July 24, 1934. H. F. DALPAYRAT 1,967,570

BAND PASS TUNING CIRCUITS

Filed May 10, 1930

Fig. 1

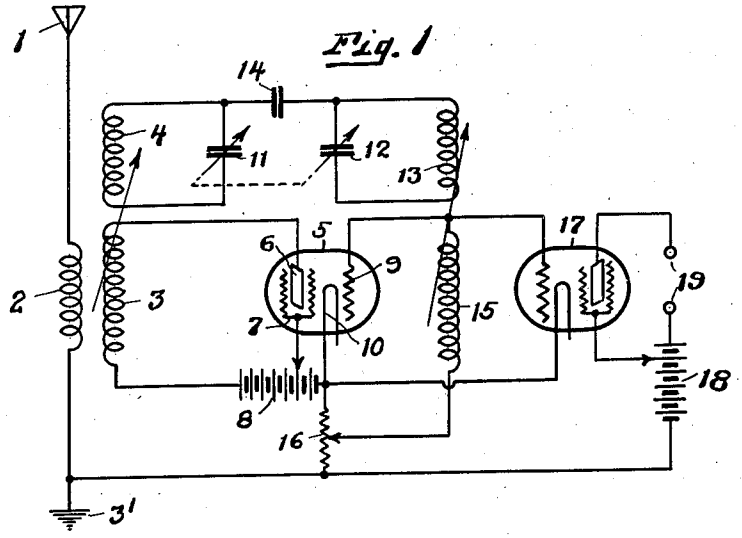


Fig. 2

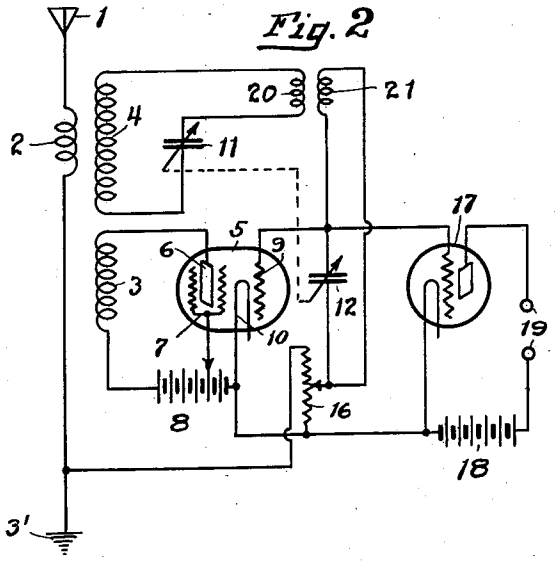


Fig. 3

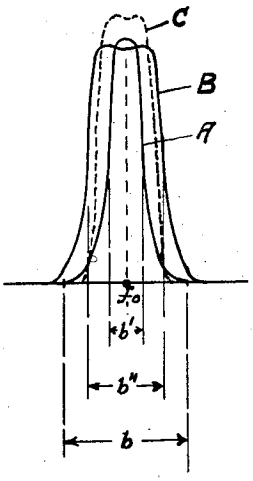
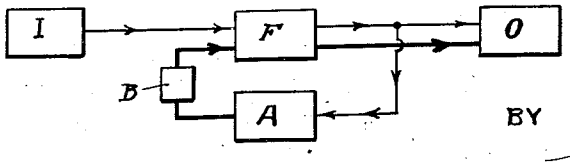


Fig. 4



INVENTOR
Henri François Dalpayrat

BY Samuel Astrolenke

ATTORNEY

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BAND PASS TUNING CIRCUITS

Henri François Dalpayrat, New York, N. Y., assignor to Radio Patents Corporation, New York, N. Y., a corporation of New York

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9 Claims. (Cl. 178—44)

The invention described relates to electric tuning circuits, and more particularly to circuits for receiving alternating current signals, including a band of frequencies. The invention is especially applicable to receivers for wireless telephony or similar wireless transmission where the signal is transmitted by modulation of a carrier wave and is composed of a definite band of frequencies.

When selectivity, or the degree of separation of a radio signal of one carrier frequency from undesired waves of different carrier frequencies, is accomplished by the usual method employing a tuned circuit or several circuits, the frequency response characteristic of the receiver is rather peaked, since there is only one frequency at which the capacitive and inductive reactances of the circuit are balanced. At any other frequency there will be an unbalanced reactance, which cuts down the response to such frequency. Thus, in receiving a modulated wave of the character referred to, comprised of a band of individual 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 a resulting signal distortion.

In order to overcome this disadvantage, it has been proposed, in the past, to construct a receiving circuit in such a manner that it is, so to speak, transparent for a definite band of frequencies, instead of a single frequency, or in other words, that its frequency response characteristic assumes a shape as near as possible to rectangular form, instead of the markedly peaked shape corresponding to a single tuned circuit. Such circuits are well known in the art and commonly referred to as electric filters. They consist essentially of a definite number of individual units or circuits, thus constituting a chain of reactance units connected alternately in multiple and in series. As is well known, the sharpness of the frequency response characteristic of such a filter increases with the number of filter units, or in other words, the cut off frequencies at both ends of the band become more marked and the curve assumes a shape more equal to the ideal rectangular form as the number of the individual units of the filter increases.

Another means which has been suggested for obtaining a broad band reception characteristic of a receiver, consists in the use of a number of variable condensers placed in different tuned circuits, such as the tuned circuits coupling successive amplifying stages and detuning these circuits in respect to each other in such a manner that by the superposition of their individual peaked resonance characteristics, the resultant action of a broad band characteristic in the output circuit of the receiver is obtained.

The disadvantage of the latter means to create an extended frequency response curve of a receiver, lies in the necessity of a great number of tuning elements at each stage, or a combination of staggered tuning elements at several stages whereby the construction of the set is unnecessarily complicated, or else the energy amplification at each of the staggered stages of tuning does not reach its maximum amount, since the maximum amplification will only occur when exact tuning is satisfactory at each stage.

Furthermore, it has been found, when using a filter circuit as referred to above, in the antenna, or between the antenna and the receiver, it is necessary to use more than two units for such filter, in order to obtain a practically rectangular shaped response curve such as is required in broadcasting where only a restricted channel of frequencies has been allotted to the individual broadcasting stations, and where it is highly desirable to place the carrier waves of the individual stations as near together as possible, without interference of the individual signal channels with each other. This calls for a frequency response characteristic which sharply cuts off with the limit frequencies of a radio broadcasting signalling band, which it has been found, has to have a width of at least 10,000 cycles, in order to insure faithful reproduction of speech and music.

My invention refers to a new, improved band pass filter system, especially suitable for radio reception, which with a small number of filter units, preferably two, provides a considerably increased effect as to the sharpness of the cut off frequencies at the extremities of the band. In other words, I provide a band pass filter, in accordance with my invention, which will have at least a double effect as to its effectiveness or sharpness of the frequency cut off. To obtain this effect, my invention consists broadly in that the energy applied to the input of the filter, after passing the same, is wholly or partly fed back, preferably after amplification, to pass the filter a second time and is only then applied to the receiver itself. By thus utilizing the filter, so to speak twice, the effect is obtained of a filter having the double number of circuit units and accordingly presenting an improved response characteristic as to the sharpness of the cut off frequencies.

A further object achieved by my invention, is

that of stable regeneration sufficient to increase the signal to a considerable extent over the full wavelength range of tuning and, at the same time, retaining the band pass filter action suitable for the proper reception of signals.

A further object is to provide a system in which the desired signal is transferred and even accentuated, while the undesired signals are suppressed or minimized.

Another object is to provide two tuned circuits with extremely small capacity coupling by means of which band pass filter action is secured over the desired wavelength range.

This and further objects of my invention, as well as other desirable features of same, will be explained at length in the following detailed description taken with reference to the accompanying drawing. I wish it to be understood that the drawing and the description are intended to be illustrative only of my broad inventive idea and that the invention is subject to many modifications coming within the broad and most comprehensive terms, as expressed in the appended claims.

Figure 1 shows a radio receiving circuit with the feature of the invention embodied in it.

Figure 2 is a circuit similar to Figure 1, in a simplified arrangement.

Figure 3 illustrates the frequency response characteristic of a single tuned circuit and of complex circuits or filters as used according to the invention.

Figure 4 is a schematic diagram illustrating the broad idea underlying the invention.

Referring more particularly to Figure 1, I have shown a radio receiving system comprising an antenna-ground system 1, 3' for picking up a modulated radio wave such as a broadcast wave, or any other signal comprised of a definite band of frequencies. The antenna circuit includes an inductance 2, which is coupled to the input inductance 3 for applying the received waves to the receiver. Inductance 3 is connected to the anode 6 and the screen grid 7 of an ordinary screen grid vacuum tube 5, this tube thus being connected in reverse sense, in respect to the antenna or input circuit. 8 is an anode battery for supplying the space discharge current of the tube. A further inductance coil 15 is connected between the control grid 9 and the filament 10 of the tube 5. I have shown furthermore a band pass filter for extending the frequency response range consisting of two multiple tuned circuits, each comprising an inductance 4 and 13, and a variable condenser 11 and 12 respectively. Both these circuits are coupled by a series condenser 14 of comparatively small capacity. The variable plate systems of the condensers 11 and 12 are coupled mechanically, so that they may be controlled by a single knob in the same way as in the case of a single tuned circuit, whereby the operation of the receiver is by no means more complicated than the operation of an ordinary receiver without band pass filter. I have found that the specific type of filter, as just described, is simple and cheap in design and gives increased results as to the sharpness of the cut off in respect to frequencies outside the receiving band, but I wish it to be understood that any kind of band pass filter may be incorporated in this new circuit, in accordance with the broad spirit of my invention. The inductance 15 is coupled to the grid and filament of a further vacuum tube 17, which is provided with anode battery 18 and output terminals 19. This vacuum tube 17 may be a further amplifying tube or a rectifying tube, depending on the specific use of the receiver.

The operation of the circuit as described, is as follows: The high frequency input energy collected by the antenna is transferred across the coupling coils 2, 3, to the input of the filter, and after passing the filter circuit, is applied across the coupling coils 13, 15, partly to the grid of the tube 5 and partly to the grid of the succeeding tube 17. Thus, the energy applied to the tube 5 is amplified and retransferred in a kind of feedback through the anode circuit of tube 5 to the filter, which is thus passed for a second time. The amplified energy, after passing the filter is then directed to the succeeding tube 17. Thus, the filter circuit is traversed twice in succession by the input currents the second time in an amplified form and the effect is obtained of a filter circuit possessing an increased number of circuit units and a correspondingly extended width and improved sharpness of the cut off frequencies from frequencies outside the receiving band.

Considering a signal of a frequency to which the filter is tuned, it will be readily seen that such a signal is not only amplified during the passage through the tube 5, but on account of the feedback arrangement there is also regenerative action by means of which the signal is considerably increased above the normal amplification values. I have found by experiments, however, that such regeneration is quite stable and does not result easily in oscillations, especially if a resistance such as 16 is included in the grid return circuit.

Another feature that will become apparent, is that a signal coming in at a frequency different from that to which the filter is tuned, will pass through tube 5 in such a direction as to have the minimum effect on the output circuit. Thus, this current will be applied to the plate 6, which is properly screened, and will exercise only extremely small effect on the grid 9 of the same tube.

Referring to Figure 3, I have shown a frequency response characterictic A for a single tuned circuit of a natural frequency equal to f_0, consisting of a single inductance coil and a single capacity. This curve illustrates the well-known very peaked characteristic of such a circuit.

A curve of this nature is obtained by plotting as ordinates the amount of current or voltage passing through the filter at different applied frequencies. Thus, if the applied frequency is varied through a range b, the response of the output circuit will vary in accordance with curve A, reaching a maximum at the value f_0, which is called the resonant frequency. If, however, two filter circuits similar to those of Figures 1 or 2 are coupled together by a small capacity or by a loose inductive coupling; then although these two circuits are individually tuned to the same resonance point f_0, their combined effect will be to widen the range of tuning; thus, instead of curve A, curve B is obtained. Assuming that the frequency band of the message to be received is equal to b'', it will be seen that the filter according to curve A would pass only a portion of the frequencies of the message and that more than half of the side frequencies will be cut off since the range of maximum energy of this filter marked b' in the diagram is considerably narrower than the range b''.

On the other hand, both the filter with curve

A and curve B have a certain amount of fringing to frequencies outside of the range b'' and up to the full range of the frequencies b. Thus, if another station outside of the range b'', but with some wavelength within the range of b is sending a strong signal, this strong signal would be passed through such a filter and would produce undesirable effects in the receiving system.

I have illustrated by curve C the filter action which may be expected by utilizing the system of connections in accordance with my invention.

I have shown this curve to a reduced ordinate scale approximating the scale of the other two filter curves for the purpose of illustration. The actual effect of passing the message through the same filter twice, with an intermediate regeneration by tube 5, is to raise the peak values to very much higher amplitudes while reducing, at the same time, the fringing frequencies outside of the range b''. In this way, a filter curve approaching very closely to ideal is secured. A similar effect could, of course, be obtained by utilizing filters similar to the one described in connection with Figures 1 and 2 between several stages of amplification in a multi-stage set but necessarily the connections would be very complicated and the arrangement would require very careful tuning adjustment. On the other hand, the system of my invention, presents a simple and convenient way of securing effective filter action.

In Figure 4 I have shown a schematic diagram which illustrates the invention further as to its broadest spirit. I have shown at I the input circuit, such as antenna circuit, and at O the output circuit, such as an amplifier or any other translating device. The input energy supplied to the input circuit I is passed through a filter F and afterwards diverted into two directions, one part being passed on to the output circuit O and the other part being fed back, preferably through an amplifier A and re-applied to the filter, through which the amplified energy passes a second time and is then applied to the output circuit O. B is a means for preventing the primary input energy from directly passing through the shunt path to the output circuit and thus forcing it through the filter. In the examples shown in Figure 1 and Figure 2, the operation of the devices A and B is obtained by the use of a vacuum tube, preferably a screen grid tube. On account of the screening action of the screen grid to which the input circuit is connected, practically no amount of energy is passed directly from the input through the vacuum tube 5 to the output circuit without passing the filter. It may, however, be understood that in place of a vacuum tube, any kind of a device which exhibits unilateral electric conductivity may be provided for this purpose and that furthermore, it is not absolutely necessary to employ amplification of the feedback energy such as is the case, according to the circuits of Figures 1 and 2, owing to the use of a three-electrode vacuum tube which, besides acting as a unilateral resistance device, also performs an amplification action, as is well understood.

In Figure 2, I have shown a modified circuit arrangement embodying my invention. This figure differs from the arrangement of Figure 1, in that the multiple tuned circuits constituting the filter are coupled inductively by means of coils 20 and 21, in place of a capacitive coupling by the condenser 14, in accordance with Figure 1. Furthermore, the input inductance coil 4 of the filter is coupled with the antenna self-inductance 2 directly and the condenser 12, forming part of the filter, serves at the same time as a coupling means of the vacuum tubes 5 and 17. According to this arrangement, the input energy passes directly from the antenna to the tuned circuit comprised of the coil 4, condenser 11 and primary 20 of the coupling transformer. From this circuit the energy passes through the other tuned circuit comprised of the secondary 21 of the coupling transformer and variable condenser 12. From here part of the energy will be fed back through the screen grid tube 5 to pass the tuned circuits 4, 11, 20, 21 and 12 a second time whereby, in the same manner as described in reference to Figure 1, an improved band pass filter action is secured.

At 16, I have shown a variable resistance in the feedback path whereby the amount of feedback energy may be adjusted to a suitable value and the circuit prevented from producing self-oscillations. In the circuits shown, this resistance performs the further function of supplying grid bias potential for the vacuum tubes.

Although I have illustrated two preferred forms of my invention, it will be readily seen to those skilled in the art, that further modifications of the particular filters and their coupling to the regenerative tube may be used without departing from the scope of my invention as defined in the appended claims.

Having thus described my invention, what I claim to be secured by Letters Patent is:

1. In a system for receiving the transmission frequency band of a modulated signal wave, an input circuit, an output circuit, a band pass filter arranged between said input circuit and said output circuit designed to pass said transmission band, a return circuit from said output circuit to said input circuit including a unilateral conducting device for returning part of the signal energy to said input circuit and passing it through said filter repeatedly.

2. In a receiving system for receiving the transmission frequency band of a modulated signal wave, an input circuit, an output circuit, a band pass filter arranged between said input circuit and said output circuit designed to pass said transmission band and having control means for gradually shifting the receiving wave band along the frequency scale, and a return path from said output circuit to said input circuit including a vacuum tube having its input connected with said output circuit and having its output connected with said input circuit.

3. In a receiving system for receiving the transmission band of a modulated signal wave, an input circuit, an output circuit, a three-electrode vacuum tube having its input connected with said output circuit and having its output connected with said input circuit, and a band pass filter arranged between said input circuit and said output circuit designed to pass said signal wave.

4. In a system for receiving the transmission band of a modulated signal wave, an input circuit, an output circuit, a screen grid vacuum tube having anode, cathode, control grid and screen grid electrode, said input circuit being connected to the anode and cathode of said vacuum tube, and said output circuit being connected to the cathode and control grid of said vacuum tube, a band pass filter also arranged between said input circuit and said output circuit passing said signal wave.

5. In a system for receiving the transmission band of a modulated signal wave, a signal re-

ceiving input circuit, an output circuit, a vacuum tube having anode, cathode, control grid and screen grid electrodes, said input circuit being connected to the anode and cathode of said tube and said output circuit being connected to the control grid and cathode of said tube, a band pass filter also arranged between said input circuit and said output circuit for passing said signal wave.

6. In a system for receiving the transmission band of a modulated signal wave, a wave receiving input circuit, an output circuit, a vacuum tube having anode, cathode, control grid and screen grid electrodes, said input circuit being connected to the anode and cathode of said tube, and said output circuit being connected to the control grid and cathode of said tube, a band pass filter comprising two mutually coupled multiple tuned circuits, said filter being coupled to said input circuit and said output circuits, respectively, and passing said signal wave.

7. In a system for receiving the transmission band of a modulated signal wave, a wave receiving input circuit, an output circuit, a vacuum tube having anode, cathode, control grid, and screen grid electrodes, said input circuit being connected to the anode and cathode of said tube, and said output circuit being connected to the control grid and cathode of said tube, a two unit band pass filter comprising two multiple tuned circuits coupled serially by a single capacity and including control means for gradually shifting the transmission wave band along the frequency scale, said band pass filter being electrically connected between said input circuit and said output circuit.

8. In a system for receiving the transmission wave band of a modulated signal wave, a wave collecting input circuit, an output circuit, a vacuum tube having anode, cathode, control grid and screen grid electrodes, said input circuit being connected to the anode and cathode of said tube and said output circuit being connected to the control grid and cathode of said tube, a two unit band pass filter comprising two multiple tuned circuits consisting each of an inductance coil and a variable capacity in parallel and being coupled in series by a capacity, one of said multiple tuned circuits being in coupling relationship with said input circuit and the other one of said multiple tuned circuits being in coupling relationship with said output circuit, said variable condensers of said filter units being operated by a single control means for gradually shifting the transmission wave band of said filter along the frequency scale.

9. In a system for receiving the transmission wave band of a modulated signal wave, a wave collecting input circuit, an output circuit, and a two unit band pass filter comprising two multiple tuned circuits consisting each of an inductance coil and a variable capacity in parallel and being coupled with each other in series by a capacity of comparatively small value, one of said inductance coils being in coupling relationship with said input circuit, and the other of said inductance coils being in coupling relationship with said output circuit, and a single control means for said variable condensers for gradually shifting the transmission wave band of said filter along the frequency scale.

HENRI FRANÇOIS DALPAYRAT.