

July 4, 1939.

C. D. KENTNER

2,164,745

INTERMEDIATE FREQUENCY AMPLIFIER

Filed Oct. 31, 1934

6 Sheets-Sheet 1

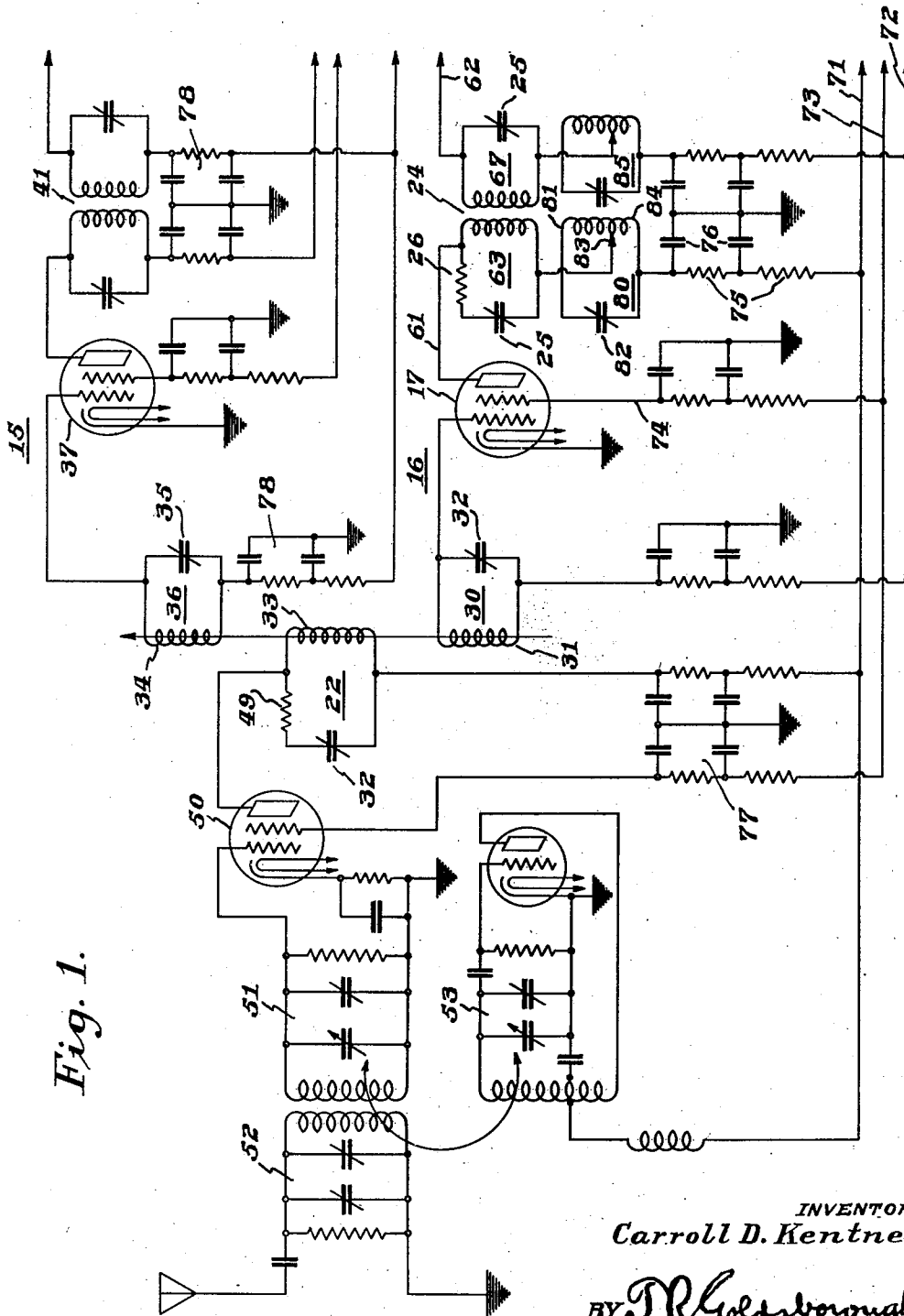


Fig. 1.

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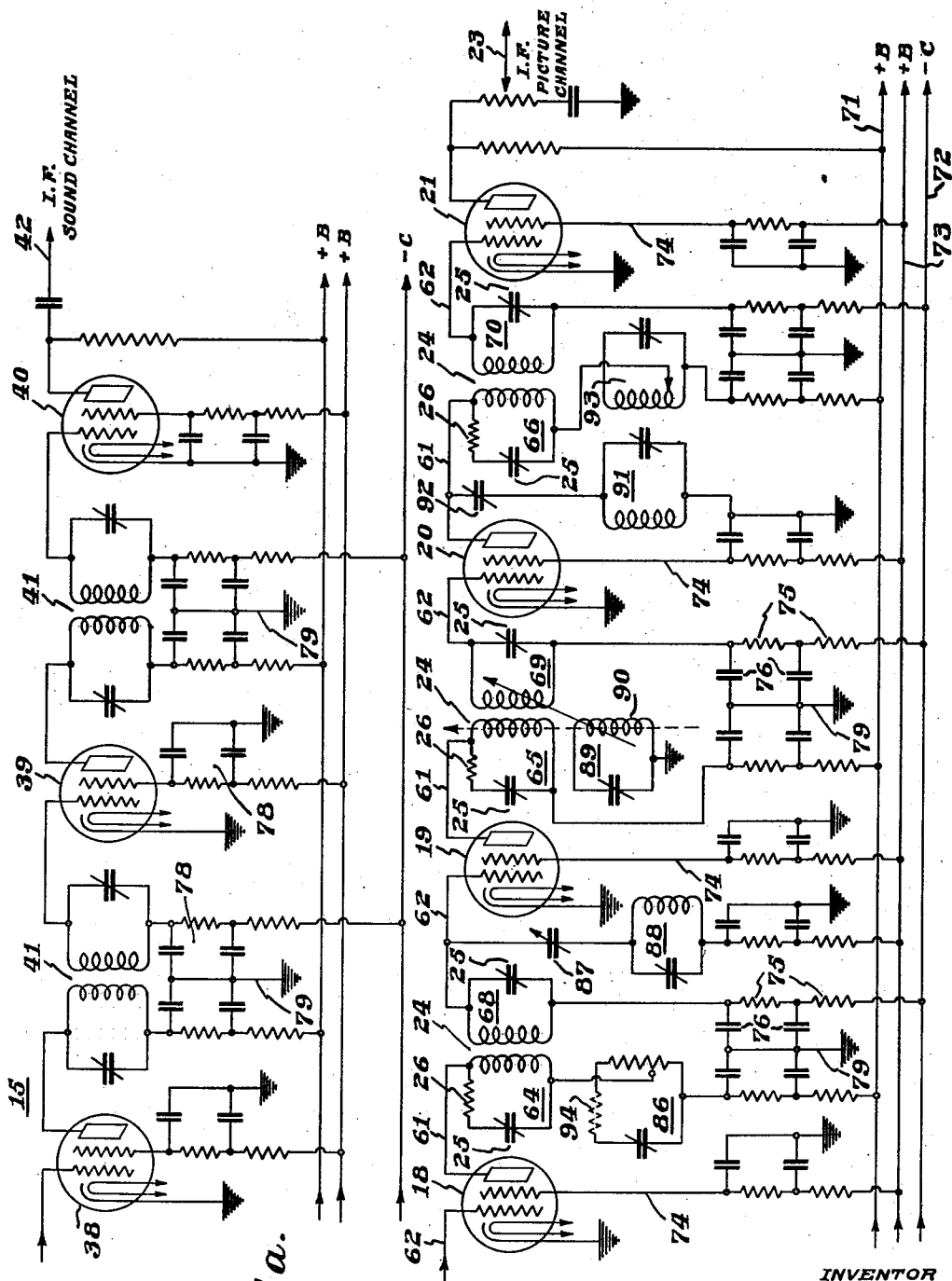
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6 Sheets-Sheet 2



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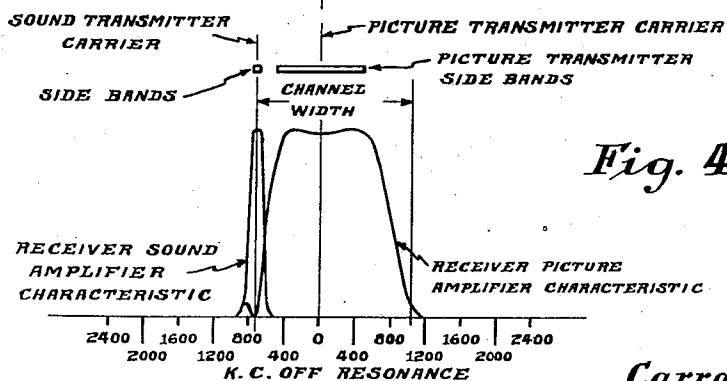
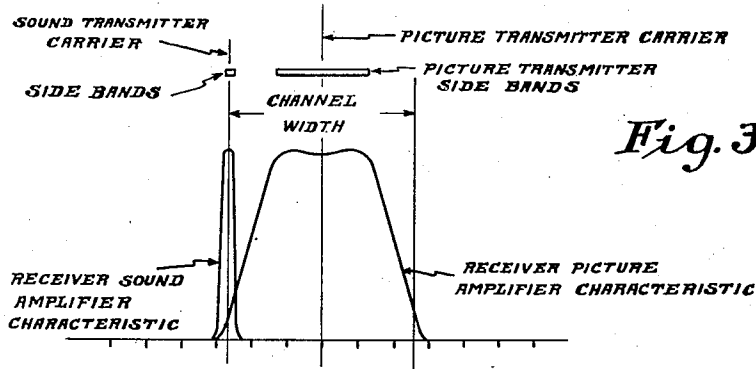
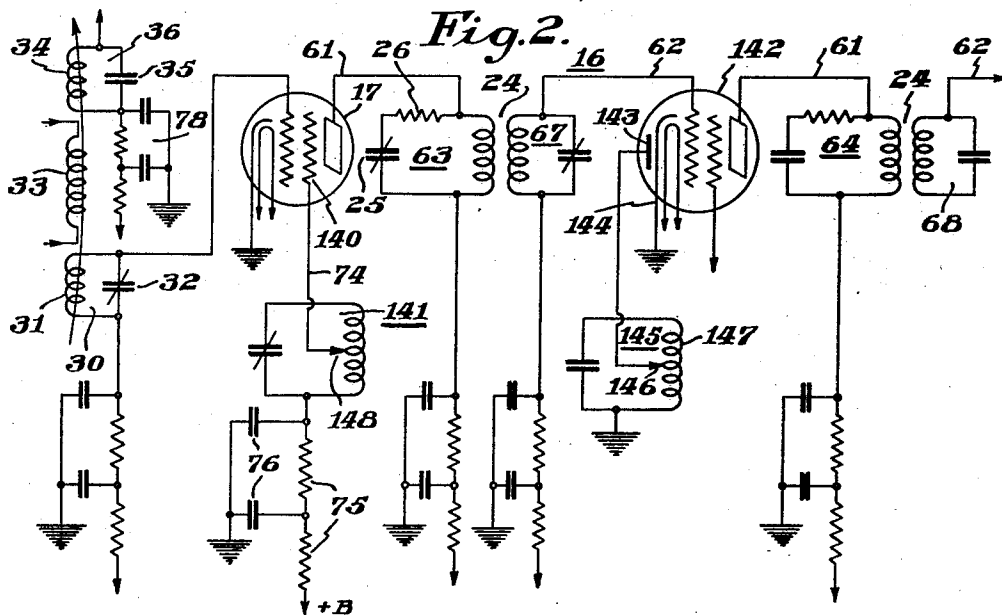
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6 Sheets-Sheet 3



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Fig. 5.

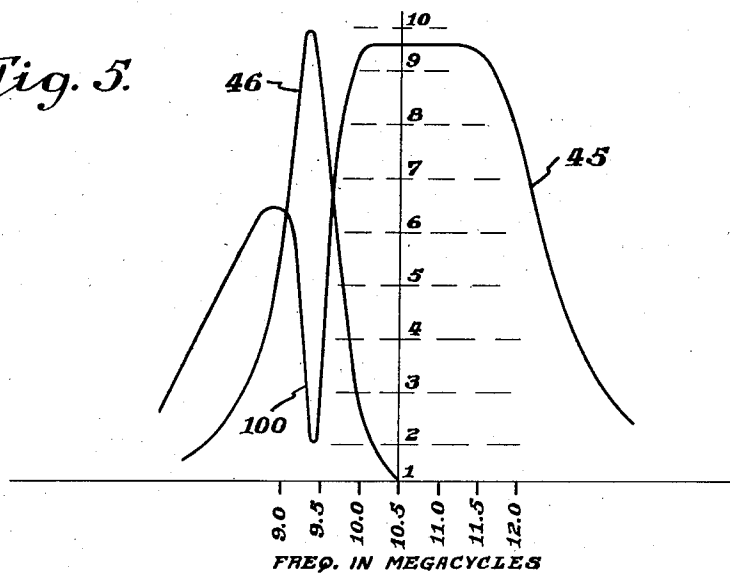
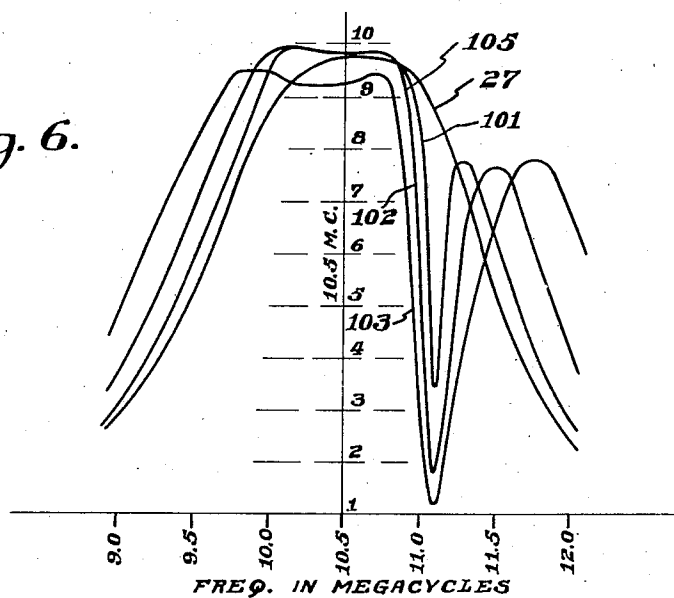


Fig. 6.



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Fig. 7.

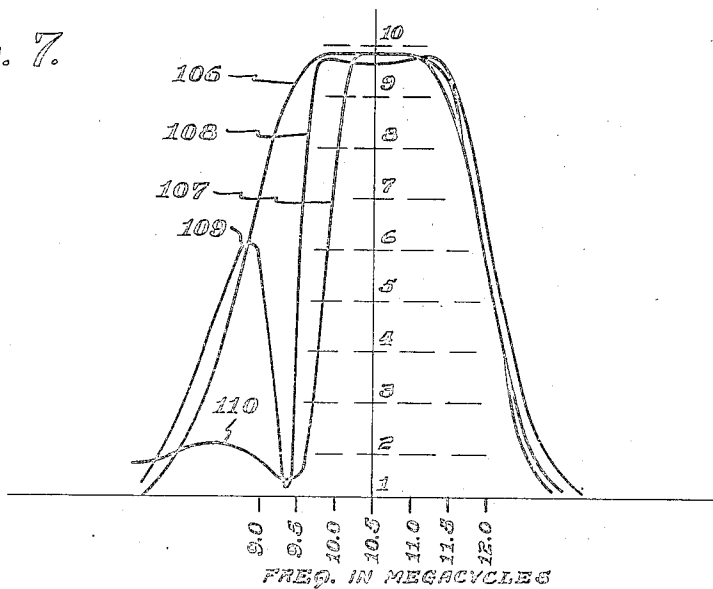
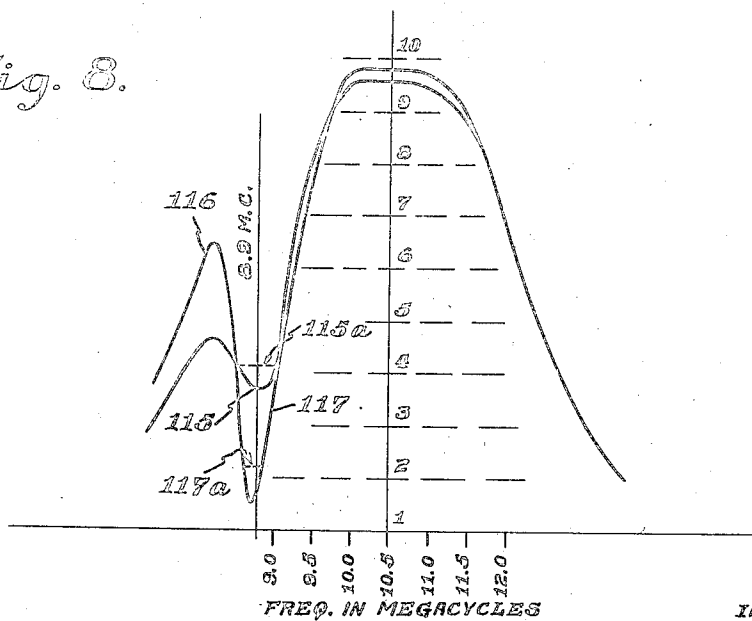


Fig. 8.



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INTERMEDIATE FREQUENCY AMPLIFIER

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Fig. 9.

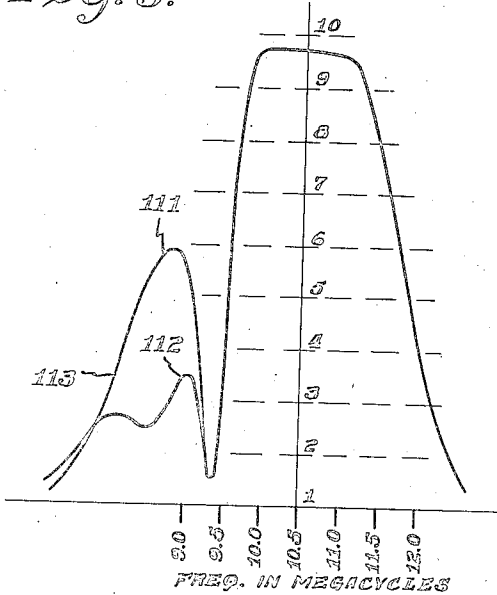


Fig. 10.

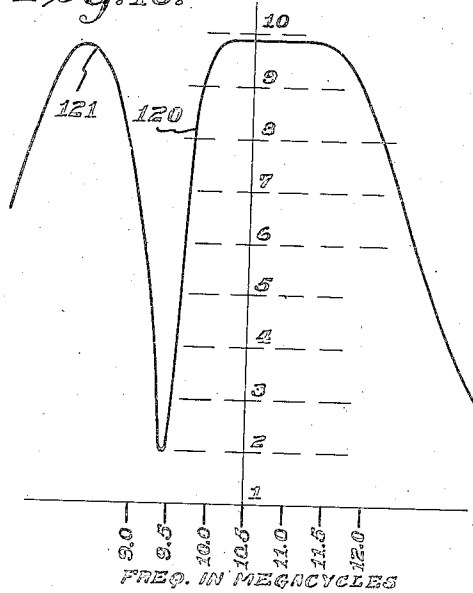


Fig. 11.

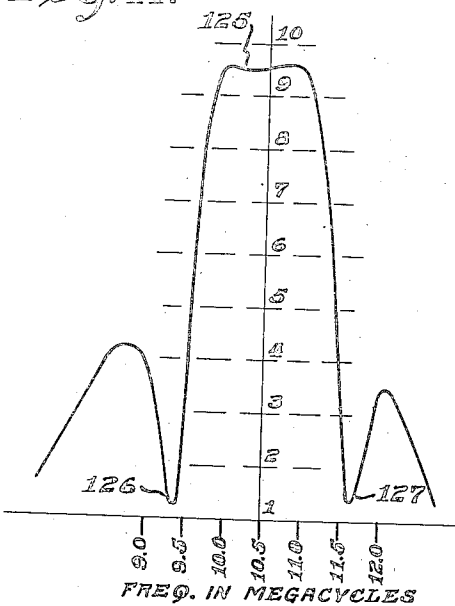
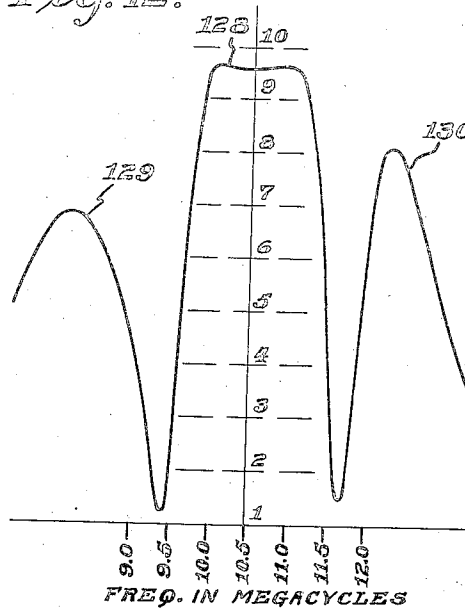


Fig. 12.



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UNITED STATES PATENT OFFICE

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INTERMEDIATE FREQUENCY AMPLIFIER

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Application October 31, 1934, Serial No. 750,770

12 Claims. (Cl. 178—5.8)

The present invention relates to intermediate frequency amplifiers for superheterodyne receiving systems, and more particularly to high frequency intermediate frequency amplifiers for amplifying a plurality of signals in adjacent frequency channels. An amplifier embodying the invention is, therefore, particularly adapted for use in television receiving systems wherein the sound and the picture are transmitted on separate but adjacent carrier frequencies, but it is not limited thereto.

The total channel width, required for one complete sound and picture transmission of given fidelity and detail, depends upon the frequency spacing necessary between the two carriers, and likewise, on the guard band required between the picture carrier and the sound carrier of an adjacent sound-picture combination channel. It is desirable to keep this channel narrow in order to make available as large a number of channels as possible in a given television band. This requirement applies to any amplifier system having the same or similar multi-channel signal transmission, the channels being closely adjacent in frequency.

In television receiving systems and the like, one signal channel in the intermediate frequency amplifier may occupy a relatively wide frequency band, such as the picture amplifying channel, while the adjacent channel or channels may occupy relatively narrow frequency bands, such as the sound amplifying channel. For example, the sound amplifier band width may be 30 kilocycles while the picture band width may be 1500 kilocycles.

In high frequency amplifiers requiring a wide band pass, such as in the intermediate frequency amplifier of a television receiver, it is necessary to utilize a comparatively large number of amplifier stages, each comprising an electric discharge amplifier or tube provided with suitable tuned input and output circuits to obtain proper gain as well as selectivity, as indicated by steepness of the sides of the over-all amplification characteristic.

It is an object of the invention to provide an amplifier of the above type wherein each of a plurality of the amplifier stages is tuned for relatively broad response, while comparatively a flat response over the pass portion or frequency band over which the amplifier is desired to be responsive is provided.

The invention relates further and more specifically to intermediate frequency amplifier systems wherein the tuned input and output circuits

for the amplifier tubes include the coupling windings of suitable interstage transformers and tuning means therefor, providing a series of fixed-tuned, coupled, amplifier circuits. In accordance with the invention, a relatively large number of such amplifier stages are provided as above pointed out, and the tuning response of each is caused to be individually broad to obtain a desired over-all characteristic hereinafter described.

It is, therefore, a further object of this invention to provide a multi-channel intermediate frequency amplifier wherein a desired over-all response characteristic is obtained with fixed-tuned transformer interstage coupling and with individually broadly tuned circuits.

It is a still further object of this invention to provide, in an intermediate frequency amplifier of the type above referred to, means for increasing the over-all selectivity characteristic, and, more particularly, to decrease the response to signals on either or both sides of and adjacent to the widest band of signal frequencies to be transmitted through the amplifier, including the side bands, to permit signals in relatively narrow frequency bands to flow through said amplifier in adjacent and normally overlapping channels. In a television receiver, for example, the signal response on either or both sides of the picture intermediate frequency band in the intermediate frequency amplifier channel is reduced to permit the sound carrier or intermediate frequency to flow in a channel closely adjacent in frequency, without interference.

In carrying out the above and further objects of the invention hereinafter pointed out, a plurality of auxiliary circuits are provided in conjunction with the interstage coupling transformers and associated fixed-tuned circuits, each of the auxiliary circuits being loosely coupled to the said fixed-tuned circuits, in a plurality of stages. The auxiliary circuits may be capacitively or magnetically coupled to the signal circuits and arranged to provide circuits more generally known as absorption circuits, or such auxiliary circuits may be conductively coupled to the signal circuits, and may be arranged to provide a series of frequency traps. The auxiliary circuits are tuned preferably more sharply than the signal transmission circuits with which they are loosely coupled and the coupling may be conductive, magnetic or capacitive with the input, the output or associated circuits of a particular amplifier tube or amplifier stage for the purpose of attenuating signals at a certain frequency or

within a band of frequencies or within the scope of the frequency coverage of the main interstage transformer characteristic as will hereinafter be described, and such attenuation circuits will be referred to hereinafter as rejector or trap circuits.

It is a further object of the invention to provide, in a multi-channel intermediate frequency amplifier, comprising fixed-tuned circuits and interstage coupling transformers, a plurality of loose coupled auxiliary circuits, tuned to a frequency or a narrow band of frequencies closely adjacent to or lying within a portion of the characteristic curve of a relatively wider signal band of frequencies passed by the amplifier to increase the selectivity thereof and to separately amplify signals in said narrow band or at a single frequency on either or both sides of said wider band of frequencies.

It will be understood that the present invention is adapted to systems of the above character wherein a frequency band of signals to be rejected is narrow compared with the frequency band of signals to be passed by the amplifier circuits and the interstage transformers. As a present preferred embodiment of the invention, various auxiliary loosely coupled circuits providing rejectors or traps in association with the broadly tuned individual interstage circuits may be provided to obtain a given band width and a given attenuation of a broad or narrow band of signals within the normal band or immediately adjacent to the normal band of signals passed by the main interstage transformer channel.

The invention is particularly applicable to television receivers, and, accordingly, it is a still further object of the invention to provide an intermediate frequency multi-channel amplifier for television receivers and the like arranged as above described, wherein the voltage developed in trap circuits associated with the main picture channel or other relatively wide band amplifier may be used to supply signals at the rejected adjacent channel mean frequency or a relatively narrow frequency band to an amplifier for an adjacent sound channel.

It is a still further object of the invention to provide a superheterodyne type of receiver for television reception wherein sound is transmitted by a separate carrier adjacent to the picture carrier, with means for preventing the sound carrier or sound modulation from mixing with the picture signal in the amplifier system and thus causing interference patterns to appear on the finally projected picture.

The point of rejection or the mean rejection frequency is made to coincide with the frequency of adjacent channel carriers or intermediate frequency signals to prevent interference and to increase the selectivity of the main amplifier channel. In television receivers, for example, the point of rejection, in connection with the relatively wide picture intermediate frequency signal band, is preferably at the sound intermediate frequency. The sound signal voltage in the trap or auxiliary absorption circuit, may then be utilized to supply the sound intermediate frequency amplifier as pointed out hereinbefore. The system, is, therefore, readily adapted to plural channel fixed-tuned amplifiers in which the frequency band to be rejected is relatively narrow with respect to the frequency band to be passed by one of the intermediate frequency channels or main intermediate frequency channel.

The invention will, however, be better under-

stood from the following description when taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the drawings, Figures 1 and 1a combine to show a schematic circuit diagram of a signal receiving circuit and intermediate frequency amplifier system of a superheterodyne receiver adapted for television reception and embodying the invention.

Fig. 2 is a circuit diagram of a portion of the diagram of Fig. 1 showing a modification of the invention.

Figs. 3 and 4 are curve diagrams showing the effect upon the channel width of a signal receiving system embodying the invention, and

Figs. 5 to 12, inclusive, are curve diagrams illustrating the response characteristic for various circuits arranged in accordance with the invention.

Referring to Fig. 1, the circuit diagram illustrates a receiving system having two intermediate frequency amplifier channels 15 and 16, and represents any receiver having a plurality of separate intermediate frequency amplifier channels wherein signals in adjacent frequency bands may be amplified. The amplifier 10 is provided with a plurality of amplifier stages including electric discharge amplifier devices 17, 18, 19, 20 and 21, coupled in cascade relation between a signal input circuit 22 and an output circuit represented by a lead 23. Interstage coupling transformers 24 are employed between the tubes and are preferably tuned on both the primary and secondary sides by suitable adjustable condensers 25, to a predetermined intermediate frequency. In the present example the intermediate frequency of the amplifier channel 15 may be between 9 to 9.5 megacycles, for example, and that of the amplifier channel 16 may be between 10.5 to 11.5 megacycles.

The amplifier 16 is fixed-tuned after the condensers 25 are adjusted, to bring the various circuits into resonance at the desired intermediate frequency. It will be noted that in each of the primary circuits, a resistor 26, representing any suitable lossy means, is provided for broadening the frequency response characteristic of the individual stage, whereby each stage is broadly responsive to a relatively wide frequency band. A characteristic resonance curve shows relatively low selectivity as indicated by the curve 27 in Fig. 6.

In providing an amplifier having relatively broad tuning in the individual stages, a plurality of stages are required for obtaining an over-all desired degree of selectivity. In the present example, five stages have been shown, although fewer or more stages than is illustrated, may be used depending upon the character of the signal to be transmitted through the main channel, which may be taken as channel 16 in the present example and in a television receiver as the picture amplifier channel.

In general, however, the amplifier consists of a plurality of fixed-tuned amplifier stages, transformer coupled, and providing in at least one stage means for broadening the individual frequency response of the stage, whereby the fidelity is improved by the broadness of the response characteristic and a degree of selectivity is obtained through the use of a series of stages.

The receiver output circuit 22 is coupled to the first intermediate frequency amplifier tube 17 of the amplifier 16, through a transformer having

a primary winding 33 in the output circuit 22 and a secondary winding 31 in a tuned input circuit 30 for the tube 17. The output circuit 22 and the input circuit 30 are tuned by condensers 32 to the desired intermediate frequency. The circuit 22 is broadly responsive to both the sound and picture signals while the circuit 30 is broadly responsive to only the picture frequency band.

The receiver output circuit 22 is also coupled to the second intermediate frequency amplifier 15 through a secondary winding 34 of the same transformer which provides with a tuning condenser 35 a tuned input circuit 36 for the amplifier tube 37 of the amplifier 15.

The latter amplifier comprises a series of amplifier tubes 38, 39 and 40 including the input tube 37, having suitable interstage coupling means 41 and having an output circuit represented by the output lead 42. The amplifier represents any suitable intermediate frequency amplifier for a relatively narrow frequency band of operation as compared with the frequency band of operation of the amplifier 16, and closely adjacent thereto in frequency.

Other amplifier channels may similarly be provided in connection with the output circuit 22 and suitably coupled thereto, and may be tuned above or below the frequency band covered by the amplifier channel 16. The amplifier channel 15 may be tuned to a frequency such as 6 megacycles, while the channel 16 may be tuned to a frequency broadly including 7 megacycles, or, as indicated in Fig. 5, the amplifier channel 16 may be tuned to have a response characteristic indicated by the curve 45 with a mean frequency of 10.5 megacycles, while the channel 15 is tuned as indicated by the curve 46, to a frequency of substantially 9.5 megacycles.

The output circuit 22 is supplied with signals for both amplifier channels from any suitable receiver means. In the present example, a suitable receiver is represented by a detector tube 50, a tuned input circuit 51 therefor coupled to a tuned antenna circuit 52 and to an oscillator circuit 53.

The circuits 51 and 52 are tuned broadly whereby signals for both the amplifier channels are permitted to pass through and to be amplified by the tube 50, and combined with the oscillator signals from the circuit 53. In a television receiver, the sound carrier is heterodyned into the sound intermediate frequency system 15 and simultaneously the picture carrier is heterodyned into the picture intermediate frequency system 16. Each intermediate frequency amplifier is caused to be sufficiently broad in its response characteristic, to accommodate the side bands accompanying the carrier which it must pass. As hereinbefore stated, for the sound amplifier, this band may be 30 kilocycles wide, and for the picture amplifier, it may be 1500 kilocycles wide. However, any suitable receiving system for applying the received signals to the respective channel may be provided although, for television reception, the system shown is at present preferred.

Referring now to Figs. 3 and 4, the receiver sound amplifier characteristic such as the amplifier characteristic for the channel 15 and the receiver picture amplifier characteristic such as the characteristic of the channel 16 are indicated in Fig. 3 and it will be noted that the channel width of both the sound and picture signal together with the side bands is relatively wider than the corresponding curves in Fig. 4, the scale associated with Fig. 3 and the legend for each element of the curves indicating the characteristic.

In Fig. 4, the sound and picture characteristic are contained within narrower limits about the resonance point or mean frequency indicated by the line extending from zero on the scale and it will be noted that the side of the picture characteristic in Fig. 4 is improved in slope and approaches the more ideal form for a flat top and straight sides, while the sound channel is separated therefrom sufficiently to permit of effective amplification of both signals in a duo-channel amplifier such as is indicated in Fig. 1.

Fig. 3 also shows the scope of the frequency coverages of the main or picture interstage transformer characteristic with sound carrier located as closely as possible without interference. In accordance with the invention, means are provided in the amplifier for increasing the steepness of the sides of the above characteristic without attenuating the side bands thereof as will be seen by comparing the curves of Figs. 3 and 4.

In Fig. 4 the sound carrier or signal lies within the frequency coverage of the main characteristic of Fig. 3. The interference from the adjacent channel signal, however, is no greater because of the steeper slope obtained as shown in Fig. 4.

Further referring to Fig. 4, the curves show the amplifier channel response characteristics when the picture or side band channel is provided with suitable auxiliary circuits preferably more sharply tuned than the amplifier circuits and loosely coupled thereto in connection with a plurality of stages.

Each of the auxiliary circuits are tuned to the frequency to be rejected or attenuated. Instead of fully attenuating the undesired signal in one stage by tightly coupling a rejector circuit thereto, the signal is attenuated throughout a plurality of stages, to a lesser degree in each stage, by loose coupling, the over-all response characteristic being retained and the selectivity improved as indicated by the curves in Fig. 4. In a television receiver, therefore, the same fidelity of sound and detail of picture may be maintained, as in a system having a channel width as indicated in Fig. 3. It is desirable to maintain the channel width for the over-all sound and picture signal as narrow as possible in order to make available as large a number of channels as possible in a given television band.

It will be noted that in the main amplifier channel 16 the tuned transformers 24 provide a series of tuned circuits in the input and the output side of each stage, the output circuits being connected with the anodes through anode circuit leads indicated at 61 and the input circuits being connected with the control grids through suitable grid circuit leads 62. The tuned output circuits are indicated at 63, 64, 65 and 66, the tuned input circuits are indicated at 67, 68, 69 and 70.

It will be further noted that each anode circuit lead 61 extending through the respective tuned anode circuits is connected with a supply lead 71, positive with respect to ground, for supplying anode potentials thereto, while the grid leads 62 through their respective tuned input circuits are connected to a supply lead 72, negative with respect to ground for supplying biasing potential to the control grids. Additional grid electrodes, such as screen and other grids in the amplifier tubes are supplied from a lead 73 positive with respect to ground through supply leads indicated at 74.

In each of the supply leads 74, 62 and 61 there is provided a two stage electrical filter, for preventing interstage coupling through the supply

leads and the potential supply means (not shown). Two stage filters have been found to be desirable in a high gain high frequency amplifier of the type shown, particularly for television reception, where the intermediate frequency signals are, for example, in the high frequency range of from 6 to 12 megacycles. Each of the said filters may comprise a pair of series connected resistors 75 of relatively high resistance value and by-pass condensers 76 to ground.

The detector 50 and the sound frequency amplifier 15 are likewise supplied with grid and anode potentials through suitable two stage filters indicated at 77 for the detector 50, and at 78, in the amplifier 15. Since such filters are, per se, well known, further description of the same is believed to be unnecessary except to point out that each supply lead is provided preferably with a two stage filter and with a separate ground return from each stage as indicated at 79 for example.

In connection with the main amplifier channel 15 and in the input circuit for the sound amplifier 15, there are provided a series of auxiliary circuits, loosely coupled to the main filter circuits to provide for attenuating gradually throughout the amplifier, undesired signals such, for example, as the sound frequency signals in an adjacent frequency channel. In the case of the input circuit 36 for the sound amplifier 15, the voltage available in the trap circuit provided by the secondary 34 and tuning condenser 35, is utilized to supply input voltage to the first amplifier tube 37, the input or trap circuit 36 being tuned to the sound signal frequency.

An auxiliary circuit 80, comprising an inductance 81 and a shunt condenser 82, is loosely coupled with the output circuit 61 of the tube 17 in which the tuned signal conveying circuit 63 is connected. The coupling is conductive and coupling is varied by a movable tap 83 on the inductance 81. When the coupling is loose as shown, the tap is adjacent to the low potential end of the inductance 81. In this manner a small primary portion 84 is in circuit with the tuned circuit 63 while the entire winding 81 as a secondary is tuned by the condenser 82. A similar circuit 85 is provided in connection with the tuned signal conveying circuit 67, being thereby conductively coupled to the grid circuit of the tube 18 in the next stage. In a similar manner, a third auxiliary circuit indicated at 86 is connected conductively, and loosely coupled, with the anode circuit of the tube 18 and the signal conveying circuit 64. In the next succeeding stage input circuit, a capacity coupled rejector circuit 88 is provided, the variable condenser 87 serving as a variable coupling means with the grid circuit 62 of the tube 19 and the signal conveying circuit 68.

In connection with the tuned signal conveying circuit 69 in the input lead of the tube 20, magnetic coupling is provided for an auxiliary or rejector circuit 89, through the inductance winding 90 thereof, which is coupled, as indicated, to the secondary of the transformer connected in the tuned circuit 69. Coupling may also be made with the primary winding in the circuit 65 as indicated by the dotted arrow connection.

A second capacity coupled auxiliary or rejector circuit is indicated at 91 in connection with the output circuit of the tube 20 and is variably coupled therewith through a variable condenser 92. A second rejector circuit 93 is also loosely coupled conductively with the output or anode

circuit of the tube 20, in association with the tuned signal conveying circuit 66.

The circuits 65 and 69, taken by way of example, constitute a normal picture intermediate transformer with sufficient loss, added at 26 in the form of a resistor, or provided in any other suitable manner, to broaden its characteristic. A typical response curve of such a stage is shown by the curve 27 of Fig. 6. The circuit 89 loosely magnetically coupled to the circuit 69 is an example of a low loss rejector inductively coupled to the secondary of the transformer and tuned below the amplifier band, and the characteristic curve as taken across the circuit 69 is shown by the curve 45 of Fig. 5. Thus the selectivity of the low frequency side of the characteristic is greatly increased. The voltage response characteristic of the rejector or auxiliary circuit 89, and also the rejector circuit 36, is indicated by the curve 46. The characteristic curve taken across the circuit 30 may also be represented by the curve 45 in Fig. 5. The energy which is taken from the sound characteristic and causes the sharp dip 100 in the curve is permitted to circulate in the circuit 36 and this response may be made to correspond to the frequency of the sound carrier by proper spacing of the sound and picture carriers. Therefore, sound carrier voltage appears across the circuit 36 and is utilized in the grid circuit of the first intermediate frequency amplifier tube of the sound system. It is apparent from an inspection of the response curve that the band width and gain represented thereby is such that one less stage in the sound intermediate frequency amplifier may be used to obtain a desired over-all gain.

The curves in Fig. 5 may also be taken to show rejection by means of conductively coupled trap circuits 85 and 86 in a single stage, the characteristic of which without rejector circuits, is similar to the curve 27 of Fig. 6. The trap may be adjusted for maximum rejection at any distance from the center of resonance of the transformer 24 and on either the high or low frequency side thereof. The amount of rejection (ratio of maximum transformer response to the response at the point of rejection) and the band width of the transformer characteristic increases as the trap is tuned further from the transformer resonant frequency if the rejector coupling remains constant. It is, therefore, evident also that the auxiliary or rejector circuit may be placed in either the primary or the secondary circuit of the transformer through which the main signal is passed.

Referring now to the curves shown in Fig. 6, the curves 101, 102 and 103 show rejection (arbitrarily at 11.15 megacycles) for various degrees of coupling of the trap circuit with the main or signal conveying circuit, as by variation of the condenser value at 92 in connection with the circuit 91, and the condenser 87 in connection with the circuit 88. It will be noted from the curves that as the coupling with the auxiliary circuit is increased from a condition without coupling, represented by the curve 27, to a condition with tight coupling, represented by the curve 103, the higher the degree of coupling the lower the amount of rejection and the smaller the band width of the transformer characteristic measured from the center of the transformer response to a point on the curve in the region of 105.

While rejection has been shown in connection with the high frequency side of the amplifier re-

sponse characteristic, the response on the lower frequency side may also be reduced as is indicated in connection with the curve shown in Fig. 7, which also serves, along with the curves in Fig. 6 above noted, to show the desirability of loose coupling throughout a plurality of amplifier stages rather than tight coupling in one stage to reject the undesired frequency response.

The response curve shown in Fig. 7 may be taken as representing the response curves of the rejector circuits 80 and 86, for example, and illustrates the advantages to be gained by using loose coupling over tight coupling. In taking these curves the circuits were adjusted to give the same amount of rejection in each case so that the steepness of each curve can be compared in both cases. The curve 106 in this figure is an over-all characteristic of two amplifier stages such as the stages including the tubes 17 and 18 without rejectors or auxiliary circuits. The curve 107 shows the over-all response of the same two stages by a tightly coupled trap placed in one stage as by moving the tap 83 upwardly until it includes all of the coil 81. Tight coupling may also be accomplished in a single stage by increasing the capacity of coupling capacitor 87, for example, in the case of the trap circuit 88.

The curve 108 shows the response characteristic of two loosely coupled rejector or auxiliary circuits placed in each of two stages as the circuits 80 and 86, for example, and adjusted for the same amount of rejection. The two over-all characteristics, shown by the curves 107 and 108, may directly be compared, and the increased band width for a given selectivity of the curve 108 clearly indicates its superiority.

The curve 107 representing a condition wherein the trap is tightly coupled, indicates that the band width at 90 per cent is restricted and that the sides of the curve are caused to slope. In contrast, curve 108 representing a similar characteristic of a circuit utilizing a trap with the same L/c ratio, but more loosely coupled, indicates that the band width of the main characteristic is preserved, while the sides are greatly steepened, as is desirable for selectivity.

The response characteristic indicated at the point 109 of the curve 108, usually occurs when utilizing a sharply tuned rejector circuit, and is caused partly by the circuit tending to function along the remaining portion of the curve 106 which exists in that region, and partly by the impedance which is reflected from the rejector circuit into the transformer, the latter usually causes the response at 109 to rise somewhat higher than the corresponding portion of the curve 106.

When it is desired to eliminate such response peak as indicated at 111 in Fig. 9, it is possible to insert another trap in the amplifier and tune it to the frequency at 111 whereby the response is reduced, as indicated in the curve 112, for example.

Referring further to the Fig. 9, the curve 113 having the peak at 111 is the over-all characteristic of two stages with the rejection or auxiliary circuit in connection with one stage such as the rejector circuit 80, Fig. 1, in connection with the output circuit 63 of the tube 17. The curve 112 is the same with the addition of a high loss trap in the second stage tuned to the frequency at 111. The maximum response in the region 111 is thereby reduced by two to one and the addition of further stages, as shown in the diagram, Fig. 1a, further reduces this response.

Further referring to Fig. 1a, the high loss trap in the second stage may be considered as the trap circuit 86 in conjunction with the tube 18, and the loss is induced by a suitable means such as the variable resistor 94, to broaden the response characteristic, although it should be understood that the auxiliary circuits normally are sharply tuned and loosely coupled to fixed and broadly tuned transformer coupled circuits.

Referring to Fig. 8, the curves further illustrate how the width of the rejection band may be varied by introducing loss into the trap. The curve 117, for a coil wound with copper wire, has a band of rejected frequencies as indicated by the length of the broken line 117a. The curve 115 taken with a trap identical to the one used for curve 117 except the coil being wound with resistance wire having a resistance of 4.5 ohms per foot has a broader rejection band as indicated by the length broken line 115a. The added loss decreases rejection, decreases the amplitude of response at a peak resonance point, indicated at 16 on the curve 117 (in approximately the same ratio as rejection is decreased and broadens the band of rejected signals at the maximum rejection point which, in the curve shown, occurs at substantially 8.9 megacycles.

Referring again to the curve shown in Fig. 9, the curve 112 illustrates the response characteristic of a circuit which includes a trap wound with 10.5 ohms per foot resistance wire in the second stage, the resistance being indicated at 94 in dotted lines, in Fig. 1a, and the curve 113 by comparison illustrates the characteristic of a circuit which includes a copper winding in the trap circuit 80 with no trap in the second stage following.

The response curve indicated at 120 in Fig. 10, indicates the rejection characteristic of an auxiliary or trap circuit loosely magnetically coupled to the main interstage transformer circuits. In the present example, this curve may be taken as indicating the characteristic of a trap or rejector circuit in Fig. 1a, such as circuit 89, coupled as indicated by the dotted arrow and the full line arrow. The circuit may be coupled magnetically to the secondary as shown, or alternatively to the primary winding of the transformer 24 which is connected between the tuned circuits 65 and 69. The magnetic type of coupling is suitable when the trap circuit includes an inductance adapted to be coupled magnetically with one of the interstage transformer windings.

It should be noted that rejection with any of the types of trap or rejector circuits hereinbefore described may be adjusted to a frequency on either side or both sides of the frequency band covered by the main amplifier channel, for the purpose of attenuating adjacent channel signals, such as the sound signals in conjunction with a picture amplifier, and, at the same time, to increase the selectivity on either or both sides of the main amplifier band.

The response on either side of the rejection frequency, in the case of the curve 120 shown in Fig. 10 is of relatively high amplitude as indicated on the lower frequency side at 121, and the voltage in the trap circuit may be utilized to feed a separate amplifier under certain conditions as for example as described in connection with the circuit 36, Fig. 1, and the amplifier 15.

In the case that both sides of the frequency signal band to be covered by the main amplifier are attenuated by suitable rejector circuits, a symmetrical and improved straight sided re-

sponse curve may result, as shown in Figs. 11 and 12, for example.

Rejection by two successive trap circuits in the same or in two successive amplifier stages may briefly be considered. The effect upon the selectivity of the main amplifier channel, of rejection in two stages, wherein a rejector circuit is coupled to one of the transformer circuits in one stage and a second rejector circuit is coupled to a transformer circuit in a following or second stage, is indicated by the curve 125 in Fig. 11. The rejection on either side of the $10\frac{1}{2}$ megacycle frequency band is indicated by the curves at 126 and 127 for loosely coupled traps, such as the trap circuits shown in Fig. 1a at 88 and 93, for example, or the trap circuits 89 and 91, the trap circuit 89 being then coupled to the primary winding in the tuned circuit 65.

It will be noted that the response on either side of the rejection points 126 and 127 is relatively lower than is the case where double rejection is provided in one stage. This will be seen by referring to Fig. 12 wherein a curve 128 indicates the response of two circuits such as the rejector circuits 91 and 93 in one stage, as compared with the curve shown in Fig. 11.

In Fig. 12, the rejection of signals in adjacent higher and lower frequency channels is obtained by utilizing loosely coupled trap circuits, of the type shown in Fig. 1a, the trap circuit 91 being capacity coupled while the trap circuit 93 is conductively coupled to the output anode circuit of the tube 20 in association with the main channel tuned circuit 66. The trap circuit 91 is tuned to a frequency about the main channel band for high frequency rejection in accordance with the curve 102 in Fig. 6 while the trap circuit 93 is tuned to a frequency below the frequency band of the main amplifier for low frequency rejection after the manner of the curve 45 in Fig. 5. The curve 128 thus indicates the effect of a capacity and conductively coupled trap combined in one stage for rejection at any distance from the transformer resonance frequency. The effect of high loss traps in addition, as indicated by the curve 112 in Fig. 9, may be applied in the following stages, as is found to be necessary to smooth or reduce the undesired response peaks indicated at 129 and 130 on either side of the rejection frequency.

Referring now to Fig. 2, wherein like reference numerals, as used in Fig. 1, refer to like parts, it will be seen that the amplifier 16 may be arranged to include trap or rejector circuits in circuit with certain of the electrodes of the amplifier tubes other than the electrodes connected with signal conveying circuits as in Figs. 1 and 1a. By way of example, a loosely coupled trap circuit 141 may be provided in circuit with the screen grid 140 of the tube 17, in this case being connected in the supply lead 74 between the screen grid and the filter 75, 76. The trap or rejector circuit is similar to the trap circuits provided in connection with the amplifier 16 of Figs. 1 and 1a, and is conductively coupled.

Tuned trap circuits may be provided in connection with various other electrodes of certain types of amplifier tubes such as screen grid tubes, for filtering the interfering signal, such as the sound channel frequency in the present amplifier. By way of example, it will be noted that in circuit between the signal circuits 67 and 64, a tube 142 is provided with a diode plate electrode 143 in association with the cathode 144. The tube func-

tions otherwise as an amplifier in the circuit shown.

The trap circuit function is provided by a tuned trap circuit 145 connected in circuit between the diode plate 143 and the cathode 144. The trap circuit is loosely coupled by means of a variable contact 146 on the inductance 147. Similar loose coupling is provided in the trap circuit 141 through a variable contact 148. The trap circuits shown are tuned to the frequency to be rejected, and may thus be located in any suitable electrode circuit provided in connection with tubes employed as amplifiers in the main signal channel.

In connection with the amplifier tube 142, the tuned diode rectifier circuit provided by the plate 143 and the cathode 144, together with the trap circuit 145 is coupled to the signal circuit through electron coupling, since the cathode 144 is common to the amplifier elements of the tube which are in the signal channel.

It should be understood that the electron coupling provided between the diode anode 143 and the cathode 144 results from the fact that the two electrodes are associated with the electronic stream of the amplifier device 142, which is connected with the input circuit 67 and the output circuit 64. It is thought that this coupling may result from a capacity relation between the anode 143 and the other electrodes in the device 142. A device of the character shown may be provided by any suitable electric discharge amplifier device having a diode anode arranged to rectify in connection with the cathode and be associated with the electronic stream of the device. For example, the device 142 may be of the type represented by the RCA 6B7 or the RCA 55 tube.

In the case of the tube 17, the screen grid 140 is raised to a high intermediate frequency potential by the insertion of the trap circuit 141 and therefore serves to control the electron stream in the tube 17. It will be apparent that other similar grid electrodes may be employed for a similar purpose, such as suppressor grids, for example, and that the circuits of Fig. 2 are particularly adaptable to amplifiers wherein the signal conveying circuits are preferably operable at more nearly ground potential. However, the inductive coupling circuit of Fig. 1a as shown at 88 may be used in such cases.

It will also be apparent that other amplifier tubes in the intermediate frequency amplifier may be similarly provided with rejector circuits in connection with grid and other electrodes for improving the selectivity of the amplifier and for attenuating adjacent channel signal interference.

The use of a rejector circuit in connection with a tube electrode associated with but not in the direct electron stream of the tube, has the advantage that all of the main electrodes may be operated in a normal manner and without raising the signal conveying circuits above ground potential. Furthermore, it will be noted that in the modification of the trap or rejector circuits shown in connection with the amplifier 16 in Fig. 2, the said rejector circuits are connected in circuit with electrodes of the amplifier tubes which are not connected with signal conveying circuits. This has the advantage, as hereinbefore stated, that the signal conveying circuits may be operated more nearly at ground potential.

From the foregoing description it will be seen that in a superheterodyne receiver adapted for receiving signals in two or more adjacent channels, one of the channels occupying a relatively wide frequency band with respect to the other

or others, the selectivity of the wide band channel may be maintained at substantially a maximum degree, while still retaining its band width at substantially 90% peak through the use of low loss rejector circuits or auxiliary circuits loosely coupled to broadly tuned or high loss main channel transformer circuits.

The auxiliary or rejector circuits serve to attenuate signals in a relatively narrow band of frequency within the normal frequency coverage or adjacent to the normal relatively wide frequency band of signals passed by the main amplifier channel, and in the case of sound and picture frequency carriers or intermediate frequency signals, the latter are spaced to provide response in the trap or rejector circuits at the same frequency as the sound carrier or intermediate frequency thereby to eliminate interference from the sound signals and, if within the scope of frequency coverage of the main interstage transformers, the attenuated signals serve to increase the selectivity of the main amplifier channel.

A system embodying the invention is therefore readily adapted to plural channel amplifiers in which the frequency band to be rejected is relatively narrow with respect to the frequency band to be passed by one of the intermediate frequency or the main intermediate frequency amplifier channels.

The combination of a plurality of successive amplifier stages, each stage being broadly tuned and the number of stages being increased to obtain a desired overall voltage gain and flat top response, is of advantage in providing a suitable number of successive amplifier stages to which a plurality of absorption or trap circuits may readily be coupled as desired. Advantage may then be taken of loose coupling in each stage with a relatively large number of trap circuits to obtain improved selectivity and a reduction of adjacent channel interference, while retaining the desired over-all amplifier response as has been pointed out.

It should be understood that the trap circuits and amplifier circuits shown are illustrated only by way of example as indicating circuits which are at present preferred and that other circuits may be provided and arranged in accordance with the invention to obtain similar results.

I claim as my invention:

1. A superheterodyne receiver adapted to receive a relatively wide frequency band of picture signals and a relatively narrow frequency band of sound signals in immediately adjacent channels, including in combination, means for receiving said combined sound and picture signals including a detector device having an output circuit broadly responsive to said sound and picture signals, an intermediate frequency picture signal amplifier coupled to said output circuit and comprising a plurality of electric discharge amplifier stages having tuned input and output circuits, each stage being individually broad in frequency response, means providing a plurality of trap circuits loosely coupled to a plurality of said tuned circuits and being individually tuned to respond to the sound signal frequency band, whereby the overall response characteristic of the picture signal amplifier may be represented by a selectivity curve having steep sides and whereby the picture signal band and the sound signal band may occupy a minimum overall frequency band, a tuned trap circuit coupled to the input circuit of the picture signal amplifier and to the detector output circuit responsive to the sound signal

frequency band, and a sound signal amplifier connected therewith to receive the sound signal voltage developed therein

2. In a superheterodyne receiver, an intermediate frequency amplifier adapted to amplify signals in a relatively wide frequency band, a second intermediate frequency amplifier adapted to amplify signals in a relatively narrow and immediately adjacent frequency band, the successive stages of the first named amplifier being supplied with signals through intermediate frequency transformers, a plurality of tuned trap circuits loosely coupled to said transformers, said trap circuits being tuned to the frequency response band of said second amplifier to attenuate the signals in said narrow band progressively in the stage of said first amplifier, and means for utilizing one of said trap circuits to supply signals to said second amplifier.

3. In a superheterodyne receiver, the combination of means providing at least two signal conveying channels, one of said channels comprising a plurality of electric discharge amplifier tubes and interstage transformer means connecting said tubes in cascade relation to each other, means for tuning said transformers to a relatively wide frequency band of response, a plurality of auxiliary tuned circuits loosely coupled to certain of the tuned circuits in a plurality of the successive stages, said loosely coupled circuits being tuned to a relatively narrow frequency band lying immediately adjacent to said first-named frequency band and outside thereof to attenuate signals in said narrow frequency band progressively in each of said stages, and means connecting the input circuit of the other of said channels to one of said auxiliary circuits to supply signals thereto within said relatively narrow frequency band.

4. In an intermediate frequency amplifier having a plurality of electric discharge amplifier devices, the combination of interstage coupling means therefor providing a series of tuned circuits, each broadly responsive to a fixed frequency band, one of said electric discharge amplifier devices having a cathode associated with the amplifier electrodes therein and having an auxiliary diode plate associated with the cathode and the electronic stream of said device in the same envelope, and means providing a tuned circuit between said diode plate and cathode for attenuating signals in adjacent channels with respect to the band of signal frequencies to which the amplifier is responsive.

5. In a television receiver, the combination of a single sound signal and picture signal detector having an output circuit, an intermediate frequency amplifier comprising two separate amplifier channels tuned to operate at immediately adjacent and widely differing frequency band widths for the sound and picture signal, means providing relatively high loss tuned interstage coupling circuits in the picture signal amplifier channel, means providing a plurality of relatively low loss rejector circuits loosely coupled to a plurality of said interstage coupling circuits and tuned to the frequency band of the sound signal, and a tuned trap circuit for sound signals providing a coupling means between the detector output circuit and the input circuit of the sound signal amplifier channel.

6. In a superheterodyne receiver for television signals comprising sound signals in a relatively narrow frequency band and picture signals in an adjacent relatively wide frequency band, the com-

5 bination of a sound signal intermediate frequency amplifier system and a picture signal intermediate frequency amplifier system including a series of interstage coupling transformers, said picture signal amplifier being relatively broadly
10 tuned, and a plurality of rejector circuits relatively sharply tuned to the sound carrier frequency and loosely coupled to the input and successive transformer circuits to attenuate the sound carrier frequency, progressively and to a relatively low degree in each stage to provide a desired substantially full overall attenuation.

7. In a superheterodyne receiver for television signals, the combination of a sound signal intermediate frequency amplifier system and a picture
15 signal intermediate frequency amplifier system including a series of interstage coupling transformers, a plurality of rejector circuits tuned to the sound carrier frequency and loosely coupled to the input and successive transformer circuits to
20 attenuate signals at the sound carrier frequency progressively in successive stages of said picture amplifier, and means for utilizing the voltage at the frequency of the sound carrier in one of said rejector circuits for supplying sound signals to the sound amplifier channel.

8. A superheterodyne radio receiving system for television signals, comprising receiver means broadly tunable to the sound and picture
30 carrier waves, oscillator means associated therewith and tunable to produce in the output circuit of the receiver means an intermediate frequency sound signal and an intermediate frequency picture signal in adjacent frequency channels, the picture intermediate frequency band being relatively wide with respect to the sound intermediate
35 frequency band, a sound signal intermediate frequency amplifier, a picture signal intermediate frequency amplifier, means for supplying sound intermediate frequency signals to the sound signal intermediate frequency amplifier including a tuned trap circuit coupled to the receiver output circuit, said trap circuit being tuned to the sound
40 signal intermediate frequency, and a plurality of rejector circuits tuned to the sound signal intermediate frequency and loosely coupled to the picture signal amplifier system to attenuate signals at the sound carrier frequency in a plurality of stages therein and to increase the selectivity of the picture signal intermediate frequency
50 amplifier.

9. In a television receiver an intermediate frequency picture signal amplifier, comprising a plurality of electric discharge amplifier devices and tuned transformer means interconnecting
55 said devices to provide a series of amplifier stages, means for causing the frequency response charac-

teristic of the individual stages of said amplifier to be relatively broad whereby the amplifier provides increased fidelity of response, and a series of sharply tuned rejector circuits loosely coupled to certain of said stages for increasing progressively and by a small degree in each stage, the overall selectivity of said amplifier while maintaining the overall fidelity.

10. In a television receiver, an intermediate frequency picture signal amplifier including a plurality of electric discharge amplifier devices and tuned interstage coupling transformers therefor providing successive amplifier stages tuned to a relatively wide picture frequency band, means providing a plurality of rejector circuits loosely coupled to the transformer circuits and tuned to a fixed relatively narrow frequency band adjacent to the frequency band to which the amplifier is tuned, and means for varying the coupling of at least one of said rejector circuits.

11. In a television receiver, an intermediate frequency picture signal amplifier having a plurality of stages, a plurality of auxiliary rejector circuits more sharply tuned than the amplifier circuits and responsive to an adjacent channel frequency of relatively narrow band with respect to the frequency response band of the amplifier, said rejector circuits being loosely coupled to the signal conveying circuits of the amplifier in a plurality of stages, said rejector circuit frequency band further being substantially in overlapping relation to the frequency response band of the amplifier, and the coupling thereof being such that the narrow band frequency signals are attenuated to a relatively small degree in each stage, while the frequency response characteristic of the amplifier is relatively broad in addition to being wide with respect to said narrow band channel, whereby an overall frequency response for the amplifier having high fidelity and steep sides is provided.

12. In an intermediate frequency amplifier, the combination of an electric discharge amplifier device having input electrodes, output electrodes and an auxiliary electrode, tuned signal conveying circuits connected with said input electrodes and said output electrodes, respectively, said signal conveying circuits being tuned to a fixed relatively wide frequency band, and a second tuned circuit connected with said auxiliary electrode of said device, said auxiliary electrode lying outside of but associated with the electron stream of said device, said second tuned circuit being responsive to signals in a relatively narrow frequency band outside of and adjacent to said first-named band of frequencies.

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