier common to the channels, apparatus for selecting the channels and detecting signals from the channels for transmission to listeners, and means for restricting the range of frequencies to be selected by said apparatus comprising a filter common to all of the channels designed to substantially suppress all frequencies lying outside of two limiting frequencies and also substantially suppressing a band of frequencies within said limits.

5. A multiple channel radio receiver comprising an antenna common to the channels and substantially aperiodic over the frequency range employed by the channels, a radio frequency amplifier common to the channels, apparatus for selecting the channels and detecting signals from the channels for transmission to listeners, and means for restricting the range of frequencies to be selected by said apparatus comprising a filter common to all of the channels designed to suppress frequencies lying outside a predetermined range of free transmission and a supplemental network common to all channels designed to substantially suppress certain frequencies lying within the range of free transmission of the filter.

In testimony whereof, we have signed our names to this specification this 9th day of December 1924.

OTTO B. BLACKWELL.
DE LOSS K. MARTIN.