March 30, 1937. W. L. CARLSON 2,075,501

RADIO RECEIVING SYSTEM

Filed July 17, 1934 2 Sheets-Sheet 1

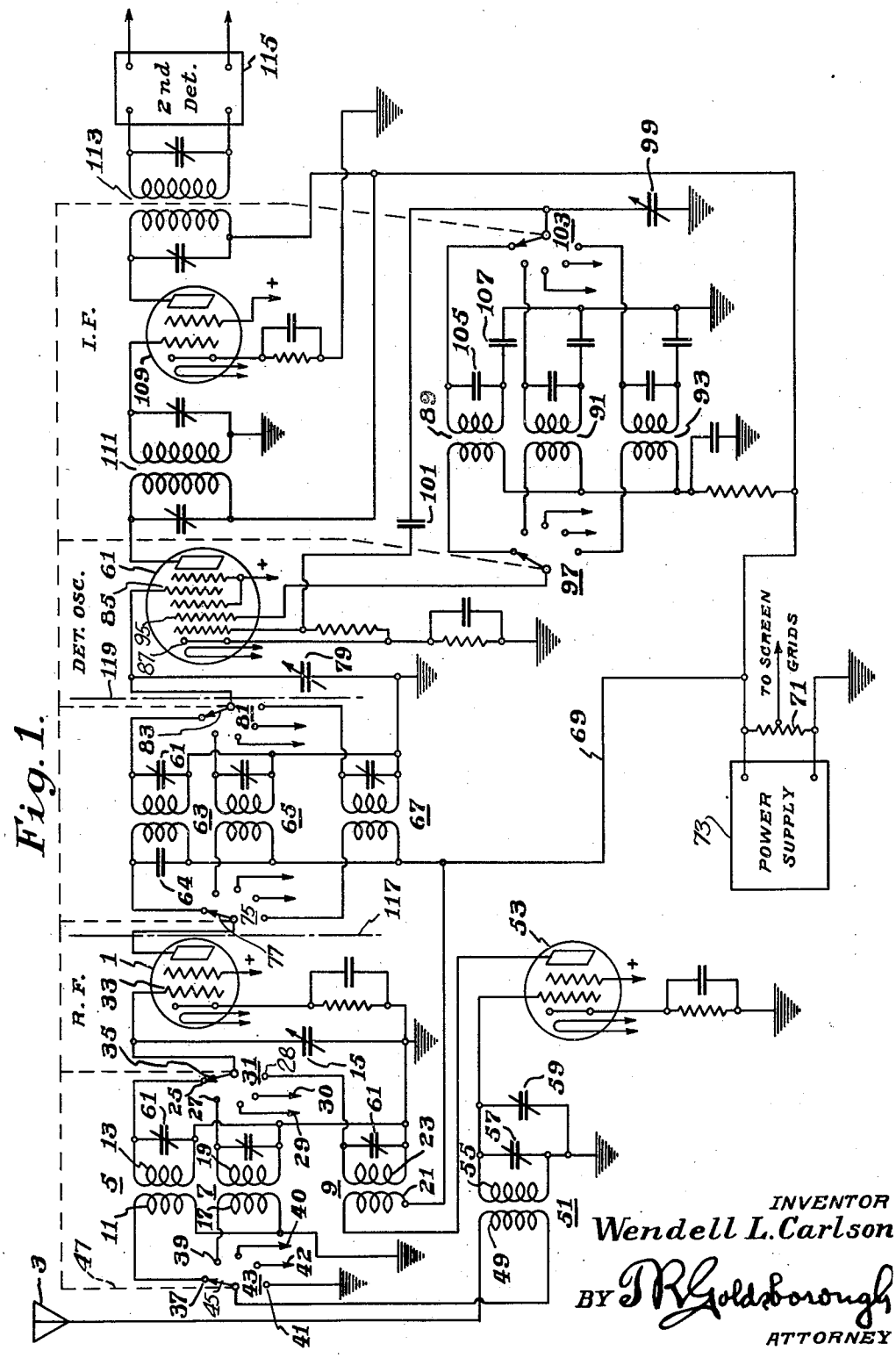

Fig. 1.

INVENTOR
Wendell L. Carlson
BY R. V. Goldsborough
ATTORNEY

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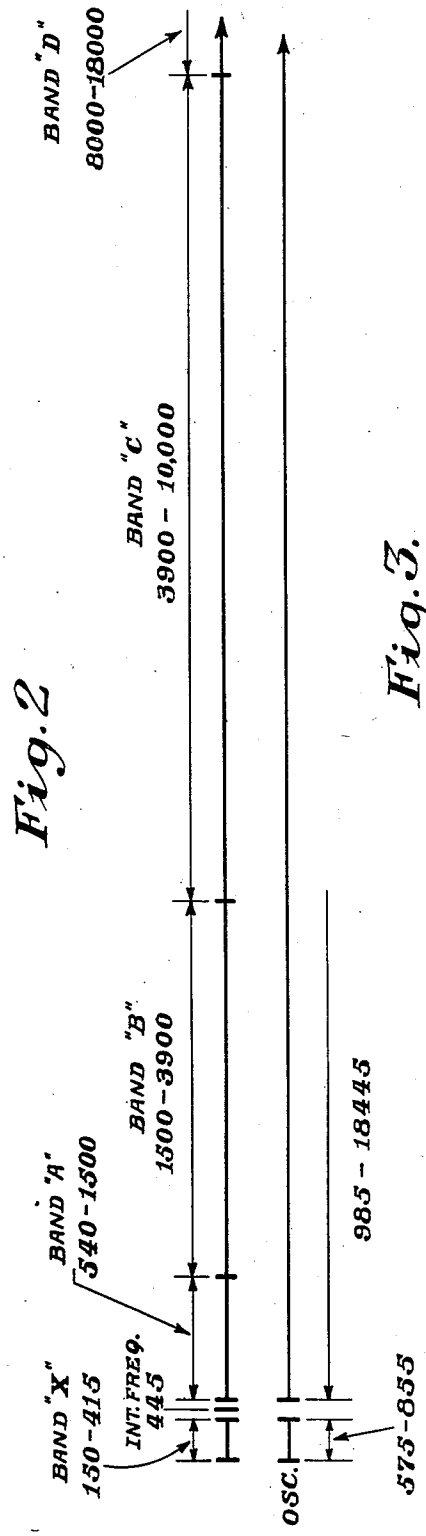

Fig. 2

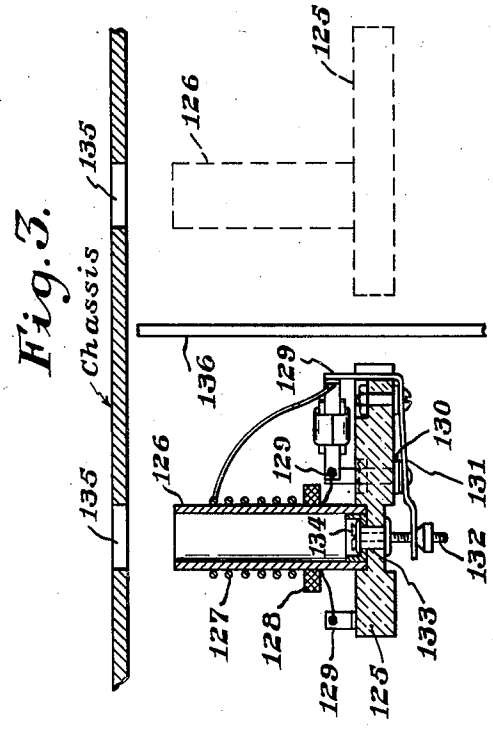

Fig. 3.

INVENTOR
Wendell L. Carlson
BY R. R. Goldsborough
ATTORNEY

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RADIO RECEIVING SYSTEM

Wendell L. Carlson, Haddonfield, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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7 Claims. (Cl. 250—20)

The present invention relates to superheterodyne radio receiving systems, and more particularly to receiving systems of that type wherein radio signals are selectively receivable in a plurality of differing signal wave or frequency bands.

A system of that character for uniform gain over a wide frequency range is shown, described and claimed in my co-pending joint application with Vernon D. Landon, Serial No. 691,594, filed September 30, 1933, Patent No. 2,024,816, Dec. 17, 1935, entitled Radio receiving systems, and assigned to Radio Corporation of America.

As shown in the above referred to application, it has been found that the tendency for the gain to vary for the different frequency ranges may be reduced to a certain extent by modifying the design of the amplifier coupling means, such as the amplifier coupling transformers for the lower frequency ranges or bands. Modification of the coupling units or transformer design is limited, however, by the preferred and desirable use of a common variable tuning element for all of the wave bands, such as a single gang tuning condenser, while obtaining substantially uniform amplification throughout the different wave bands.

It is also desirable to provide improved operation free from image frequency response over the various frequency bands, and accordingly, it is an object of this invention to provide an improved multi-range superheterodyne receiving system providing reduced image frequency response.

This is obtained by spacing certain of the signal bands and adjusting the intermediate frequency to a point between the spaced signal bands and, for certain purposes, at the same time providing that the second harmonic of the intermediate frequency lies between the corresponding oscillator tuning ranges for the spaced bands, as will hereinafter be described. This results in improved reduction of image frequency response and provides a tuning system which may more easily be initially tuned and adjusted for gang variable tuning.

It is also an object of the present invention to provide an improved superheterodyne receiver having an improved relation between the intermediate frequency and the signal, oscillator and image frequency ranges, whereby interference is reduced to a minimum and a relatively high degree of amplification is obtained at the intermediate frequency.

It is also a further object of the invention to provide an improved signal-frequency-band selecting system whereby the intermediate frequency amplifier may be tuned to a single intermediate frequency lying between two of the signal frequency bands, thereby to provide a reduced image frequency response and easier alignment of the oscillator at the higher frequency bands.

It is also an object of the invention to provide an improved multi-range superheterodyne radio receiver, having an improved tuning inductance system.

In practicing the invention, in one embodiment thereof, there is provided a plurality of tuned radio frequency transformers in each radio frequency amplifier stage, and switching mechanism for connecting the proper transformer into the amplifier circuit for each frequency band, in connection with a common gang tuning condenser. The intermediate frequency is so chosen that a single frequency may provide suitable amplification for all of a plurality of wide wave bands without interfering with the bands or permitting image frequency response interference. Furthermore, each of the transformers is individually adjustable through the shielding of the receiver or apparatus chassis.

Other objects, features and advantages of the invention will appear from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a circuit diagram of a portion of a superheterodyne radio receiver constructed in accordance with one embodiment of the invention;

Fig. 2 is a diagram illustrating the relation of the intermediate frequency to the various wave bands for the incoming signals and the oscillator; and

Fig. 3 is a sectional side view, substantially full size, of one of the radio frequency transformers shown in Fig. 1.

Referring to Fig. 1, the receiver is of the superheterodyne type and may be a receiver of that type as described in my above-named copending joint application, wherein a radio frequency amplifier 1 having an input circuit may be coupled to an antenna 3 through any one of a plurality of transformers 5, 7, and 9.

A transformer is provided for each frequency band that is to be covered, the number of transformers which are employed depending upon the width of the frequency range to be covered by the receiver.

In Fig. 1, the receiver is shown designed for operation over three or more frequency bands. Transformer 5, having a primary winding 11 and a secondary winding 13, is designed to cover one

frequency band in conjunction with the common variable tuning condenser 15. Transformer 7, having a primary winding 17 and a secondary winding 19, is designed to cover a higher frequency band, and transformer 9, having a primary winding 21 and a secondary winding 23, is designed to cover a still higher frequency band. The common tuning condenser 15 is used for tuning each transformer secondary through each band, as will be seen hereinafter.

The lower ends of the secondary windings 13, 19, and 23 are connected to ground and to one terminal of the tuning condenser 15. The upper ends of the secondary windings 13, 19, and 23 are connected to the switch points 25, 27, and 28, respectively, of a switch 31 which forms part of one section of a gang switch. The upper ends of these secondary windings may be selectively connected to the upper terminal of the variable condenser 15 and to the control electrode 33 of the radio frequency amplifier 1 through a switch arm 35.

Additional frequency bands may be covered by similar connections to additional switch points as indicated at 29 and 30, the complete connections thereto being omitted for the purpose of simplifying the drawings.

The lower ends of the primary windings 11, 17, and 21 are connected to ground, while their upper ends are connected to the switch points 37 and 39 of a switch 43 which forms a second part of a section of the above-mentioned gang switch. These primary windings may be selectively connected to the antenna 3 through a switch arm 45 which is operated simultaneously with the switch arm 35 through a uni-control connection indicated by the dotted line 47. Additional primary windings may similarly be connected to additional switch points indicated at 40 and 42.

The switch arm 45 is not connected directly to the antenna 3, but, instead, is connected to the antenna through the primary winding 49 of a transformer 51, included in the input circuit of a second radio frequency amplifier 53. This is for the purpose of connecting the second amplifier 53 in cascade with the radio frequency amplifier 1 when the receiver is set for operation on the highest frequency band, to increase the gain in that band to the level of the other lower frequency bands.

The coupling of the output circuit of the amplifier 53 to the input circuit of the radio frequency amplifier 1 is provided through the transformer 9, the primary winding 21 of which is included in the plate circuit of the amplifier 53.

In the input circuit of the amplifier 53, the secondary winding 55 of the transformer 51 is provided with the usual trimmer condenser 57 and with a tuning condenser 59 which last condenser may be varied simultaneously with the tuning condenser 15 through a suitable common control connection.

The lower contact point 41 of the switch 43 is connected to ground whereby the primary winding 49 is connected directly between the antenna 3 and ground when the receiver is set for reception on the high frequency band.

It will be noted that the amplifier 53 is ineffective when operating over the lower frequency bands since the secondary winding 23 of the transformer 9 is not connected to the input of the radio frequency amplifier 1. Although the primary winding 49 is connected in series with the primary windings 11 and 17 of the transformers 5 and 7 when operating over the lower frequency bands, this does not produce any detrimental effect since the inductance of the primary winding 49 is comparatively low.

When the receiver is set for operation on the highest frequency band, the switch arm 45 is grounded through contact point 41 and the other switch arm 35 connects the secondary winding 23 to the input circuit of the radio frequency amplifier 1, whereby the two amplifiers 1 and 53 are connected in cascade.

Attention is called to the fact that since the switch arm 45 is grounded when the amplifiers 1 and 53 are in cascade, there is no possibility of regeneration due to capacity coupling between the two switches or switch sections of the same gang. It should be noted that if a conventional switching arrangement were employed, the switch arm 45 and lower contact point 41 would be connected to the high potential end of a primary winding and undesirable regeneration would result.

The radio frequency amplifier 1 is provided with an output circuit which is coupled to the input circuit of a first detector 61 through one of a plurality of radio frequency transformers 63, 65, and 67. The lower ends of the primary windings of these transformers are connected through a conductor 69 to a positive point on the voltage divider 71 of a power supply 73. The upper ends of these primary windings are connected to the switch points of a switch 75, whereby they may be selectively connected to the anode of the radio frequency amplifier 1 through a switch arm 77.

The lower ends of the secondary windings of transformers 63, 65, and 67 are connected to ground and to the lower terminal of a variable tuning condenser 79. The upper ends of these secondary windings are connected to the switch points of a switch 81, whereby they may be selectively connected through a switch arm 83 to the upper terminal of the tuning condenser 79 and to the control grid 85 of the first detector 61.

The secondary windings of the transformers 63, 65, and 67, as well as the secondary windings of the transformers 5, 7, and 9, are shunted by the usual trimmer condensers, indicated at 61, for the tuning condensers 79 and 15. The primary winding of transformer 63 is shunted by a condenser 64 for lowering the gain of the receiver when set at the low frequency band so that the gain will be the same at all three frequency bands.

The vacuum or electric discharge tube elements of the superheterodyne oscillator are included in the same evacuated envelope with the tube elements of the first detector 61, the oscillator and first detector having a common cathode 87. Coupling between the oscillator and the first detector 61 is provided by having the oscillator elements and the detector elements in a common electron stream.

The oscillator is of the type in which the plate circuit is coupled to the grid circuit through a transformer and in which the frequency is determined by the tuning of the grid circuit. In the receiver illustrated, a separate feed-back transformer is provided for each frequency band to be covered by the receiver, these transformers being identified by the reference numerals 89, 91, and 93. Thus, for the lowest frequency band, the primary of the transformer 89 is connected in series with the power supply and the plate 95 of the oscillator by means of a switch 97, and the

secondary of the transformer 89 is connected to a tuning condenser 99 and to the grid circuit of the oscillator through a coupling condenser 101 by means of a switch 103.

In each frequency band the oscillator frequency may be varied by means of the variable tuning condenser 99 which is preferably operated simultaneously with the other variable tuning condensers through any suitable common control such as the usual gang tuning control. The secondary winding of the transformer 89 is provided with a trimmer condenser 105 and with a series tracking condenser 107 in accordance with well known practice. The secondary winding of transformers 91 and 93 are similarly provided with trimmer condensers and series tracking condensers.

The intermediate frequency output of the first detector is fed to an intermediate frequency amplifier 109 through an intermediate frequency transformer 111. The output of the intermediate frequency amplifier 109 is fed through another intermediate frequency transformer 113 to the second detector 115.

From the foregoing description it will be seen that a plurality of coupling transformers are provided in conjunction with the radio frequency detector and oscillator stages. For a five band tuning system, 15 separate transformers are provided. It is obvious that such transformers must be of small compact construction to be embodied in a small receiver chassis of small dimension. The trimmer or band adjusting condensers, indicated at 61, are incorporated in the transformer design and are arranged for easy adjustment from the exterior of the chassis as will hereinafter be explained.

The switches for selecting the various transformers for different receiving bands are gang connected for simultaneous operation, as indicated by the dotted line connection for the various switches in the drawings.

The type of transformer which has been found to be suitable for use in a receiving system of the type shown in Fig. 1, is shown in Fig. 2, to which attention is now directed. Referring to Fig. 2, the various transformers are of substantially duplicate construction except for the number of turns on the windings. Each transformer comprises an insulating base 125 on which is mounted a small diameter insulating tube 126 providing a coil form, for supporting a secondary winding 127 and a primary winding 128 in coaxial coupled relation to each other. The leads from the primary and secondary are connected to suitable terminals mounted on the insulating base, some of which terminals are indicated at 129. A trimmer condenser for the secondary winding is provided by two insulated metallic strips or plates 130 and 131, mounted on the opposite face of the base and arranged to be drawn into adjusted relation to each other by a screw 132 extending through a tapped ferrule 133 in the base. The screw and ferrule are aligned with the tubular opening in the form 126 as shown, whereby the screw driver head 134 of the adjusting screw may be engaged through the upper end of the tube 126.

In the receiver, the transformers are mounted adjacent to an outer or bottom chassis wall in suitable rows or groups after the manner indicated in the drawings, with or without shielding 136 therebetween. The tubular openings in the coil forms 126 are in alignment with openings 135 in the chassis through which an adjusting screw driver (not shown) may be inserted for adjusting the condenser while the transformer is located in the shielded chassis and is in operation.

This arrangement has the advantage that the adjusting openings for the various transformers may be grouped in the bottom of the chassis, for example, and all adjustment for the tuning of the transformers for the various bands may be made at the same time from the same location on the receiver.

Furthermore, the coil form 126 is of such small diameter and is so arranged that it forms a guide tube for an adjusting device or screw driver when inserted through the opening 135, for adjusting the trimmer condenser on the transformer base.

By making the coil form of relatively small diameter, the electro-magnetic field is reduced to such a point that a relatively simple shield is required between the coils or transformers, which permits the receiver design to be more compact without introducing undesired feed-back or coupling.

Referring now to Fig. 3, the relation and extent of the various wave bands to which the receiver is tunable are indicated diagrammatically at A, B, C, D, and X, together with the oscillator bands and intermediate frequency. The intermediate frequency is so selected that it lies between two of the bands, in this case, between the bands X and A which are spaced apart in frequency. It should also be noted that the corresponding oscillator bands to produce the said intermediate frequency are also spaced apart.

With this arrangement of intermediate to oscillator and signal frequency bands, the image frequency is always spaced sufficiently widely to prevent the production of the intermediate frequency and interference therefrom.

In the present example, for band A, the intermediate frequency is lowest followed by the signal frequency, the oscillator frequency and the image frequency in that order, the signal frequency being below the oscillator frequency range and the intermediate frequency being below the signal frequency range.

For band X the signal frequency is lowest followed by the oscillator frequency and then the image frequency, with the intermediate frequency located between the signal and oscillator frequency ranges. Referring to Fig. 1 in conjunction with Fig. 3, the receiver is adjusted for reception in the band X when the switch 45 is connected through the point 37, and the other switches are similarly adjusted to the corresponding contacts. Likewise, the band A corresponds to the point 39 and band D corresponds to the point 41, with the bands B and C insertable therebetween in conjunction with the contact points 40 and 42.

While the invention has been described in conjunction with a 5 band superheterodyne receiving system, it is obvious that it may be embodied in the other superheterodyne receiving systems having a greater or less number of bands, and it may be utilized in conjunction with a plurality of receiver stages adapted to be tuned through the same frequency ranges by common tuning means such as a gang condenser.

I claim as my invention:

1. In a coupling transformer for high frequency amplifiers and the like, frequency adjusting means comprising a tuning capacitor having a rotatable adjustment device and a coil form having a relatively small internal diameter there-

by to cooperate therewith as a guide for an adjusting tool for said adjusting device.

2. In a superheterodyne receiver, the combination of oscillator and detector means tunable simultaneously through differing frequency ranges to produce a predetermined intermediate frequency, and an intermediate frequency amplifier tuned to respond to signals at said intermediate frequency, which intermediate frequency lies between two of the frequency ranges through which the detector means is tunable, and the second harmonic of the intermediate frequency lying between two of the frequency ranges through which the oscillator means is tunable.

3. In a superheterodyne receiving system, the combination with a plurality of tunable coupling transformers, of adjusting condensers for each of said transformers mounted thereon and including an adjusting screw, and each of said transformers comprising a tubular coil form of relatively small diameter aligned with said adjusting screw to provide a screw driver guide therefor.

4. In a superheterodyne receiving system, the combination with a plurality of tunable coupling transformers, of an individual adjusting condenser for each of said transformers mounted thereon and including an adjusting screw, and a tubular coil form of relatively small diameter aligned with said adjusting screw to provide a screw driver guide therefor, and shielding means for said transformers providing a casing wall having openings in alignment with the axes of said tubular coil forms.

5. In a superheterodyne receiving system, the combination as defined in claim 4, further characterized by the fact that the transformers are mounted in a group having the coil forms arranged in axially parallel relation to each other thereby to group the openings in the shielding means in alignment with the axes of the tubular coil forms and to facilitate adjustment through said openings and through the coil forms as guides.

6. In a superheterodyne receiver, having a predetermined intermediate frequency, the combination of means for tuning said receiver through differing frequency ranges above and below, but not including, said intermediate frequency, and an oscillator simultaneously tunable therewith above and below a harmonic of the intermediate frequency to provide said intermediate frequency for each frequency range.

7. In a radio receiving system having an intermediate frequency amplifier, a plurality of signal receiving circuits tunable through differing frequency ranges above and below the frequency response range of said intermediate frequency amplifier, and certain of said tunable circuits being further tunable through frequency ranges above and below a range of harmonic frequencies of said response range of the intermediate frequency amplifier.

WENDELL L. CARLSON.