

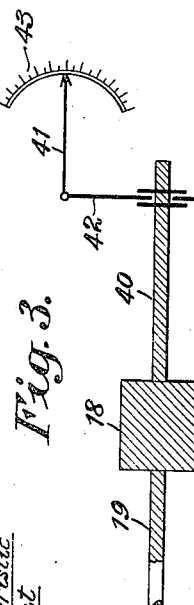
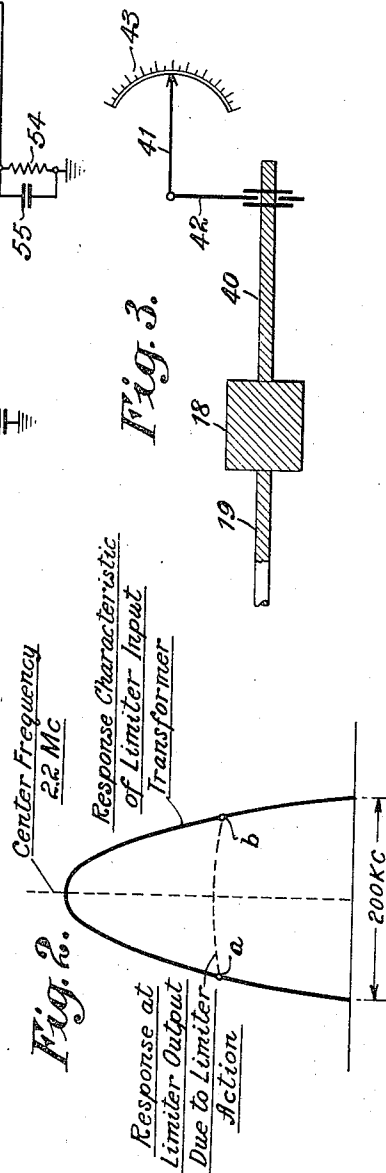
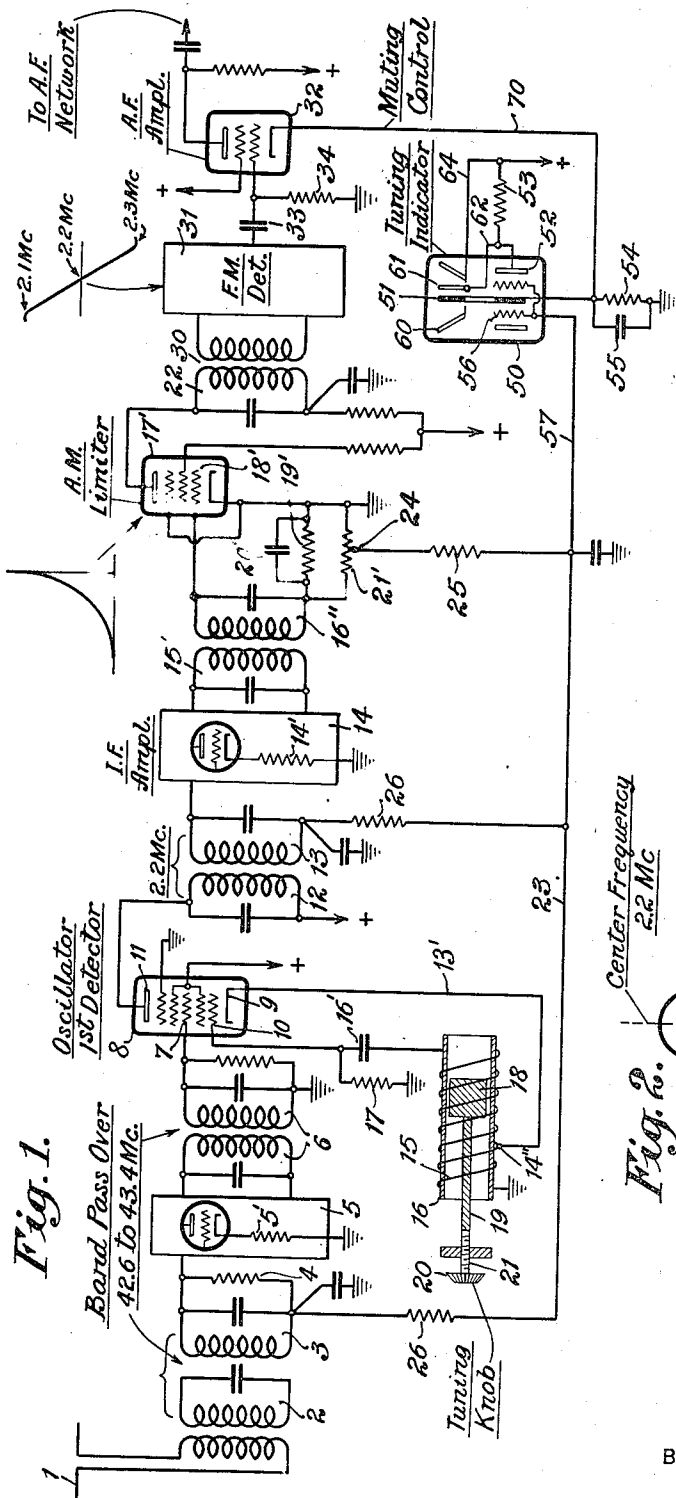
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ULTRA HIGH FREQUENCY RECEIVER

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ULTRA HIGH FREQUENCY RECEIVER

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319,831. Divided and this application August
16, 1940, Serial No. 352,857

5 Claims. (Cl. 250—20)

My present invention relates to signalling systems of the ultra-high frequency type, and more particularly to a frequency modulated carrier wave receiver of novel and efficient construction. This application is a division of my application Serial No. 319,831, filed February 20, 1940.

One of the main objects of my present invention is to improve and simplify ultra-high frequency receivers of the superheterodyne type by providing but a single adjustable inductance coil as the sole tuning means of the receiver.

Another important object of my invention is to provide wide band fixedly tuned networks for the signal transmission path to a converter operating in the ultra-high frequency range, and tuning being effected by solely varying the oscillator tank coil inductance value.

Another object of my invention is to provide a visual tuning indicator tube of the variable shadow area type for a frequency modulated (FM hereinafter) carrier wave receiver, wherein the operating bias for the indicator tube is derived from a point in the receiving system at which the resonance curve is of the single-peaked type.

Still another object of this invention is to provide a noise muting device for an FM receiver whereby the excessive noise developed between channels, or in the absence of received signals, will not be reproduced.

Still other objects of my invention are to improve generally the efficiency, simplicity and reliability of FM receivers, and more especially to provide an ultra-high frequency receiver of the FM type which is economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows a circuit diagram of an FM receiver embodying the invention,

Fig. 2 graphically shows the response characteristic of network feeding the indicator tube,

Fig. 3 illustrates a frequency indicator device adapted for association with the tuner of Fig. 1.

Referring now to the accompanying drawing, there is shown in Fig. 1 a superheterodyne receiver of a type adapted to receive FM, or phase

modulated, waves of the ultra-high frequency ranges. These ranges may be in the 26, 43 or 117 megacycle (mc.) bands. The particular receiver shown will be described in connection with the 42.6 to 43.4 mc. band, and in this band there are five channels spaced 0.2 mc. apart. The maximum band width of emission is specified as 200 kilocycles (kc.), and this means that the maximum mid-channel frequency deviation is something less than 100 kc. In general, and as is known to those skilled in the art, an FM wave is one with unvarying amplitude whose frequency is altered, or deviated, cyclically above and below its mean unmodulated value. The generic expression "timing-modulated" carrier wave is used in this application to refer to phase or frequency modulated carrier waves. The present receiving system is adapted for receiving amplitude modulated waves in the ultra-high frequency ranges, provided the proper type of detector is used.

Assuming, then, that FM signal waves in the 42.6 to 43.4 mc. band are to be received, they may be collected by a dipole 1, and fed to the primary tuned circuit 2 which is fixedly tuned to 43 mc. In other words, circuit 2 is tuned to the middle of the multi-channel spectrum of the receiver. The circuit 2 is magnetically coupled to tuned circuit 3, also fixedly tuned to the mid-band frequency. The coupling between circuits 2 and 3, and the value of shunt damping resistor 4, are so chosen that the network feeding the amplifier 5 has a pass band of 1 mc. That is to say, the network 2—3 passes to amplifier 5 substantially all the signal frequencies existing in the receiver tuning range between 42.6 and 43.4 mc.

In a similar manner the bandpass network 6 transmits the amplified output band of amplifier 5 to the input signal grid 7 of the converter tube 8. The latter is a pentagrid converter tube of the 6SA7 type, and has a cathode 9, an oscillation grid 10, a pair of positive screen grids on either side of signal grid 7 and an output electrode, or plate, 11. A grounded suppressor grid may be interposed between the plate and screen grid. There is connected to the plate 11 an I. F.-tuned output circuit 12, and the I. F. value may be chosen from a range of 2 to 4 mc. The specific value of 2.2 mc. is chosen, since there is less probability of interference at that center frequency than elsewhere in the desired intermediate frequency range.

The signal grid 7 is connected to the high potential side of its tuned input circuit, while cathode 9 is connected by lead 13' to an inter-

mediate tap 14'' on the oscillator tank coil 15. The latter is wound on an hollow insulation form 16. One end of the coil is grounded, while the opposite end is coupled to the oscillation grid 10 through a direct current blocking condenser 16'; the grid side of condenser 16' being connected to ground by resistor 17. The magnitude of the inductance of coil 15 is varied over a desired wide range by means of the metallic cylindrical plug 18 located within the form 16. The plug, or core, 18 may be composed of any non-magnetic metal as long as the latter is a good conductor. For example, aluminum or brass may be used, although brass is preferred for this purpose. The plug 18 may be reciprocated by a projecting rod 19 provided with a manually adjustable knob 20. The rod 19 is threaded, as at 21, to enable the rod to be adjusted laterally with respect to a bearing. The coil 15 comprises the sole tuner device of the receiver, and its inductance value is varied by virtue of the variable coupling between the turns of coil 15 and the plug 18.

When the plug 18 is out of engagement with the windings of coil 15 there is substantially no coupling between the two. However, as the plug 18 is drawn into the interior of the hollow form 16 then the inductance value of coil 15 is decreased. Of course, the magnitude of coil 15 and the geometric relations of plug 18 are such that the tuning device is readily able to cover the 42.6 to 43.4 mc. tuning range of the receiver. It will, therefore, be seen that in order to tune the receiver it is only necessary to vary knob 20. Since the network feeding signal grid 7 of the converter tube 8 passes a wide band of 1 mc., the chosen oscillator frequency will beat with all the accepted carrier frequencies within the pass band of the signal network, but only that signal frequency will be detected which develops the I. F. of 2.2 mc. Because of the relatively limited band to be covered, the brass plug inductance tuner provides adequate frequency range. With the I. F. value of 2.2 mc. employed no image difficulties should be experienced. The selection mechanism shown here provides coverage of the entire 43 mc. reception band by variation of the oscillator tank coil inductance. Of course, the resonance effects of the tank circuit are developed by virtue of the distributed capacity of coil 15.

The I. F. energy is passed through the band-pass I. F. transformer 12—13. The latter passes a 200 kc. band, and the bandpass primary and secondary tuned circuits are constructed to pass the band with substantially uniform response. The I. F. amplifier 14 amplifies the I. F. energy, and the I. F.-tuned output circuit 15' is coupled to the I. F.-tuned input circuit 16'' of the amplitude modulation limiter tube 17'.

The limiter tube functions to eliminate any amplitude modulation from the modulation envelope of the carrier wave. The specific type of limiter tube circuit shown herein is described in detail in application Serial No. 219,830, filed February 20, 1940, by D. E. Foster and J. A. Rankin. It is, therefore, not necessary to give more than a general explanation of the functions of the limiter tube circuit in this application. The tube 17' has its signal grid 18' connected to the grounded cathode through a path which includes the coil of input circuit 16'' and the resistor 19', the latter being shunted by condenser 20'. A second resistor 21' is connected in shunt with resistor 19'. Each of the screen grid and plate electrodes of the limiter tube are

supplied with positive potentials from a common source of potentials, and through suitably chosen resistors. As pointed out in the aforesaid Foster and Rankin application, the time discharge constant of the network 19'—20' is chosen to have a value of the order of 1 to 25 microseconds. Briefly, the amplitude limiter consists of a tube whose signal grid is biased by grid current-developed bias, and utilizes reduced screen potential to secure limiting on both the positive and negative halves of the wave envelope. The limiting action on the positive half of the wave is due to the developed grid bias fluctuations and on the negative half by plate current cut-off.

The I. F. energy applied to signal grid 18' consists of an FM carrier with a certain amount of amplitude modulation thereon produced from various sources. Under these conditions the bias developed across resistor 19' will be proportional to the peak signal and only the tips of the wave draw grid current. The negative half of the envelope swings beyond plate current cut-off so that amplitude variations in that direction do not appear across the I. F.-tuned output circuit 22 of the limiter tube. Amplitude variations in the positive direction are substantially "lined up" along the zero grid potential axis by virtue of the diode action of the grid to cathode circuit of the limiter tube. Only enough grid current is drawn from the charging source to supply the necessary bias. The screen and plate resistors are in general, chosen so as to maintain an invariable screen potential, while the plate direct current potential varies by virtue of the varying bias of grid 18' so that the proper limiting action is secured.

The direct current voltage developed across resistor 19' is further utilized for providing A. V. C. bias. The A. V. C. lead 23 is, therefore, connected to an intermediate tap 24 on resistor 21', and the tap is chosen so that approximately 23 percent of the developed direct current voltage is applied to the control tubes. The A. V. C. bias from point 24 is passed through a filter resistor 25, and filter resistors 26 are included in the leads to the signal grid circuits of the controlled amplifiers 5 and 14. It is pointed out that an additional I. F. amplifier stage may be used between circuits 15' and 16'' if desired, and in such case A. V. C. bias will be applied to the second I. F. amplifier signal grid. As pointed out in my application Serial No. 320,103, filed February 21, 1940, it is preferred to include in the cathode circuits of amplifiers 5 and 14 degenerating resistors. Thus, the unbypassed cathode resistor 5' of amplifier 5 prevents cross-modulation effects between the various carriers in the accepted signal energy band. The cross-modulation effects are prevented by virtue of the degenerative feedback across resistor 5', and to the signal grid of amplifier 5, which maintains operation on the linear portion of the amplifier characteristic. The degenerating resistor 14' in the cathode circuit of amplifier 14 prevents detuning effects upon the application of A. V. C. bias to the signal grid of the amplifier tube.

At the ultra-high frequencies of the signal range the A. V. C. bias causes variation in the input capacity of the controlled tubes. The degenerative feedback across resistors 5' and 14' effectively prevent such input capacity variation, and any consequent detuning of circuits 3 and 16'' which might otherwise result. The function of the A. V. C. circuit is not only to prevent the

usual carrier fading effects, but also to maintain the desired limiter characteristic. Since the limiter tube functions in the manner of a class C amplifier when strong signals are applied to the signal grid 18', harmonics of the I. F. value are produced. Since the output I. F. transformer 30 can only pass signal energy of the fundamental I. F. value, the total signal energy delivered to the following FM detector 31 is decreased. This is evidenced by a droop in the horizontal section of the limiter characteristic. The droop in the limiter output with large signals is prevented by applying the A. V. C. bias to at least certain of the tubes preceding the limiter tube.

The FM detector 31 may be of any well known form. Essentially, and as is well known to those skilled in the art, the FM detector is a device for deriving the audio modulation from the FM wave. Preferably, and as disclosed and claimed in the aforesaid Foster and Rankin application, it is preferred to use as a detector one of the back-to-back type consisting of two tuned circuits with associated rectifiers whose output loads are connected in phase opposition. One rectifier has its input circuit tuned to a frequency to one side of the I. F. value, while the second rectifier has its tuned input circuit tuned to a frequency on the other side of the I. F. value by an equal frequency amount. The detector characteristic is then a slope between the two rectifier input circuit frequencies, and since the rectifier output loads are oppositely connected, the unidirectional voltage output of the detector network depends on frequency variation and not on amplitude variation. In an FM wave the instantaneous frequency is varied at an audio rate, so that if such a wave is applied to a detector of the aforesaid type the unidirectional voltage output of the detector will vary at the audio frequency rate. The voltage reconstitutes the original modulation imposed on the carrier at the transmitter. It is believed that further description of the FM detector is unnecessary.

The audio voltage output of the detector 31 is impressed on the audio input grid of a following audio frequency amplifier 32 through an audio coupling condenser 33, and the signal grid may be connected to ground through a resistor 34. The audio amplifier may have its plate coupled to one or more audio amplifiers, and any desired type of reproducer can follow the final audio stage.

In Fig. 3 there is shown a method of associating a frequency indicating device with the tuning means. The brass plug 18 may be provided with a metallic rod 40 projecting therefrom in the opposite direction of the rod 19, but the two rods being in axial alignment. An indicator needle 41 may be mechanically coupled to the end of rod 40 by any well known mechanical leverage, and the latter is designated by the numeral 42. Needle 41 may be arranged for movement along a scale 43 which has provided thereon the various channel indications of the operating signal band of the receiver. It will be obvious that as the plug 18 is reciprocated rod 40 will be similarly actuated, and thereby cause motion of the indicator needle 41 along the scale 43.

It is comparatively difficult to tune an FM receiver. By virtue of its detection characteristic it is essential to locate the center frequency of the I. F. energy accurately in alignment with the center frequency of the detection characteristic. A visual tuning indication means is provided to facilitate such alignment. For this purpose

there is provided the electron discharge device 50 which may be a tube of the 6E5 type.

This type of tube is very well known in the art, and comprises, in general, a tube having a direct current voltage amplifier section and a controlled fluorescent target section. A common cathode 51 having two electron emission sections supplies electrons to both sections. The plate 52 of the amplifier section is connected to a source of positive potential through a resistor 53. The cathode 51 is connected to ground through a biasing resistor 54 which is shunted by I. F. bypass condenser 55. The input grid 56 of the amplifier section is connected by the direct current voltage connection 57 to the filter resistor 25, so that the signal-derived A. V. C. bias may be applied to grid 56.

The fluorescent target 60 is dish-shaped, and the pertinent cathode section is centrally located with respect to the interior face of target 60 which is coated with the fluorescent material. The electron deflection rod 61 is located between cathode 51 and the inner face of the target 60, and a rod 61 is connected by the direct current voltage connection 62 to the anode end of resistor 53. A lead 64 connects the target 60 to the opposite end of resistor 53 so that the target is maintained at a higher positive potential than plate 52. In the absence of received signal energy no direct current voltage is produced across resistor 19', and, therefore, the grid 56 has a bias equal to the voltage developed across bias resistor 54.

Hence, there is maximum space current flow through the amplifier section of tube 50, and the voltage drop across resistor 53 is a maximum. This results in the shadow rod 61 being far less positive than the target 60. As a result electrons flowing in proximity to rod 61 are deflected to a great extent from that portion of the inner face of target 60 adjacent the rod 61. As a result a wide non-luminescent area, or shadow band, is produced on the inner face of the target. This indicates that no station is being received, or that the receiver is not accurately tuned to the center frequency of any desired channel.

By imparting a response characteristic to I. F. circuits 15'—16'', as shown by the full line curve in Fig. 2, it is possible to have the shadow band on the target assume a very narrow appearance when the receiver is tuned to the center frequency of a desired channel. It will be noted that the response curve in Fig. 2 is single-peaked. Of course, circuit 12—13 may also have the single-peaker response characteristic if desired. Assuming, however, that it is the limiter input transformer which is given the response characteristic of Fig. 2, then the A. V. C. bias applied over lead 57 will not have a maximum value until the receiver is tuned to the center frequency of the desired channel of the signal frequency range of the receiver. At the center frequency, the maximum A. V. C. bias will cause the rod 61 to have minimum deflection effect on electrons flowing to the target, and, therefore, the shadow band width will be a minimum.

It is pointed out that the functioning of the visual indicator tube will not interfere in any way with the necessity for maintaining the I. F. energy input to the detector 31 free of amplitude modulation. Even though the response characteristic at 15'—16'' is single-peaked, yet the limiter action results in a flattening of the characteristic to the dotted line shown between points a—b of Fig. 2. The peak of the response

characteristic in Fig. 2 is flattened by the limiter action so that on any signal large enough to operate the limiter, side-band cutting will not be present. By virtue of this tuning indication device, and the single-peaked response characteristic at the point of the receiving system which develops the control voltage for the indicator tube, it is possible to utilize continuously variable tuning, and yet secure accurate tuning to the center frequency of each of the FM channels.

In order to secure muting control, or inter-channel noise suppression, the cathode of tube 32 can be connected by the direct current voltage connection 70 to the cathode end of biasing resistor 54. In the absence of signal energy, or in the presence of very weak signals, the voltage across resistor 54 will be a maximum. This means that the signal grid of tube 32 will have a high negative bias. The bias can be made sufficiently high so that tube 32 is biased substantially to plate current cut-off. Of course, when the desired channel is tuned in the voltage across resistor 54 will be a minimum, and will be sufficiently small so that the bias applied to tube 32 will be reduced to the proper operating negative bias value. In this way the amplifier section of the visual indicator tube performs the double function of controlling the electron deflection rod 61, and the effectiveness of the audio amplifier 32. Since in an FM receiver there is a large noise background in the absence of carrier, it is important to utilize a muting control. When carrier energy is received the normal and inherent noise reduction properties of the FM receiver will greatly reduce noise reproduction.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In a timing modulated carrier wave receiver, a limiter tube having a tuned input circuit including an impedance for deriving a direct current voltage from impressed waves, an electronic indicator tube of the fluorescent target type adapted to have a variable luminescent area provided thereon, means for applying said voltage to said tube to control the said area, said limiter input circuit having a single-peaked resonance curve demodulator having an input circuit coupled to the limiter output circuit, and said limiter acting to provide a substantially flat-

top response at said demodulator input circuit.

2. In a timing modulated carrier wave receiver, a limiter tube having a tuned input circuit including an impedance for deriving a direct current voltage from impressed waves, an electronic indicator tube of the fluorescent target type adapted to have a variable luminescent area provided thereon, means for applying said voltage to said tube to control the said area, and said limiter input circuit having a single-peaked resonance curve, a detector coupled to said limiter output circuit, and means responsive to said indicator tube for controlling the noise reproduction in the absence of received signals of a desired amplitude.

3. In a timing-modulated carrier wave receiver, a detection network for deriving from modulated waves a unidirectional voltage varying at the modulation rate, means for utilization of the voltage, means, responsive to a decrease of received waves below a predetermined amplitude, for rendering said utilization means ineffective, an amplitude modulation limiter preceding said detection network, said limiter having an input circuit whose response is substantially single-peaked, said last means being connected to said limiter to utilize unidirectional voltage derived by the limiter from said waves.

4. In a frequency modulated carrier wave receiver of the type comprising a plurality of cascaded resonant circuits broadly tuned to a desired carrier frequency, an amplitude modulation limiter tube coupled to the last of the cascaded circuits and deriving a direct current voltage from modulated waves, a visual voltage indicator device connected to said limiter tube for utilizing said voltage, and at least one resonant circuit preceding said limiter tube and following said cascaded circuits and having a single-peaked response characteristic.

5. In a receiver of timing modulated carrier waves, a transmission network of such waves having a relatively wide pass band to accommodate the maximum center frequency deviation, a detector having an input circuit, a limiter network constructed and arranged to reduce amplitude modulation effects in said waves and producing a unidirectional voltage from the waves, said limiter having an input circuit, coupled to said transmission network, which has a pass band sufficiently narrow to permit said voltage to maximize at accurate tuning of the receiver to a desired carrier, a voltage indicator device connected to utilize said voltage, said detector input circuit being coupled to the limiter output circuit, and said limiter output circuit having a pass band with a substantially flat top.

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