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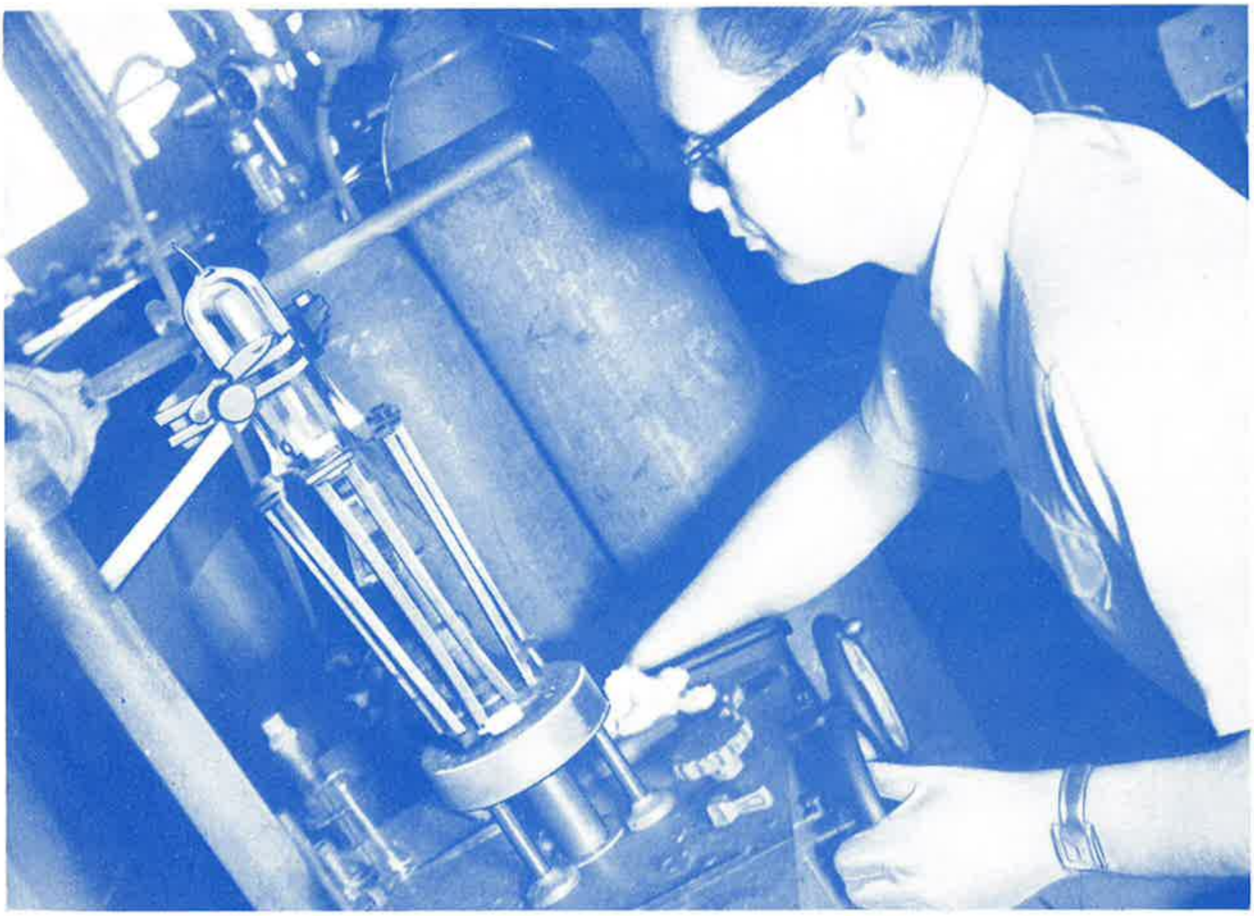
RADIOTRONICS

Volume 18 May, 1953 No. 5



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RADIOTRONICS

Volume 18 **May 1953** **Number 5**

Editor:
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By the way—

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Back issues of Radiotronics, prior to March, 1953, are no longer available.

The front cover this month shows a stage in the manufacture of a Radiotron power valve at the Amalgamated Wireless Valve Works at Ashfield, N.S.W.

By K. Fowler and H. Lippert.

VIDEO AND AUDIO CIRCUITS

1. Introduction

These circuits were discussed in a general way in Chapter 4 when the various sections of a television receiver were briefly covered and it might be well for the reader to review this section before considering the more detailed circuit analysis of the i-f circuits which is to follow.

Since two intermediate frequencies with their associated side-bands appear in the output of the mixer or converter stage, the conventional method of separation is to employ two separate i-f channels; one for the sound i-f, and the other for the video i-f.

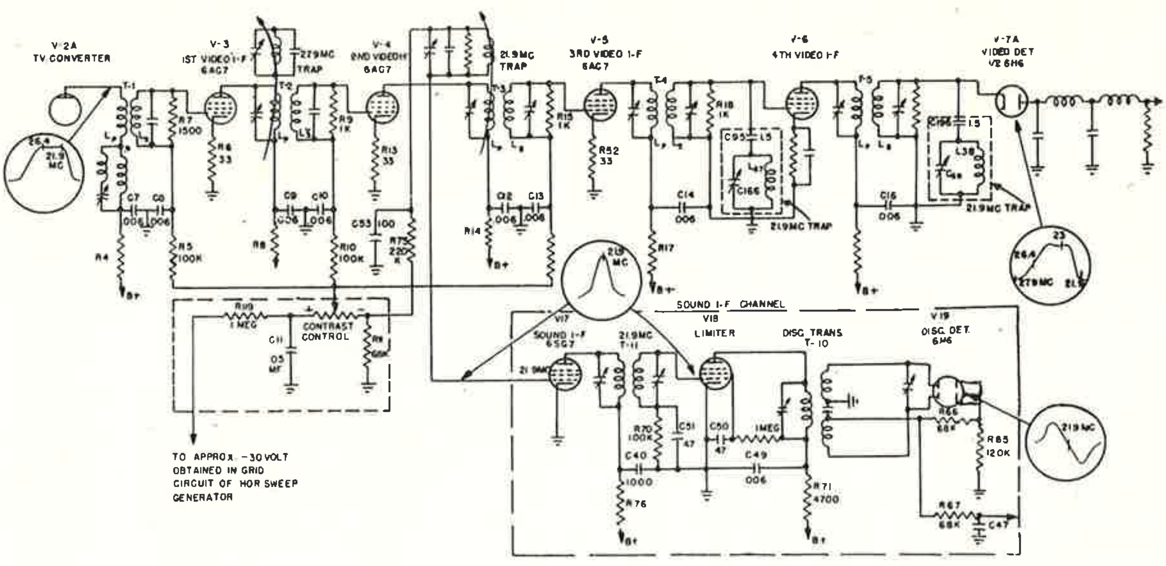
The circuit details of these i-f channels vary somewhat in different receiver models; however, the same fundamentals apply for receivers employing the conventional i-f amplifier system. For instance, the more expensive receivers may employ a video i-f channel having a pass-band of approximately 4 mc and use four stages of video i-f amplification, while other receivers may employ a video i-f channel with a pass-band of approximately 3 mc or less, and only three stages of amplification. In some receivers the i-f transformers may be capacitively tuned, while in others they are inductively tuned with an iron core. Some receivers may use as many as five trap circuits in the video i-f channel while other receivers may employ none. The sound i-f channel in some receivers is a straightforward channel for amplification of the FM television sound i-f signal only, with one or two stages of amplification preceding a limiter stage, the output of which feeds into a discriminator detector.

In other receivers, the sound i-f channel not only amplifies the television sound i-f signal, but is also used for other services (through the use of composite i-f transformers) such as AM and FM reception. As mentioned previously, although the circuit details of the i-f channels vary in different receiver models, depending upon price range, whether the receiver is to provide other services in addition to TV reception, etc., they are basically alike for all receivers.

The video i-f and sound i-f channels of the G.E. Model 901 receiver will be used for circuit analysis in the major portion of this chapter, since they typify good design considerations, especially the video i-f channel. Also, the sound i-f channel is straightforward with no complications introduced by other services such as regular FM and AM reception. More modern receivers will be described later in this course.

2. Block diagram of model 901 i-f channels

The complete circuit of the video and sound i-f channels for the Model 901 receiver is shown in Figure 6-1. In order to more easily follow the two i-f signals after they leave the mixer or converter stage and to better emphasize the important considerations in both the video and sound i-f circuits, the block diagram of Figure 6-2 will be used in conjunction with the actual circuit diagram of Figure 6-1.



By courtesy of A.G.E., with acknowledgment to International General Electric Co. of U.S.A.

Fig. 6-1. Video and Sound Channels (Model 901).

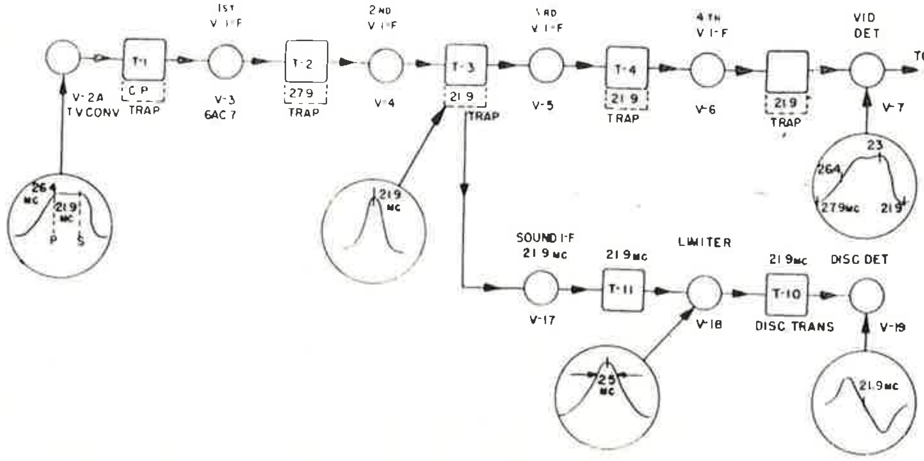


Fig. 6-2. Block Diagram of Video and Sound Channels (Model 901).

Starting at the output of the television converter V2, two i-f signals are present — the i-f corresponding to the sound carrier which is exactly 21.9 mc and the i-f corresponding to the picture carrier which is exactly 26.4 mc. These signals with associated side-bands are coupled from the converter plate to the grid of the first video i-f amplifier by means of the first video i-f transformer T1.

Both i-f signals are amplified by the first video i-f tube V3, which is a type 6AC7. This tube has a high mutual conductance and low input and output capacitances which make it desirable for use as a wide-band amplifier.

The output of V3 is coupled to the grid of the second video i-f amplifier V4 by means of the second video i-f transformer T2. V4 is another type 6AC7 tube. It should be noted that the sound i-f signal is amplified by V3 and V4 as well as the video i-f signal. Although V3 and V4 are referred to as the first and second video i-f amplifiers, they also act as the first and second sound i-f amplifiers.

Both i-f signals appear in the output of V4 and it is at this point that the audio and video i-f signals are separated by selective tuned circuits, with the audio i-f signal being taken off from a trap circuit tuned to 21.9 mc, that is coupled to the primary of the third video i-f transformer, T3, as indicated in the circuit diagram, Figure 6-1. The video i-f of 26.4 with its associated side-bands is coupled to the grid of V5, the third video i-f amplifier, by means of T3 where it is further amplified. The point at which this separation occurs is shown in Figure 6-2 with arrows indicating the path taken by each i-f signal.

After separation from the video i-f signal, by the 21.9 mc trap circuit coupled to T3, the sound i-f signal of 21.9 mc is applied directly to the control grid of V17, which is a type 6SG7 tube and acts as an i-f amplifier at 21.9 mc.

The 21.9 mc output of V17 is coupled to the grid of V18 by means of T11, which is a touble-tuned transformer at 21.9 mc with a pass-band of approximately 250 kc. V18 is a type 6SV7 tube and acts as a limiter for the FM sound signal.

The output of V18 is coupled through a conventional FM discriminator transformer, T6, to a type 6H6 detector tube. The components are the same type as used in a regular FM receiver.

As mentioned earlier the video i-f of 26.4 mc with associated side-bands, after rejection of the sound i-f signal by the 21.9 mc trap associated with T3, is further amplified by V5, the third video i-f amplifier. The output of V5 is coupled to the grid of V6, the fourth video i-f amplifier through the fourth video i-f transformer, T4. The 26.4 mc video i-f with associated side-bands after amplification by V6 is coupled into the video detector V7, by means of the last video i-f transformer, T5. The video detector, V7, makes use of one-half of a type 6H6 tube and removes the picture modulation from the i-f carrier. A total of four stages of video i-f amplification having wide-band characteristics are employed, using type 6AC7 tubes. The gain per stage is approximately 10-12. Due to the wide pass-band of the Model 901 video i-f channel and the comparatively low stage gain thus obtained, four stages of amplification are necessary instead of the usual three employed in receivers having a narrower pass-band.

It will be noted that each video i-f transformer has a trap circuit associated with it. The trap circuits associated with the last three video i-f transformers are tuned to the sound i-f of 21.9 mc. The three 21.9 mc traps are used to attenuate the sound i-f so that very little of it appears in the output of the video detector. Also the first 21.9 mc trap associated with T3 provides an audio take-off point for feeding the sound i-f signal into the sound i-f amplifier. Attenuation of the sound i-f in the video i-f channel is necessary since the 21.9 mc i-f of the accompanying sound signal is close enough to the response of the video i-f channel on its low frequency side to cause serious interference with the picture unless some means is provided to attenuate or reject the sound i-f signal so that it is at a very low level in the output of the video detector.

This interference may take the form of sound bars if the FM sound carrier is at a high enough level at the video detector for slope detection to take place. This form of interference will vary with modulation. It may also take the form of 4.5 mc interference (the difference between the video and sound i-f carriers) which will appear as very fine grain in the picture.

The 27.9 mc trap circuit associated with T2, the second video i-f transformer, is used to reject possible interference from the sound carrier of a television station that may be operating on the next lower or adjacent channel. If the sound carrier of the adjacent channel lower in frequency should reach the converter grid, it will heterodyne with the local oscillator and produce an interfering signal that is 1.5 mc higher than the video i-f of 26.4 mc. This interfering signal of 27.9 mc is close enough to the pass-band of the video i-f channel to cause serious interference in the picture if it is not rejected; therefore, the desirability of a trap circuit tuned to 27.9 mc to eliminate this possible source of interference.

The trap circuit associated with T1, the first video i-f transformer is used as a carrier placement trap. This trap adjusts the slope of the high frequency end of the overall video i-f response curve or pass-band so that the i-f of 26.4 mc which corresponds to the picture carrier, is placed at the proper point in the overall video i-f pass-band so as to compensate for the sesqui-sideband method of transmission of the picture signal. This will be considered in more detail in subsequent paragraphs.

3. Requirement of video i-f channel

The video i-f circuits must meet certain requirements, just as in the case of the r-f circuits. Some of these requirements are:—

(a) The video i-f circuits must have wide-band characteristics and be capable of providing uniform response over a range of frequencies approximately 4 mc wide.

(b) The video i-f circuits must attenuate the accompanying sound i-f so that it is at a very low level in the output of the video detector.

(c) The video i-f circuits must provide satisfactory adjacent channel selectivity, especially for the adjacent channel next lower in frequency.

(d) The overall video i-f response or pass band must be such as to compensate for the vestigial side-band method of transmission so as to provide a uniform output in the video detector for modulation components which are close to the carrier, as well as for those far removed from the carrier.

To meet the above requirements, the overall response of the video i-f channel from converter grid to the output of the video detector is made to look like the response curve shown in Figure 6-3. This is the same video i-f response curve shown at the video detector in Figures 6-1 and 6-2. This overall response is obtained by means of the five video i-f transformers and their associated trap circuits.

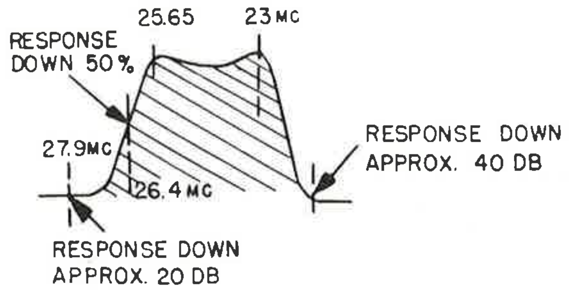


Fig. 6-3. I-F Response Curve.

Referring to Figure 6-3, it will be noted that the i-f of 26.4 mc corresponding to the picture carrier is down 50% or 6 DB from maximum, instead of being at the top of the response curve. Also, that 100% response is obtained at a frequency of 25.65 mc, which is .75 mc lower than the i-f carrier of 26.4 mc. From 25.65 mc to 23 mc the curve is essentially flat-topped and then drops off sharply so that the response at 21.9 mc, the i-f corresponding to the sound carrier, is attenuated approximately 40 DB or 100 to 1. The response at a frequency of 27.9 mc, the frequency at which adjacent channel sound interference might occur, is down approximately 20 DB or 10:1 due to the attenuation provided by the 27.9 mc wave trap. The bandwidth over which essentially uniform output from the video detector is obtained is approximately 4 mc.

4. Receiver compensation for vestigial side-band reception

As mentioned previously, one of the requirements for the video i-f channel is that the overall response or pass-band of the video i-f circuits must compensate for the vestigial side-band method of transmission. This is accomplished by placing the i-f of 26.4 mc, which corresponds to the picture carrier, fifty per cent. down from maximum on the overall response curve as indicated in Figure 6-3, rather than placing it at the top of the curve or at maximum response, as indicated in Figure 6-4.

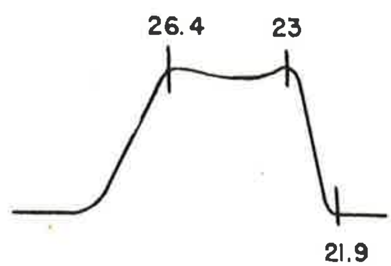


Fig. 6-4. Maximum I-F Responsé Curve.

The reason for this can be illustrated by assuming idealized curves to represent the video carrier with associated side-bands as transmitted, the overall response of the video i-f circuits and the output of the video detector

The idealized curve for the transmitted signal is shown in (A) of Figure 6-5, the idealized response curve for the overall video i-f circuits is shown in (B) of Figure 6-5, while (C) represents the idealized curve for the video detector output.

From examination of (A) it is apparent that for low frequency modulation components out to .75 mc, the double side-band method of transmission is used since side-bands extend above and below the carrier over this range of frequencies. However, for modulation components above .75 mc and extending to approximately 4mc, no lower side-band modulation components are transmitted and in effect, single side-band transmission is used. It is this transition from double side-band transmission over the .75 mc range of frequencies to single side-band transmission over the range of frequencies above .75 mc that makes it necessary to compensate for the vestigial side-band method of transmission in the video i-f channel.

The idealized overall video i-f response curve necessary to accomplish this is shown in (B) of Figure 6-5 and is similar to that of Figure 6-3, except that it is idealized for the sake of illustration. As shown, the i-f of 26.4 mc corresponding to the picture carrier is located fifty per cent. down from maximum. It should also be noted that frequencies or side-bands extending above and below the i-f of 26.4 mc are linearly attenuated over the range of frequencies at which double side-band transmission takes place, with one hundred per cent. response occurring at a frequency of 25.65 mc and essentially zero response occurring at a frequency of 27.15 mc.

In order to see how an overall video i-f response curve of this type compensates for the vestigial side-band method of transmission so that the output of the video detector is essentially uniform for all modulation components or side-bands, a 0.5 mc modulation component and a 2 mc modulation component will be considered.

Now, considering the 0.5 mc modulation component, side-bands will extend equally on either side of the video carrier as transmitted since this frequency occurs within the range where double side-band transmission is used. This is indicated by the dashed lines running between (A) and (B) of Figure 6-5. Since the overall video i-f response is such as to provide linear attenuation for frequencies .75 mc above and below the carrier i-f of 26.4 mc, then (as indicated by curve (B)) the 0.5 mc upper side-band will be attenuated approximately twenty per cent. by the video i-f channel, while the 0.5 mc lower side-band will be attenuated approximately 80%.

Therefore, although the transmitted signal contains 0.5 mc upper and lower side-bands which are unattenuated upon reaching the receiver, the corresponding 0.5 mc i-f side-bands reaching the input of the video detector are linearly attenuated.

The output voltage of the video detector for the 0.5 mc modulation component will depend upon the energy contained in the corresponding .5 mc side-bands reaching the input to the video detector. Now assuming that the output of the video detector is one volt due to the energy contained in just a single side-band that reaches the detector input unattenuated, then the output voltage for the .5 mc modulation component just considered will also be one volt, since although two 0.5 mc side-bands reach the input to the video detector, they are linearly attenuated as mentioned above. One of the 0.5 mc side-bands will pass through the video i-f channel at approximately eighty per cent. of maximum and contributes approximately 80% of one volt or .8 of a volt while the other 0.5 mc side-band passes through at only twenty per cent. of maximum and contributes 20% of one volt or 0.2 of a volt, which adds up to one volt output in the video detector due to the energy contained in the two 0.5 mc side-bands. This is indicated in (C) of Figure 6-5. The same thing is true for all modulation components from 0 to 0.75 mc.

Now suppose that the same carrier is modulated by a 2 mc modulation component. As indicated by (A) of Figure 6-4, there will be no 2 mc lower side-band in the transmitted signal since all lower side-bands more than .75 mc from the carrier are removed, which is characteristic of the vestigial side-band method of operation.

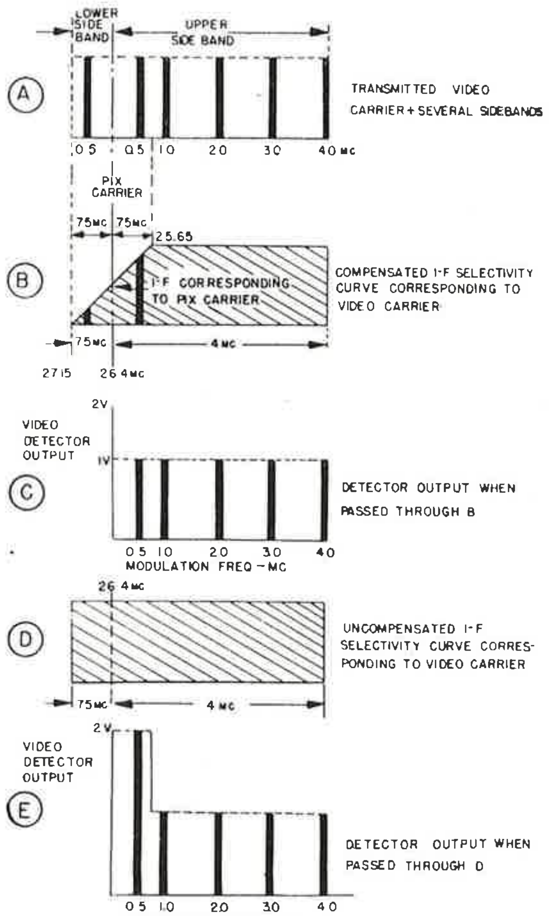


Fig. 6-5. Effect of I-F Response Curve on Detector Input.

Therefore, in the case of the 2mc modulation component, the output of the video detector will be due to the energy contained in only one side-band since only one side-band is transmitted. By referring to (B) of Figure 6-5, it will be seen that there is no attenuation of the 2 mc side-band by the video i-f circuits and that the output of the video detector will therefore be due to the energy contained in just a single side-band reaching the detector input unattenuated, which results in one volt output for the 2 mc modulation component. This is the same output as for the 0.5 mc modulation component as indicated by (C) of Figure 6-5, thus resulting in a uniform output. The same thing holds true for all modulation components from .75 mc up to approximately 4 mc, since over this range only one side-band is transmitted and there is no attenuation in the video i-f circuits over this range of frequencies.

Thus by providing linear attenuation in the video i-f channel over the range where two side-bands are transmitted and no attenuation over the range where only one side-band is transmitted, uniform output from the video detector is obtained for all modulation components, regardless of whether both side-bands are transmitted, as in the case of modulation components up to 0.75 mc or whether only one side-band is transmitted, as in the case of modulation components above 0.75 mc.

If no attenuation were provided in the video i-f channel over the range where two side-bands are transmitted, as shown in (D) of Figure 6-5, then the output of the video detector for modulation components close to the carrier, up to .75 mc, would be approximately twice that obtained for modulation components far removed from the carrier, from 0.75 mc out to 4 mc, where only one side-band is transmitted as indicated in (E) of Figure 6-5. This non-uniform output of the video detector is an undesirable condition which results in a picture having very poor quality, hence the importance of making the overall response of the video i-f channel compensate for the vestigial side-band method of transmission.

5. Need for 27.9 mc trap

It was mentioned earlier that it is possible for the sound carrier of a station operating on the adjacent channel lower in frequency than the desired channel to seriously interfere with the picture signal. Also, that this form of interference can be eliminated through the use of a trap circuit in the video i-f channel tuned to 27.9 mc.

To illustrate this type of interference, it will be supposed that the receiver is tuned to channel # 3, 60-66 mc, and that there is another television station operating in the near vicinity on Channel #2, 54-60 mc (the adjacent channel lower in frequency). Since the receiver is turned to receive Channel #3, 60-66 mc, its local oscillator will be operating at 87.65 mc (21.9 mc higher than the sound carrier of the desired Channel #3). The sound carrier of Channel #2, 54-60 mc, is located at 59.75 mc, which is only 1.5 mc away from the video carrier of the desired channel and if it is at all strong it will probably get through the r-f circuit and reach the converter grid. Therefore, the local oscillator signal of 87.65 mc will heterodyne with the 59.75 mc sound carrier of the adjacent channel lower in frequency and produce a signal in the converter output, the frequency of which will be 87.65 mc minus 59.75 mc or 27.9 mc.

The i-f signal of 27.9 mc thus produced which corresponds to the adjacent channel sound carrier, is close enough to the high frequency side of the video i-f response to cause interference in the picture, unless it is attenuated or trapped out of the video i-f channel. This is done in the same manner as for the rejection of the accompanying sound i-f by using a trap circuit, except that in this case it is tuned to 27.9 mc instead of 21.9 mc as compared to the three traps used to reject the accompanying sound i-f. Only one 27.9 mc trap is necessary since the r-f circuits provide some attenuation of the adjacent channel sound carrier. Also, in the Model 901 receiver, the carrier placement trap associated with the first video i-f transformer T1 helps to reject adjacent channel sound interference. This carrier placement trap is used primarily to place the i-f carrier of 26.4 mc at exactly 50% down on the i-f response curve for reasons mentioned previously. However, at the same time that it helps to properly place the i-f carrier on the high frequency skirt of the video i-f pass-band, it also provides some attenuation of any adjacent channel sound interference.

In some models, the carrier placement trap provides the adjacent channel attenuation and no 27.9 mc trap is used. This is satisfactory in the great majority of cases since the FCC insofar as possible is not allocating adjacent channel stations in the same locality and the possibility of serious adjacent channel interference is not very great.

6. Obtaining wide-band characteristics — transformer coupled

The wide-band characteristics of the video i-f channel in the Model 901 and some other TV receivers are obtained through the use of double-tuned, closely-coupled i-f transformers and, also, by resistive loading of the transformer secondary.

With loose coupling between the primary and secondary, the response curve would be quite sharp, as indicated in (A) of Figure 6-6. However, as the coupling is gradually increased, the response curve flattens out at the peak at the point of critical coupling (B). As the coupling is still further increased, the response curve will broaden and will dip in the centre as indicated in (C), depending

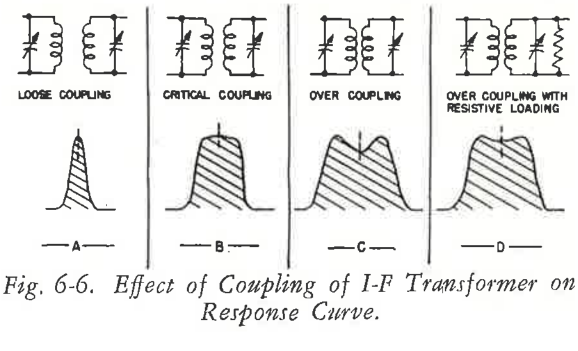


Fig. 6-6. Effect of Coupling of I-F Transformer on Response Curve.

upon the Q of the tuned circuit. The higher the Q of the circuit, the greater will be the dip in the centre. In order to eliminate the dip in the response curve and at the same time overcouple the tuned circuits to the point where sufficient bandwidth is obtained, it is necessary to lower the Q of the i-f transformers by resistive loading of the secondary, as in (D) of Figure 6-6.

7. Obtaining wide-band characteristics — impedance stagger tuned

Some of the later models of General Electric TV receivers make use of a single tuned inductance between each tube section of the i-f amplifier and obtain the necessary bandwidth by means of stagger tuning.

When stagger tuning is employed, only one tuned circuit is used between successive stages as indicated in (A) of Figure 6-7. Each tuned circuit resonates to a different frequency in the video i-f pass-band and each contributes its share of gain and bandwidth so that the overall response curve or pass-band has the desired characteristics.

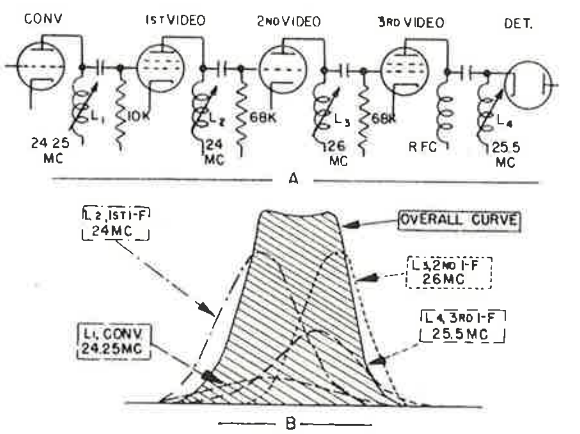


Fig. 6-7. Staggered Tuned Circuit and Response Curve.

This is illustrated in (B) of Figure 6-7 where the dashed lines represent the response of each individual tuned circuit, while the shaded area within the solid line represents the overall response obtained from converter to video detector by properly combining each individual response curve. It should be noted that the selectivity and gain of L_2 and L_3 are essentially the same although tuned to altogether different frequencies. Also that the selectivity of L_1 and L_4 is not as great as for L_2 and L_3 with L_1 being considerably broader than L_4. This difference in selectivity is obtained by varying the effective Q of each tuned circuit by means of the shunt grid resistor. Making the value of grid resistor shunted across L_1, for instance, considerably lower than for L_2 makes the effective Q of L_1 lower than L_2 and consequently the response of L_1 is broader than for L_2. In this connection, it should also be noted that the grid resistor appearing across L_2 and L_3 have the same value and, therefore, their selectivity is essentially the same.

8. Video i-f transformer design

As mentioned previously, several types of i-f transformers are used. In some receivers they are capacitively tuned by means of a trimmer, and in others they are inductively tuned with an iron core. Each type has its particular advantage, as discussed in an earlier chapter. The video i-f transformers used in the Model 901 are capacitively tuned and will be discussed first.

A separate primary and a separate secondary winding are wound on the same form and are closely coupled with resistive loading of the secondary to obtain the required bandwidth. Each winding is capacitively tuned by means of a small compression type trimmer shunted across the winding, as indicated in (A) and (B) of Figure 6-8. (B) is the schematic representation of the fourth video i-f transformer T4 in the Model 901 receiver. Note that the secondary is shunted by quite a low value resistor, only 1000 ohms. The low side of the secondary on this transformer goes directly to ground. However, the secondaries for the 1st, 2nd and 3rd video i-f transformers do not go directly to ground but are effectively grounded as far as the i-f signal is concerned, through the low impedance path offered by adequate by-pass capacitors, as indicated in Figure 6-1. The low side of the primaries are also effectively grounded, as far as the signal is concerned, by adequate by-pass capacitors, the primary of T4 being effectively grounded by means of the .006 μf. capacitor, C14.

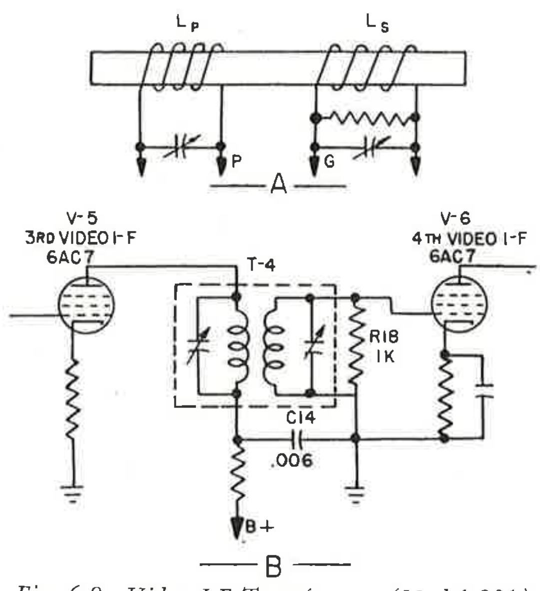


Fig. 6-8. Video I-F Transformer (Model 901).

In addition to inductive coupling between the primary and secondary windings, there is also some capacitive coupling. The capacitive coupling is due to the capacity existing between the plate end of the primary and the grid end of the secondary, as indicated in Figure 6-9. The windings are so connected that the instantaneous polarity at the grid and plate ends of the transformer is the same, so that the capacitive coupling will aid the inductive

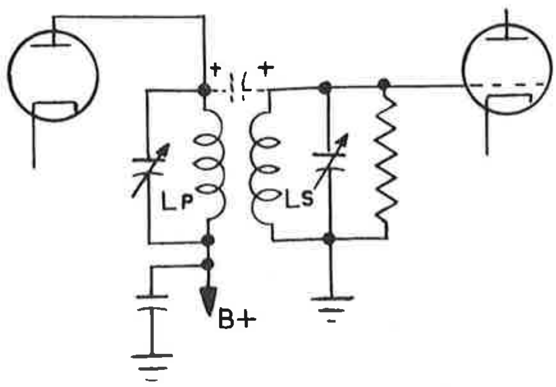


Fig. 6-9. Capacitive Coupling Between Primary and Secondary.

coupling. In order for capacitive coupling to exist at all it is necessary for the hot ends (plate and grid ends) of the transformer to be adjacent. This should be kept in mind if it is necessary to replace an i-f transformer of this type.

Due to the small number of turns of wire required to resonate the primary and secondary windings at the relative high frequency used for the video i-f, the magnetic field is not extensive enough to require shielding between stages.

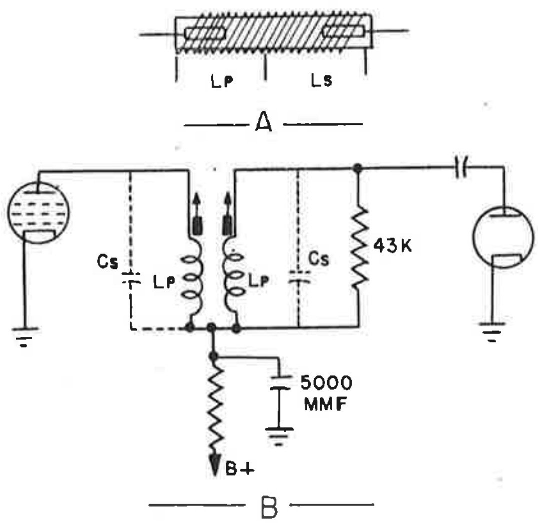


Fig. 6-10. Video I-F Amplifier (Model 810).

The video i-f transformers used in some other models of General Electric TV receivers, the Model 819 for instance, are of the inductively tuned type. Instead of the primary and secondary consisting of two separate windings, as in the case of the transformers just discussed, they consist of a continuous solenoid winding wound on a hollow form in which the iron core for tuning is inserted, as indicated in (A) of Figure 6-10. Although a continuous winding is used instead of a separate primary and secondary, its effect in the circuit is the same as though two separate windings were used.

The proper degree of coupling is determined by the diameter of the wire and coil form. As in the case of the other type of transformer, resistive loading is used in the secondary to obtain the desired bandwidth.

The schematic representation of this transformer is shown in (B) of Figure 6-10 and represents the 4th video i-f transformer used in the Model 810 receiver.

The inductance of the primary and secondary is varied by means of the iron cores so as to resonate with the tube and distributed capacity across them, as indicated by C_s shown in dashed lines.

Although B+ is applied to the centre of the transformer, placing both windings at B+ potential, this point is at a-c ground potential insofar as the i-f signal is concerned since it is adequately by-passed to ground by means of the 5000 $\mu\mu$f capacitor. Since the secondary is at B+ potential, a blocking capacitor is used between it and the following stage, which in this case is the video detector. The secondary is resistive loaded by means of the 43K ohm resistor.

9. I-F wave trap design.

The wave traps are resonant circuits which are coupled to the video i-f transformers, either inductively or capacitively, and attenuate the response of the transformers at the particular frequency to which the trap circuit is tuned. To illustrate, suppose that (A) of Figure 6-11 is the response without a 21.9 mc trap circuit. It will be noted that 21.9 mc is fairly well up on the response curve. However, if a wave trap circuit tuned to 21.9 mc is coupled

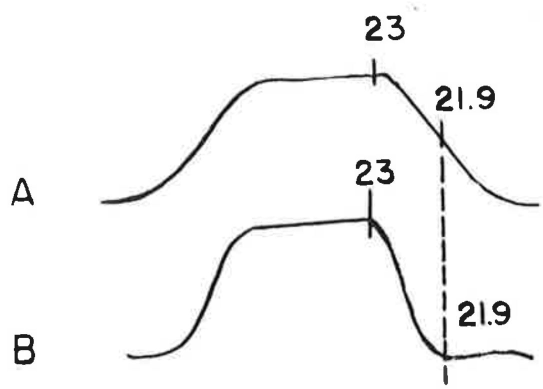


Fig. 6-11. Effect of Trap on Response Curve.

to the transformer, either inductively or capacitively, it will attenuate the response of the transformer at this frequency and the response curve will approach that of (B) where 21.9 mc is considerably down on the curve. It will also be noted that the low frequency skirt of the response curve which is adjacent to 21.9 mc, is steeper due to the use of this trap.

These trap circuits are either parallel resonant or series resonant. The parallel resonant type is inductively coupled to the transformer and attenuates the response by means of absorption.

The series resonant type is capacitively coupled and attenuates the transformer response by offering a low impedance path to ground at the frequency to which it is tuned. The trap circuits are sharply tuned so that they will attenuate the transformer response at one frequency only and not over a wide range of frequencies, as would be the case if the trap circuit were not highly selective. To accomplish this, of course, the Q of the trap circuit must be quite high.

As mentioned previously, three trap circuits tuned to 21.9 mc are used in the Model 901 receiver to provide sufficient overall attenuation of the accompanying sound i-f, and they are coupled to the third, fourth and fifth video i-f transformers. The 21.9 mc trap associated with T3 is parallel resonant and is inductively coupled with the trap inductance wound on the same form and adjacent to the plate winding, as indicated physically in Figure 6-12 and electrically in Figure 6-1.

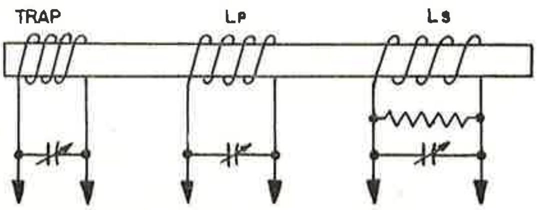


Fig. 6-12. Video I-F Transformer with Trap.

This first 21.9 mc trap not only provides attenuation of the accompanying sound i-f through the video i-f channel but in addition is used as a take-off point to feed the sound signal into the 21.9 mc sound i-f channel.

The 21.9 mc traps associated with T4 and T5 are series tuned trap circuits capacitively coupled to the secondary, as shown in Figure 6-1. At first glance it might appear as though these are not series tuned traps since the trap inductance and trimmer form a parallel resonant circuit. However, the entire trap circuit consists of this parallel combination in series with the small capacitor connecting it to the secondary and the series combination thus formed is resonant at 21.9 mc, as indicated in Figure 6-13. The parallel combination of the trap inductance and trimmer actually tunes to a higher frequency than 21.9 mc and therefore this parallel combination looks inductive at a lower frequency.

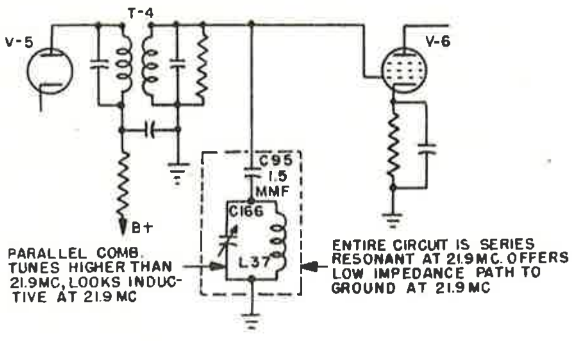


Fig. 6-13. Trap Circuit of Model 901 Receiver.

The trimmer across the trap inductance simply varies its effective inductance so that it is series resonant with the small coupling capacitor at 21.9 mc.

The trap circuit for adjacent channel sound attenuation is parallel resonant and is inductively coupled to the primary of the second video i-f transformer T2, as shown in Figure 6-1. It is tuned to 27.9 mc.

The trap circuit for correct placement of the video i-f carrier of 26.4 mc is coupled to the first video i-f transformer T1 by means of a small choke connected in series with the primary winding, as indicated in Figure 6-1. The trap is series tuned and the voltage across the choke is applied to the series tuned trap circuit which absorbs energy from T1 at a frequency that gives the proper shape to the high frequency skirt of the i-f pass-band for correct placement of the i-f carrier.

10. Manual gain (contrast) control circuit

The contrast between black and white picture elements is controlled on many G.E. TV receivers by means of a sensitivity control incorporated in the video i-f channel. On some receivers this also includes control of the converter tube. By varying the gain of the video i-f channel, the amplitude of the video signal in the output of the video detector is varied, which in turn varies the swing of the video signal between grid and cathode of the picture tube, thereby providing a means of controlling the degree of contrast between light and shade in the reproduced picture.

As shown in Figure 6-1, the contrast control in the Model 901 TV receiver varies the bias on the grids of the 1st, 2nd and 3rd video i-f amplifier tubes. As indicated, a low negative voltage is applied across the series combination of R11 and the contrast control. The grids of the controlled tubes are returned to the arm of the contrast control through the decoupling resistors, R5, R10 and R16. Moving the arm of the contrast control toward its most negative end increases the negative bias on the controlled tubes and consequently lowers their stage gain. On the other hand, moving the arm of the control in the opposite direction decreases the bias and therefore increases the stage gain.

Fixed negative bias is applied to the grid of the television sound i-f amplifier, V17, through the 21.9 mc trap circuit, the low side of which is connected by means of R75 to the junction of the contrast control and R11.

The negative voltage that is applied to the contrast control is derived from the grid circuit of the horizontal sweep generator tube V14. The voltage developed at this point is approximately –30 volts and is applied to the contrast control circuit through the 1 megohm resistor, R119.

Obtaining the negative voltage for the contrast control circuit in this manner, rather than from a voltage divider circuit in the power supply, reduces the possibility of regeneration due to common coupling through the power supply.

11. Input capacity of video i-f tubes

Referring to Figure 6-1, it will be noted that the cathodes of the 1st, 2nd and 3rd video i-f tubes are returned to ground through 33 ohm resistors that are un-bypassed. These low value un-bypassed cathode resistors maintain the input capacity of the first three video i-f tubes essentially constant as the bias on them is varied with different settings of the contrast control.

When high Gm tubes are used, such as the type 6AC7, an undesirable variation in the response curve of the video i-f stages may take place by the detuning effect of the change in input capacity caused by a change in bias. The input capacity might change as much as 10% over the bias range afforded by the contrast control unless something is done to correct this condition.

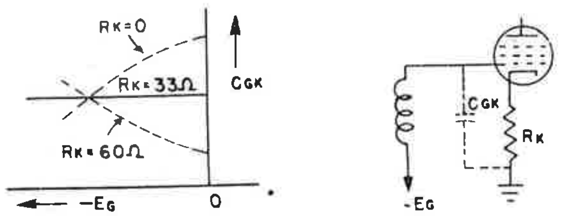


Fig. 6-14. Effect of Cathode Resistor on Input Capacity.

It has been found that this variation in input capacity may be controlled by an un-bypassed resistor of the proper value in the cathode circuit of the tube. A resistor of approximately 30 ohms tends to maintain the input capacity constant in a type 6AC7 tube, while a cathode resistor of approximately 60 ohms will cause an increase in input capacity with increased bias, and zero cathode resistance will cause the input capacity to decrease with an increase in bias. This effect is illustrated by Figure 6-14. A 47 ohm resistor gives the same results when using a type 6AU6 tube.

12. Overall video i-f circuit

Referring to the video i-f section of Figure 6-1, a brief description of the overall action is as follows:

As indicated, the output of the television converter contains both the picture and sound i-f signals and the response of the first video i-f transformer is broad enough so that both of these signals together with the necessary sidebands are coupled to the grid of the first video i-f amplifier, V3, where they are amplified and passed on to the grid of the second video i-f amplifier, V4, by means of the second video i-f transformer, T2. Thus far, no attenuation of the accompanying sound i-f signal has taken place.

After amplification by V4, both signals appear in the third video i-f transformer, T3, at which point the sound i-f signal is separated from the video and fed into the sound i-f channel by means of the first 21.9 mc trap circuit which is coupled to T3. Further attenuation of the accompanying sound i-f in the video i-f channel is provided by the other 21.9 mc trap circuits coupled to T4 and T5.

Further amplification of the video i-f carrier and its associated side bands is provided by means of the third and fourth video i-f amplifiers V5 and V6.

Rejection of possible adjacent channel sound interference is provided by the 27.9 mc trap circuit coupled to the second video i-f transformer, T2.

Proper placement of the video i-f carrier of 26.4 mc is accomplished by means of the carrier placement trap associated with the first video i-f transformer, T1. The overall response or pass-band of the video i-f channel is as shown by the curve above the video detector and is due to proper tuning of the five double-tuned, overcoupled, resistive-loaded video i-f transformers and associated trap circuits.

13. Overall television sound i-f circuit

Again referring to Figure 6-1, it will be noted that the sound i-f signal of 21.9 mc is amplified by the first and second video i-f amplifiers before it is separated from the video signal.

The resonant voltage developed at 21.9 mc across the trap circuit coupled to the third video i-f transformer is applied directly to the grid of the 21.9 mc sound i-f amplifier, V17. Fixed bias for this tube is obtained by returning the low side of the trap through R75 to one end of the contrast control. The low side of the trap is effectively returned to ground, as far as the signal is concerned, through the low impedance path offered by C53 at 21.9 mc.

The 21.9 mc sound i-f amplifier, V17, amplifies the signal, after which it is coupled to the grid of V18 by means of the double-tuned i-f transformer, T11. V18 is used as a limiter for the FM i-f signal. Limiting is provided in the usual manner by the bias voltage developed across the resistor-capacitor, R70 and C51, in the grid circuit and the fairly low value of plate and screen voltages applied to V18.

The output of the limiter stage is coupled to the FM discriminator detector by means of T10. The discriminator detector is of the conventional type used in most FM receivers. The demodulated output of the discriminator detector is taken from across the two equal value load resistors, R66 and R65, in the usual manner and fed into the audio amplifier circuits. De-emphasis of the FM audio signal is accomplished by R67 and C47.

The response curve or passband for the sound i-f channel from the 21.9 mc take-off trap to the grid of the limiter is as shown in (A) of Figure 6-15, the overall bandwidth being approximately 250 kc, which is sufficient to prevent any slight drift in the oscillator from affecting the sound. The discriminator response curve is shown in (B) of Figure 6-15 and it should be noted that the 21.9 mc i-f falls in the centre of the straight portion of the discriminator response curve.

When the signal strength is strong, it will probably be possible to tune in the sound at three different points which are close together due to the characteristics of the discriminator, as indicated by by (A), (B) and (C) in Figure 6-16. However, only one of these points, the one at the centre of the discriminator response curve, point B, will produce the clearest and loudest sound.

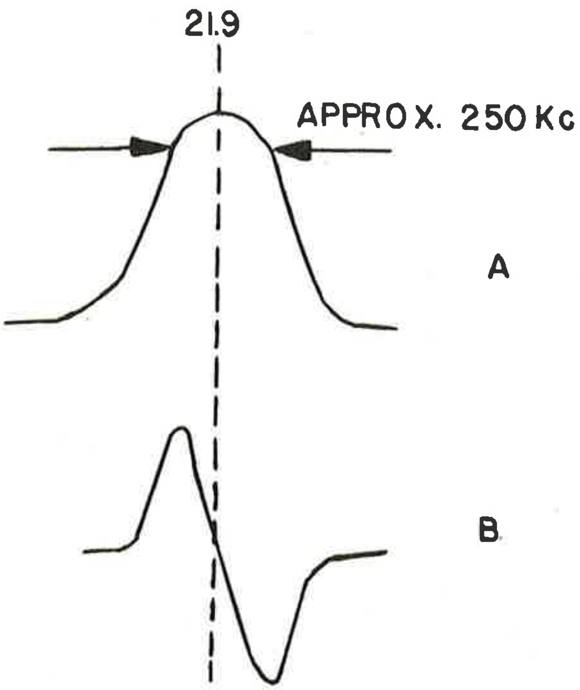


Fig. 6-15. I-F and Discriminator Response Curve.

The sound output on either side of this point will be weak and distorted. When the sound signal is properly tuned in, the sound i-f of 21.9 mc will fall exactly in the centre of the pass-band of the take-off trap and the sound i-f transformer, T11, and also in the centre of the straight portion of the discriminator response curve, as indicated by (A) and (B) of Figure 6-15.

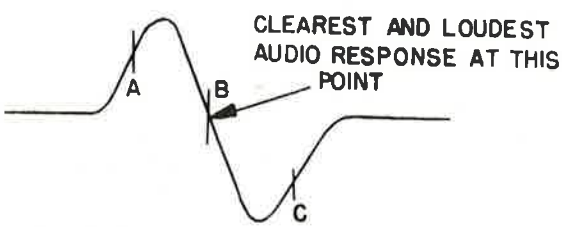


Fig. 6-16. Discriminator Response Curve and Three Point Tuning.

14. Tracking of sound with picture

The relationship existing between the overall response of the video i-f channel and the sound i-f channel when properly aligned is indicated in Figure 6-17. From this it is apparent that when the local oscillator of the receiver is adjusted so as to produce maximum sound with good quality, the best possible picture will also be reproduced, since at the same time that the local oscillator heterodynes with the sound carrier to produce the sound i-f of 21.9 mc it also heterodynes with the picture carrier to produce the video i-f of 26.4 mc with associated side bands. Therefore, with the relationship shown in Figure 6-17, the 26.4 mc i-f corresponding to the picture carrier will fall in the proper place in the video i-f pass-band, which for reasons discussed earlier is the desired condition to reproduce a picture having good quality.

If this relationship between the video and sound i-f circuits does not exist, due to misalignment, then the picture and sound will not track. That is, when the receiver is tuned for best sound, no picture or a very poor picture will result.

In remote locations from the transmitter where the signal picked up is very weak, a condition may exist which would seem to indicate misalignment, since under these circumstances it is possible to get a steadier picture with more apparent contrast and less interference in it when the sound is tuned out, than when the receiver is tuned for best sound. Although the picture thus obtained may be less affected by noise and have more apparent contrast, it will definitely lack detail and only seems better due to the weak signal and noise conditions.

However, this particular condition is not due to misalignment, although the symptoms are similar. Instead, this condition is due to the fact that the sesqui-sideband or vestigial sideband method of transmission is used (the details of which were explained earlier), and that the overall video i-f response must be such as to compensate for this method of transmission.

Under normal conditions, the receiver is tuned for best sound so that the relationship shown in Figure 6-17 exists, where the 21.9 mc sound i-f falls right in the centre of the pass-band of the sound i-f channel and the 26.4 mc i-f corresponding to the picture carrier is fifty per cent. down on the

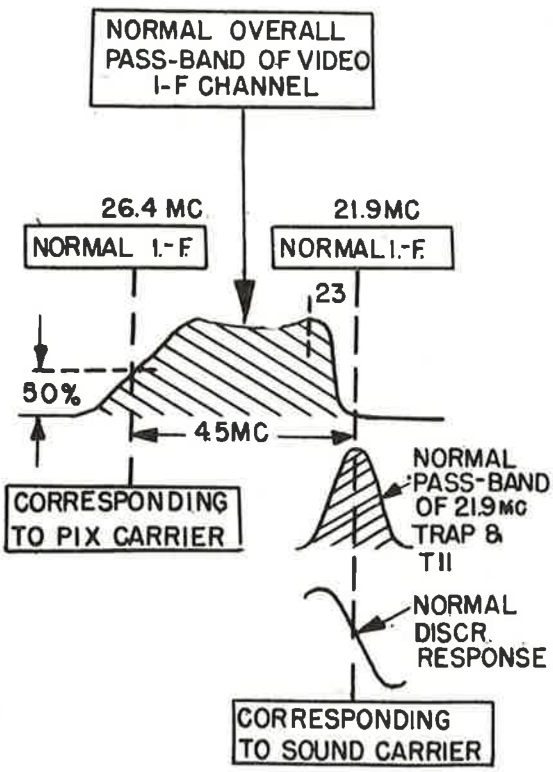


Fig. 6-17. Tracking of Video and Sound Carriers.

response curve of the video i-f channel so as to compensate for the vestigial side-band method of transmission. This is the condition where a picture having the best detail is obtained coincident with the best sound.

Now if the i-f corresponding to the picture carrier is moved up on the response curve of the video i-f channel, by slightly lowering the frequency of the local oscillator, so that when it heterodynes with the picture carrier an i-f somewhat lower in frequency than the normal 26.4 mc i-f is produced, then in weak signal areas this may result in what appears to be a better picture — but with little or no sound.

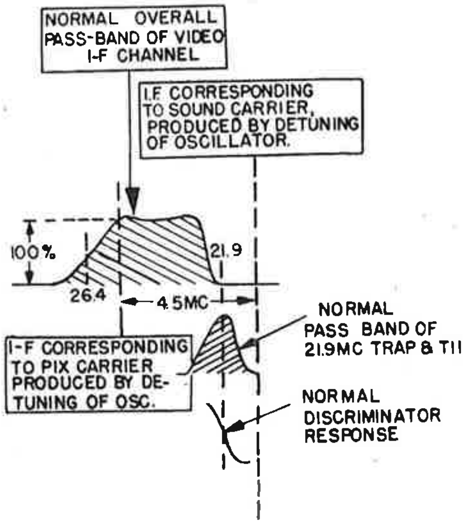


Fig. 6-18A. Incorrect Tracking of Sound and Video Carriers.

For the purpose of illustration, suppose that the i-f corresponding to the picture carrier thus produced is 25.6 mc instead of the normal frequency of 26.4 mc. This places the i-f corresponding to the picture carrier on top of the response curve of the video i-f channel, as shown in Figure 6-18 (A). Under this condition, the output of the video detector will not be uniform for all modulation components as it would if a 26.4 mc i-f were produced. Instead, due to the vestigial side-band method of transmission, the output of the video detector will be greater for the low frequency modulation components than for the higher frequency components, as indicated by the video detector output shown in Figure 6-18 (B). The dashed lines represent the increased output obtained due to putting the video i-f corresponding to the carrier up on the response curve. The solid line represents the normal, uniform output obtained when the i-f corresponding to the carrier is correctly placed. This non-uniform output results in a picture having much poorer detail as compared to the picture obtained if the normal i-f of 26.4 mc were produced. However, due to the increased output from the video detector for the low frequency modulation components which contain the synchronizing signals and which determine contrast, the picture will probably be steadier and have more apparent contrast in areas where the receiver is a considerable distance from the transmitter. It should be emphasized, however, that the picture thus obtained is not the most desirable, since it will be definitely lacking in clarity and detail although it will probably be less affected

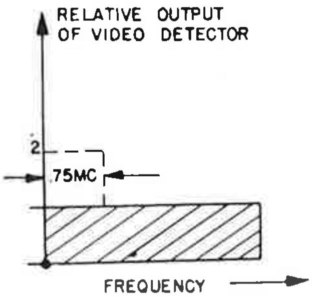


Fig. 6-18B. Detector Output for Lower Local Oscillator Frequency.

by noise. Also, there will be little or no sound accompanying it, for the reason that when the frequency of the local oscillator is lowered, so as to move the i-f corresponding to the picture carrier up on the response curve, the sound i-f produced by the local oscillator heterodyning with the sound carrier will no longer be 21.9 mc, but will be lower in frequency by the same amount that the picture i-f was lowered, as indicated in Figure 6-18 (A). The sound i-f thus produced is out of the pass-band of the sound i-f channel and, consequently, little or no sound will be heard.

In areas where the signal strength is very weak and where some picture, although lacking in detail, is better than no picture at all, there may be some justification in moving the i-f corresponding to the picture carrier up on the response curve. Instead of doing this by detuning the sound and producing a lower video i-f corresponding to the picture carrier, this should be done by slightly realigning the video i-f channel so that the normal i-f of 26.4 mc falls on top of the response curve, as indicated in Figure 6-19. When the i-f of 26.4 mc is moved up on the response curve in this manner, by a slight realignment of the video i-f channel, the sound will track or coincide with the picture.

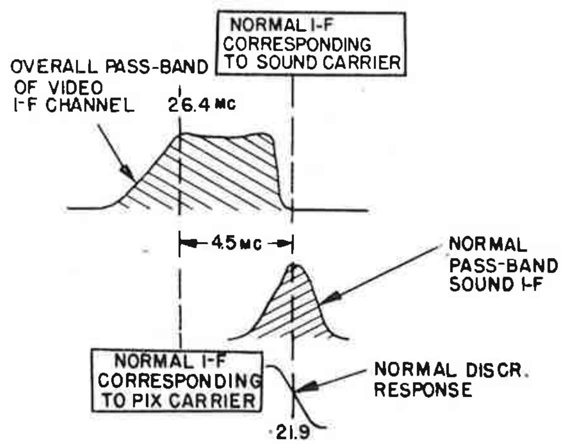


Fig. 6-19. Realigning of I-F for Weak Signals.

The slight realignment necessary to accomplish this can be done by means of the carrier placement trap.

This adjustment will definitely reduce the quality and amount of detail in the picture, but in very weak signal areas it may be better than no picture at all, or one that is very unstable. This procedure is not to be recommended except for extreme cases where it is not possible to increase the amount of signal picked up by the antenna to the point where a good picture can be obtained in the normal manner.

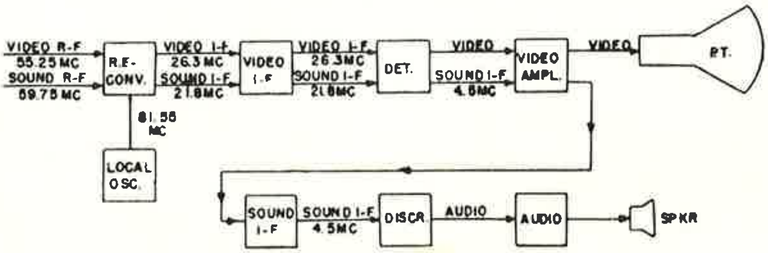


Fig. 6-20. Intercarrier Sound System.

15. Intercarrier sound

Another method for obtaining television sound which has certain operational and circuit simplicity advantages over the conventional system described in the preceding paragraphs, is called the "intercarrier sound system". This differs from the conventional system in that the video carrier is used as a local heterodyne oscillator as the video detector to give a sound i-f of 4.5 mc. This difference frequency is then amplified and amplitude limited and then demodulated by a fixed tuned discriminator detector to obtain the audio of the sound channel. A block diagram of such a system is shown in Figure 6-20, which shows the various r-f and i-f frequencies when operating on Channel #2. [This system will be treated in detail later in the course.]

The receiver is constructed along conventional lines except that the sound i-f signal is not separated from the video signal as before and fed into a separate i-f amplifier channel of 21.8 mc. Instead, the sound i-f carrier is allowed to pass through the video i-f amplifier to the video detector. The amplitude of the sound carrier through the video i-f channel is kept at a low level and is not attenuated quite so much as with the conventional i-f system. In order to make the resultant input to the second detector to be dominated by the picture i-f carrier, it is necessary to shape the pass-band of the i-f so that when the video carrier of 26.3 mc is 50 per cent. down, the sound i-f (21.8 mc) is attenuated 90 per cent. from maximum. A suitable overall selectivity curve and the relative location of the sound and picture i-f carrier frequencies is shown in Figure 6-21.

When these frequencies are impressed on the video detector, the video i-f carrier (26.3 mc) which is amplitude-modulated, acts the same way as a local oscillator in the receiver when it heterodynes with the frequency modulated sound carrier (21.8 mc) to form a resultant beat frequency of 4.5 mc. In other words, the sound carrier will appear to the picture carrier as just another sideband so that in the detector output there will be found, in addition to the video frequencies, a 4.5 mc signal frequency-modulated with the sound.

The 4.5 mc signal will be amplitude modulated to a small extent by picture modulation. This is controlled by keeping the picture carrier i-f at a level

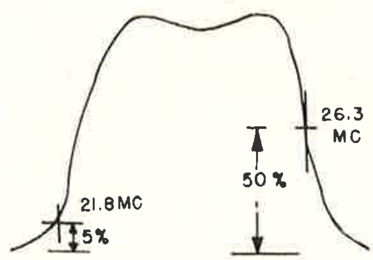


Fig. 6-21. Selectivity Curve for Intercarrier Sound System.

so that the lowest video modulation amplitude (white) is as great or greater than the amplitude of the sound carrier i-f appearing at the video detector. Any small amount of amplitude variation is removed by incorporating a limiter circuit later in the circuit. Figure 6-22 shows the resultant 4.5 mc heterodyne i-f after formation at the video detector.

The 4.5 mc output of the video detector may be amplified by the usual video amplifier, making this a common channel for both picture and sound. Separation of the sound from the picture is made at the plate of the last video amplifier, as shown in Figure 6-23. The variable inductance L_1 resonates with C_1 to form a high Q 4.5 mc series trap. This cuts down the 4.5 mc component available to the picture tube to a point where it will not cause interference to be seen on the picture. At the same time, the voltage developed across a portion of L_1 is coupled to tube V2 which serves as a limiter-amplifier to feed a ratio detector. These tubes amplify and detect the frequency modulation present on the 4.5 mc wave and the resulting audio output is fed to a conventional audio output amplifier and speaker.

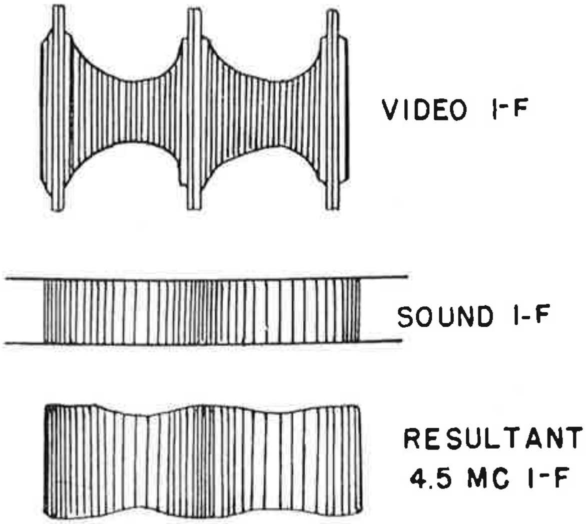


Fig. 6-22. Action of Video Detector in Intercarrier Sound System.

Since this system makes use of the quartz crystal-controlled oscillators at the transmitter for generating the 4.5 mc i-f, the nominal drifting of the local oscillator does not affect the sound. Likewise, hum modulation or microphonics in the local oscillator cannot affect the sound signal because any change in the sound i-f is accompanied by an equal change in the video i-f so that the difference frequency always remains the same.

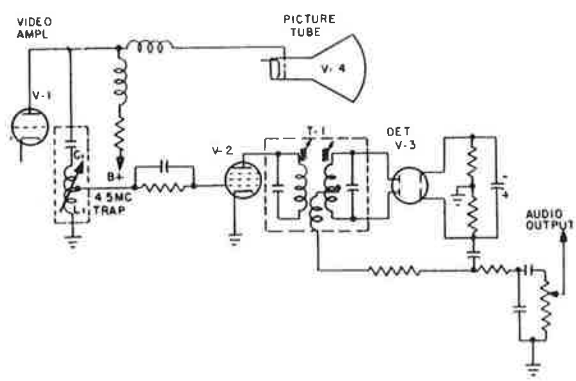


Fig. 6-23. Sound Amplifier in Intercarrier Sound System.

In tuning a receiver incorporating the intercarrier sound system, since the sound channel appears very broad in tuning, it is necessary for the operator to tune for maximum picture detail which is best determined by adjustment during the transmission of a test pattern. In weak signal areas, this system also permits the operator to disregard detail and tune the receiver for maximum picture signal to give slightly better operation in the "fringe" areas and still maintain good sound. This cannot be done without realignment on a TV receiver using the conventional sound i-f system as brought out in detail previously.

16. Automatic Gain Control (AGC) circuit

Since fading is not a problem in the reception of television signals, an automatic gain control does not have the usefulness that this type of control circuit (AVC) has to a standard AM broadcast receiver The primary usefulness as applied to television, is to reduce the necessity of changing the contrast control setting whenever a weaker or stronger station is selected by the channel switch. A secondary function is to reduce airplane "flutter". On the other hand, as shown by early attempts to incorporate AGC in television receivers, noise as it affects the picture may be emphasized unless special precautions are taken.

In a normal broadcast receiver, sufficient bias voltage for AVC is obtained from the detector by making use of the d-c component which represents the average carrier level. Thus, when the signal fades or the relative signal strengths change when tuning from station to station, the resulting automatic biasing voltage developed, controls the gain of the i-f or r-f stages to correct for the change. At the video detector of the television receiver, the voltage developed is not quite sufficient for full control at strong signal levels so that a higher level point must be taken for derivation of the AGC voltage.

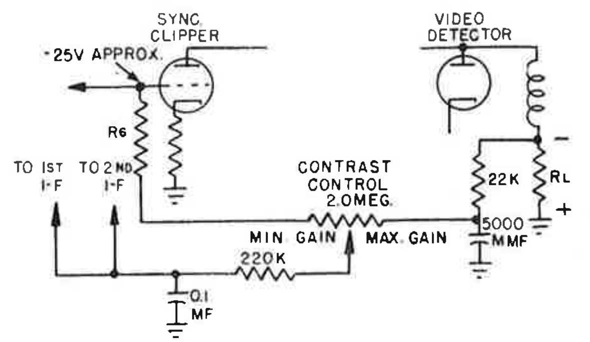


Fig. 6-24. AGC Circuit.

Figure 6-24 shows a very simple but effective method of incorporating AGC as is found in some of the G.E. television receivers. By connecting the contrast into the grid return of the sync clipper circuit, it provides a source of high bias voltage which varies directly with the amplitude of the video carrier. The other end of the contrast control connects the video detector load resistor to provide a lower potential bias voltage with the same characteristic so that it will provide for a minimum AGC voltage when operating at weak signal strengths. By connecting the potentiometer arm to the 1st and 2nd video i-f amplifier tubes as the amplitude of the signal decreases when selecting a weaker station, the bias to these tubes will be decreased which provides for greater gain in the amplifier to compensate for the weaker signal.

Radiotron-6198 Vidicon Facilitates Design of New Industrial TV Camera

Closed-circuit television as a widely-used medium for industry, research, and education moved even closer to reality with RCA's announcement that its Model ITV-5 industrial TV chain is commercially available.

Designed to maintain continuous visual checks on numerous operations that are too remote, inaccessible, or hazardous for direct viewing by human observers, the entire equipment consists of only two units, which are housed in a single, portable case smaller than a home table model TV set. The units are: (1) a $7\frac{1}{2}$-pound camera measuring $10\frac{1}{2}$ inches long, five inches high, and $3\frac{1}{2}$ inches wide; (2) a combination monitor, power supply and control unit weighing 70 pounds and measuring 20 inches long, $15\frac{1}{2}$ inches high, and 13 inches wide. The picture picked up by the camera is transmitted to the monitor's 10-inch viewing screen over a length of 18-conductor camera cable 0.625 in. diameter.

Heart of the camera — and facilitating its design — is the Radiotron-6198 Vidicon camera tube, which is about one inch in diameter by $6\frac{1}{4}$ inches in length. This tube provides 400-line resolution, employs magnetic focus and magnetic deflection, and operates with relatively low dc voltages. Utilizing a photoconductive layer as its light-sensitive element, the 6198 has a sensitivity which permits televising scenes with 100 or 200 foot-candles of incident illumination on the scene. The photoconductive layer has a spectral response characteristic approaching that of the human eye. The size and location of the photoconductive layer permit a wide choice of commercially available lenses.

Whereas a broadcast-type television camera chain employs more than 60 vacuum tubes, the entire ITV-5 system uses only 22. The monitor-power-supply-control unit contains all the controls for operation of the chain. These include controls for picture brightness and contrast, beam intensity, electronic focus, and optical focus. Once the system has been set up, all necessary adjustments can be made with only two knobs.

Three of the ITV-5 industrial TV systems were demonstrated for the first time on September 16 at a Baltimore and Ohio Railroad freight yard in Chicago. Instead of walking among trains and over tracks to list car numbers on an incoming train, for use in switching to make up trains destined for various sections of the country, a checker sat before a television screen and listed the numbers as cars passed before a small unattended camera.

Similarly, observers in a single location were enabled to see on the screen of two TV receivers the disposition and movement of all cars and switching engines in the big classification yard. These views were picked up by two Vidicon TV cameras mounted atop the yardmaster's tower on bases that could be rotated at will by means of controls at the receiver station.

A new series of components — 216D1, 217D1, 218D1, 233T1, and 234T1 — designed by RCA engineers especially for use with the 6198 Vidicon, is now available.

Employed in properly designed circuits, these new components provide good sweep linearity, high deflection sensitivity, efficient coupling between circuits, and proper focusing and alignment of the electron beam.

The components are:

RCA-216D1	Deflecting Yoke
RCA-217D1	Focusing Coil
RCA-218D1	Alignment Coil
RCA-233T1	Horizontal-Deflection-Output Transformer
RCA-234T1	Vertical-Deflection-Output Transformer

New RCA Releases

Radiotron-5ABP1 is a new, 5-inch, flat-face, cathode-ray tube of the electrostatic-focus and electrostatic-deflection type intended especially for use with wide-band vertical amplifiers but suited for general oscillographic applications in which very high deflection sensitivity and a high-intensity trace are needed.

Although similar to the older type 5CP1-A as regards ratings, dimensions, and basing arrangement, the 5ABP1 differs in that it features a flat faceplate and much higher deflection sensitivity. The deflecting electrodes nearer the base require 50 per cent. less voltage per inch per kilovolt of ultor voltage while those nearer the screen require about 20 per cent. less.

The high-intensity fluorescent spot is made possible by the high-voltage, post-deflection accelerator electrode and is achieved with minimum sacrifice in deflection sensitivity and with only slight increase in spot size. Furthermore, large changes in spot intensity can be obtained with small variations in control-grid voltage.

Radiotron-5654 is a "premium" version of the miniature sharp-cutoff pentode 6AK5 for use as a broad-band rf or if amplifier in mobile and aircraft receivers. It is constructed and processed to meet military requirements.

Featured in the 5654 is a compact structure specially designed to provide increased mount strength against shock and against vibration, and a pure-tungsten heater to give long life under conditions of on-off switching. Furthermore, each 5654 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.