# *Television* RECEIVERS

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***Technical discussion of the operation of television receivers. Frequency modulated sound channel is now standard for black and white video transmissions.***

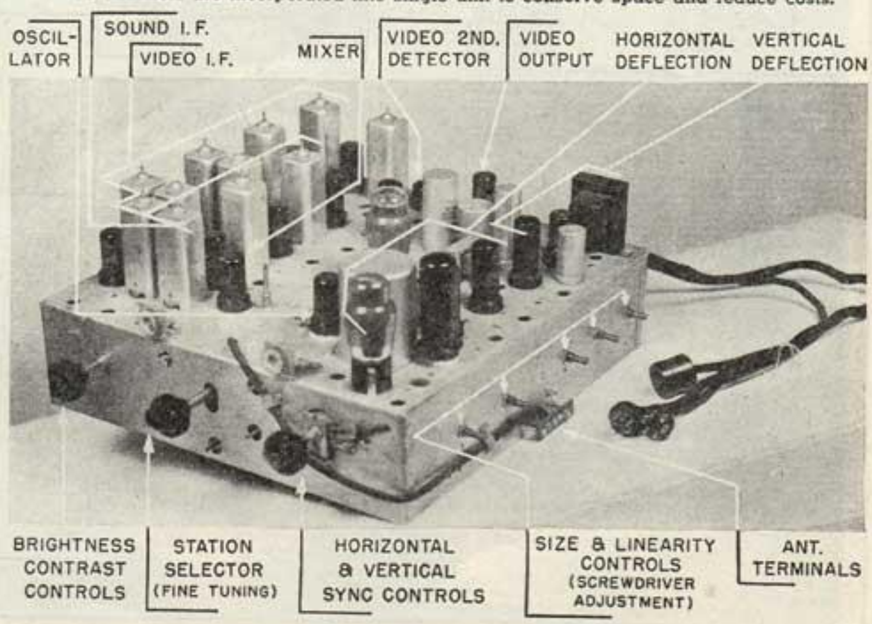
TELEVISION receivers are inherently more complicated than the ordinary broadcast receiver. Most of the broadcast receiver techniques are used, many of them in a modified form, but in addition to these there are many unusual circuits which are entirely foreign to broadcast practice. A rigorous treatment of television receivers would require many volumes; hence a discussion such as this can do little more than touch the high spots, with only minor excursions into the more theoretical aspects.

Antennas for the reception of television signals are many and varied. They may be anything from a piece of wire two or three feet long to an elaborate array with multiple reflectors and directors, depending upon the conditions surrounding the particular installation. The short piece of wire can, of course, be used only when the receiver is very close to the transmitter, and even then the results will be only mediocre. In arriving at a decision as to what type of receiving antenna is best to use in a given installation, many factors must be considered. Among other things, the receiving antenna must be high enough and there should be no intervening objects to obstruct line-of-sight between it and the transmitting antenna.

If the distance between receiver and transmitter is very great, it may be desirable to use an antenna having a greater gain; i.e., an antenna which will deliver a greater signal voltage to the receiver terminals for a given field strength. This is where the more complicated arrays enter the picture, but it should be kept in mind that, in general, the higher the gain in the antenna system, the more directive it will be, and the narrower bandwidth it will pass. When the signals from two or more television transmitters are to be received, the physical location of the transmitting antennas with respect to the receiving antenna, will have a profound bearing on the width of the receiving antenna beam and consequently the amount of gain that can be built into it. In addition to this, however, the carrier frequencies of the transmitters must also be considered in that the bandwidth of the receiving antenna must be kept broad enough to accept the two or more carrier frequencies which are of interest, and because this will also have a distinct effect on the maximum gain capabilities of the receiving antenna. Except in those two extremes where the receiver is located in a metropolitan area close to the transmitters and surrounded by tall buildings, or where the receiver is near the fringe of the service area, a simple half-wave dipole antenna will usually give fairly satisfactory results, although in the final analysis, each receiving antenna installation must be individually engineered if the best possible results are to be obtained.

Most television receivers are of the superheterodyne variety, as indicated in the block diagram of Fig. 2. It will be seen that, except for the oscillator and first detector, there are actually two separate and distinct receivers; one for the sound and another for the picture. Typical carrier frequencies, both r.f. and i.f., are shown in Fig. 2, wherein the oscillator is tuned to a frequency which is 12.75 megacycles above the picture carrier, and 8.25 megacycles above the sound carrier frequency. The 8.25 megacycle sound i.f. carrier is amplified, passed thru a limiter, a discriminator, and audio gain stages to a loudspeaker in accordance with normal FM sound broadcasting practice. It may be of interest to note that at the time most of the prewar television receivers were built, television transmission standards called for an amplitude modulated sound channel. In these receivers, the i.f. pass band was quite wide (of the order of 250 kc.). When the standards were changed to specify FM for the sound channel, some receivers

Top view of television chassis shows placement of various components. Sound and video channels are incorporated into single unit to conserve space and reduce costs.

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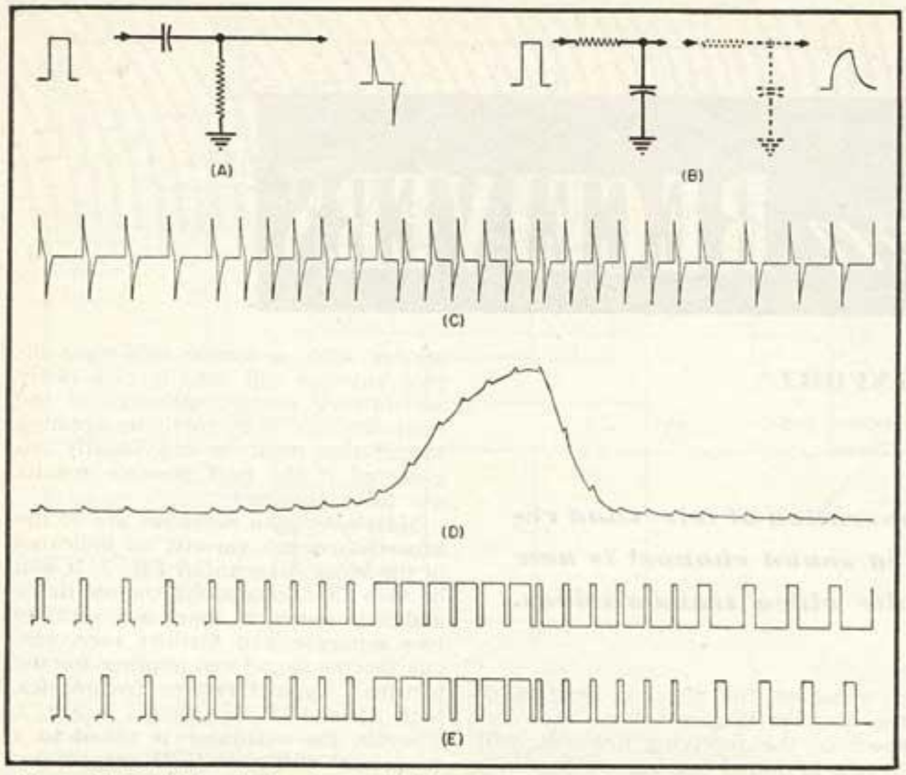


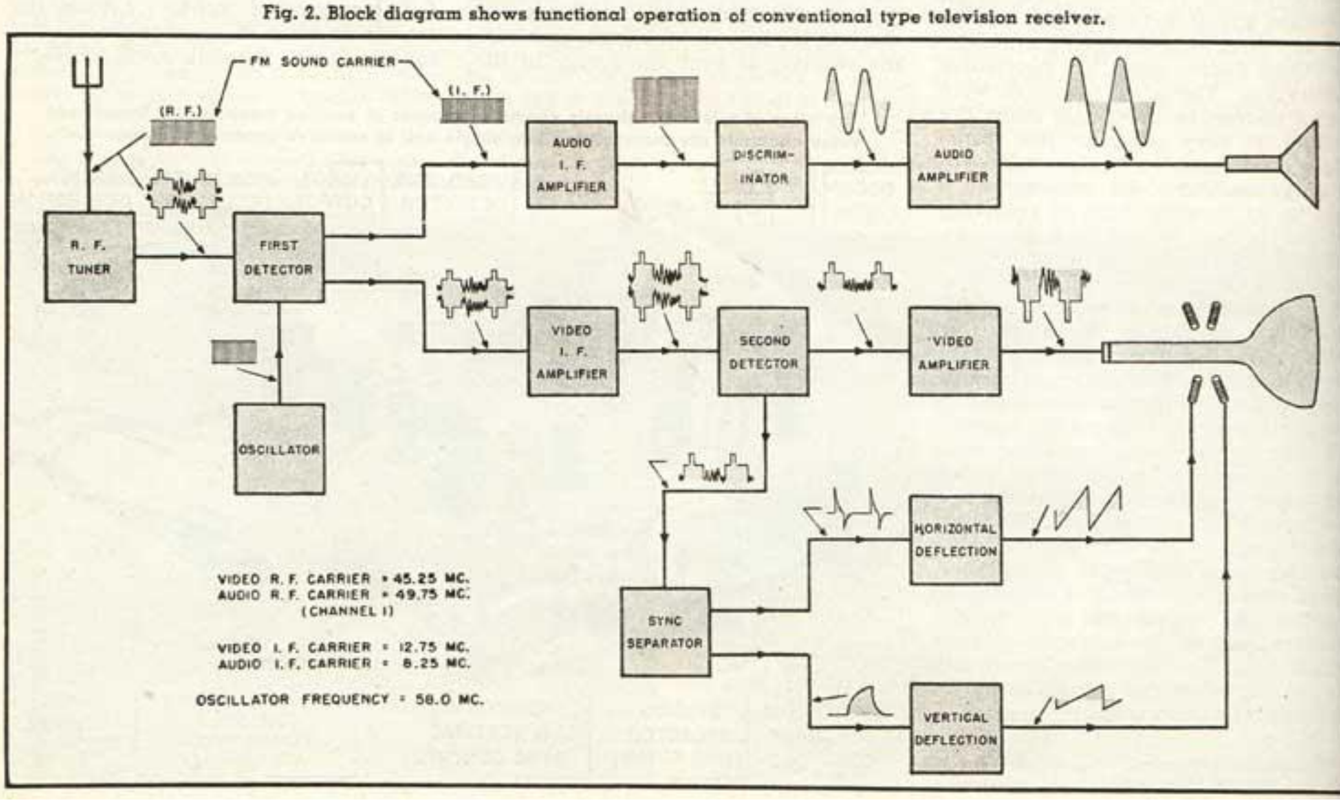

**Fig. 1. (A) RC differentiation circuit, (B) RC integration circuit, additional stages may be added as indicated by the dotted lines, (C) differentiated synchronizing signal, (D) integrated synchronizing signal, (E) television synchronizing signal, with even and odd fields shown.**

were modified to include a suitable discriminator, but in many cases the simple expedient of moving the i.f. pass band slightly so that the center frequency of the i.f. carrier fell in the middle of the slope of one side of the pass band was adopted. Thus, translation of the FM sound signal is accomplished as the frequency varies up and down along the slope of the pass band characteristic. Although this is admittedly not the ideal solution, it has, for the most part, proven satisfactory.

The picture i.f. amplifier, like the video amplifiers, should have a pass band of 4.5 megacycles. Due to the single side-band method of transmission, the slope of the high frequency side of the pass band should be such that transmission is zero at 13 megacycles, and 100% at 12.5 megacycles, thus placing the carrier midway up the slope. From 12.5 megacycles down to about 8.5 megacycles, the curve should be flat, then drop to zero at 8.25 megacycles. Generally, in the first two picture i.f. stages, 8.25 megacycle and 14.25 megacycle tuned rejection circuits are to be found. The purpose of these circuits is to insure that none of the sound i.f. signal gets into the picture side of the receiver, and to avoid crosstalk into the adjacent channel. In order to obtain the unusually wide pass band characteristic in the picture i.f. stages, double tuned circuits are frequently used. The primary and secondary are deliberately over-coupled to the extent that the double peaked transmission characteristic appears, then the secondary is sufficiently loaded with resistance to flatten out the major portion of the peaks. Obviously, the gain per stage is much less under these conditions than in the ordinary broadcast receiver. It is not unusual to find five or six such stages of i.f. amplification in a television receiver in order to provide sufficient gain.

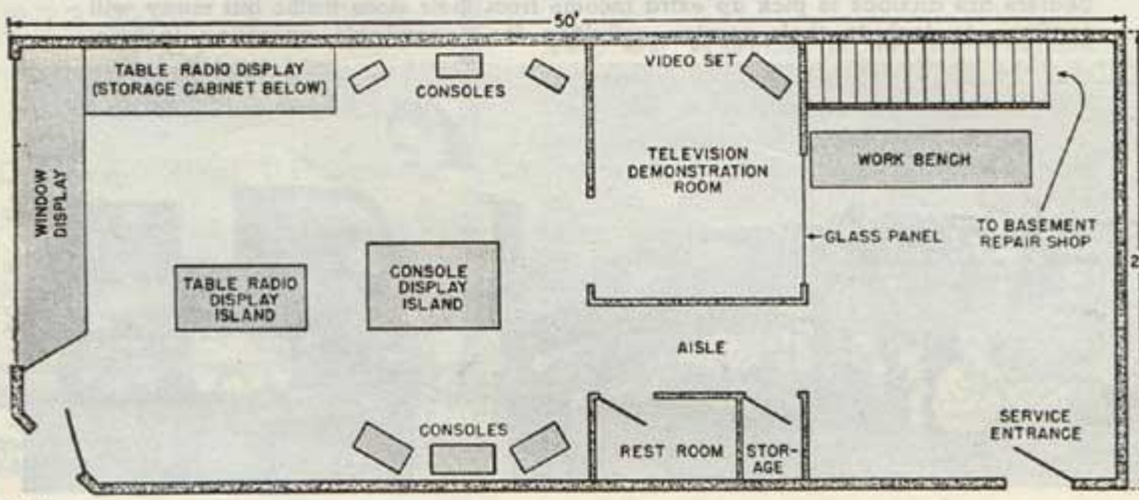
The alignment of the i.f. amplifiers in a television receiver is not simple. Of the two, the sound i.f.s are the more simple to align. Adjustment of these stages to a bandwidth of 200 to 300 kc. with the retention of a reasonable amount of gain is not too complicated, since for the most part, the technique follows broadcast practice. A sufficient bandwidth is normally allowed in the audio i.f. to permit the oscillator to be tuned for best picture re-

**Fig. 2. Block diagram shows functional operation of conventional type television receiver.**

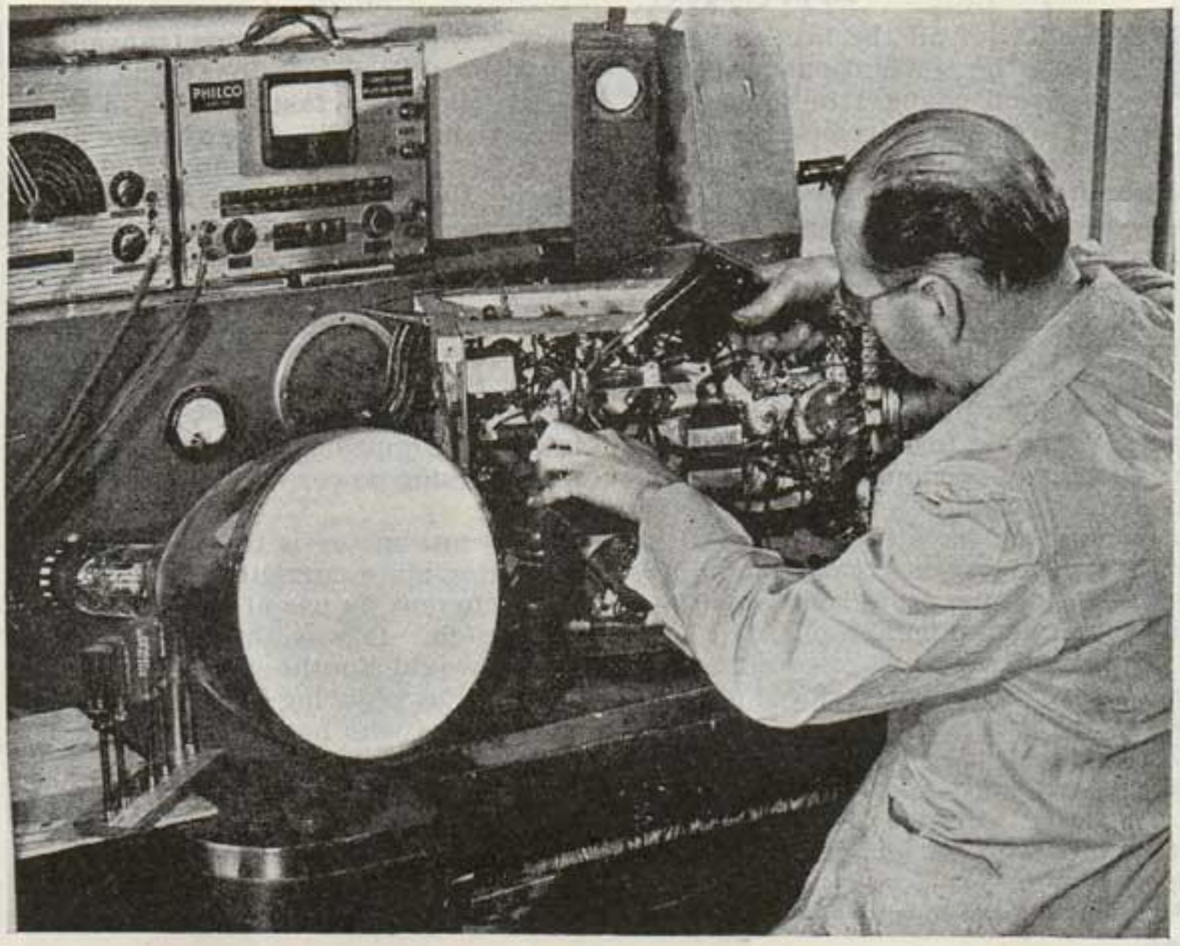


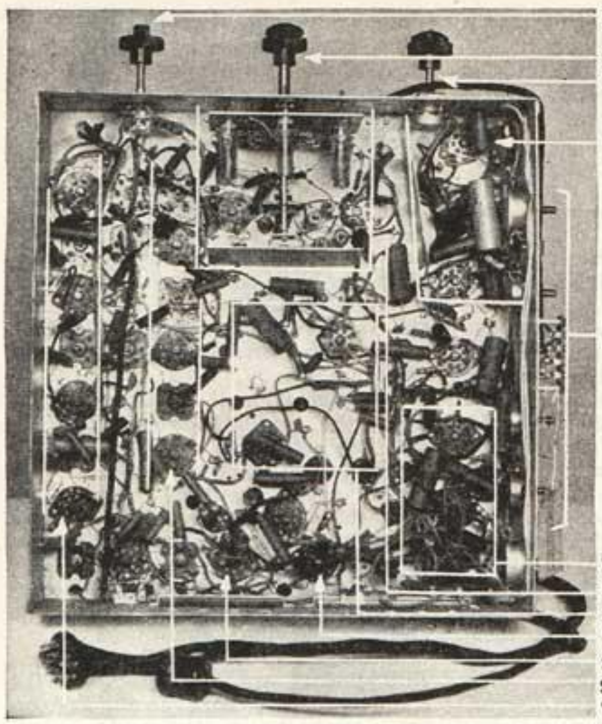
Attractively framed by the sliding plate glass window border and visible to all store customers, this shop arrangement epitomizes the use of good merchandising practices in radio service selling. Verne Wintermute, engaged here in checking the image on a video set, planned this effective arrangement when remodeling.

General layout of V. M. Wintermute Radio Service Shop in Plainfield, N. J. shows an effective utilization of display space. Radio dealers are applying good selling techniques in merchandising their various radios and traffic appliances.



Successful service centers for FM and television will be completely equipped with the best of test instruments and tools. Design of work benches and the placement of test equipment must be carefully studied to provide servicing conditions of factory efficiency. Technician solders connection with a new high speed iron.






**Under chassis view shows conventional stage-by-stage layout of television receiver.**

a greater effect on the shape of the response curve Each successive stage should be aligned for progressively less and less response at the i.f. carrier frequency (12.75 megacycles in this case) until, on the over-all response curve the response at 12.75 megacycles is approximately 50% of maximum. Typical curves for a five stage i.f. amplifier are shown in Fig. 3. After the alignment of the complete i.f. system is finished in this manner, it may be necessary to make minor readjustments in various stages. A great deal of care should be exercised when aligning the i.f.s to be sure that the sweeper output is sufficiently low that none of the i.f. amplifier stages are overloaded.

The rejector circuits may be adjusted by using the sweeper and the marker signal generator to determine the point at which rejection should occur (8.25 and 14.25 megacycles), or it can be done by dispensing with the sweeper and applying audio modulation to the marker signal generator. The signal generator is set at the desired frequency and the rejector circuits are tuned for minimum output response out of the second detector. Adjustment of the r.f. and first detector circuits should be done after a satisfactory i.f. characteristic has been obtained, and is accomplished in much the same manner except that the sweeper and marker signal generator must operate in the r.f. range; i.e., frequencies in the order of 50 megacycles, rather than 12 megacycles.

The television signal which appears across the second detector load circuit has the same characteristic as that which was delivered by the studio to the transmitter. It consists of three major portions; the synchronizing signal, the blanking signal and the picture components. At this point in the receiver circuit, this signal is directed into two entirely different types of circuits. One is the video amplifier which, as the name implies, amplifies the picture signal and applies it to the grid of the kinescope. When this signal is applied to the grid of the kinescope, it causes the beam of electrons which strike the fluorescent surface of the kinescope to be varied in intensity in accordance with the voltage variations which were obtained from the pick-up tube at the transmitting station. The brightness of the fluorescent surface of the kinescope is a function of the number of electrons which strike it and the velocity with which they strike. Hence, the variation of the beam causes the kinescope screen to be instantaneously lighter or darker at the point at which the electron beam is striking it at any given instant, in accordance with the lights and shadows in the original scene.

The blanking portion of the composite signal occurs at such a time with respect to the scanning of the kinescope beam, as to drive the grid of the kinescope to cut-off and thus extinguish the beam during the time when it is returning from right to left, or bottom to top of the picture. The amplitude of this same blanking signal with respect to the amplitude of the picture components determines the average brightness of the picture which is reproduced by the kinescope. This is accomplished by means of one of several circuits which in effect measure the voltage from the a.c. axis to the most negative portion of the signal. Since the a.c. axis is that point in the signal where the area under the curve is the same in both the positive and the negative directions, it will be seen that an increase in the amplitude of the blanking signal without a corresponding increase in the amplitude of the picture components will cause a greater voltage to appear between the a.c. axis and the most negative portion of the signal. It is, then, this voltage which is measured or rectified and applied to the grid of the kinescope as a varying a.c. voltage which retains the average brightness of the kinescope at the value determined by adjustments at the transmitting station, since there is no means of individually adjusting the relative amplitudes of blanking and picture components in a receiver. The brightness knob on a receiver supplies a fixed potential in series with that provided by the rectifier or d.c. setter as it is called. This brightness control allows the user to set the average brightness of his receiver at a pleasing value and from then on, any changes in brightness are under control of the transmitting station.

The gain of the video amplifier determines the contrast of the picture on a given receiver. The greater the gain, the greater the difference between blacks and whites until that point is reached where saturation of the kinescope or "blooming," occurs. The contrast control which appears on most receivers is, therefore, merely a gain control. It may be a gain control for the video amplifier stages, or it may be a gain control for the i.f. stages, but in either case the net result is to vary the amplitude of the signal which is applied to the grid of the kinescope.

In this discussion of the video stages, no mention has been made of the synchronizing portion of the signal. The synchronizing signal remains a part of the signal which is applied to the kinescope, but since the proper setting of the brightness control is such that the top of the blanking portion of the signal is just black on the kinescope, the synchronizing signal is therefore in a voltage region which is beyond black, or blacker than black. In other words, it drives the grid of the kinescope well beyond cut-off rather than just to cut-off as does the blanking signal. The only effect that this has is to cause the d.c. setter to develop a greater voltage than might otherwise be developed, but since the amplitude of the synchronizing signal remains constant throughout, it amounts to the addition of a constant d.c. potential to the existing kinescope bias. The adjustment of the brightness control is such as to take account of the effect of the d.c. component due to the synchronizing signal; hence there is no need to remove the synchronizing signal before application of the picture and blanking components to the kinescope grid. The synchronizing signal is, however, extremely important

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and necessary in controlling the motion of the scanning beam of the kinescope. This, then, is the second channel into which the signal from the second detector is fed. These circuits are called synchronizing separation and utilization circuits. The sync separation circuits usually consist of limiter or clipper stages. These are tubes which are normally biased by either fixed bias or self bias means, well beyond cut-off. The polarity and amplitude of the signal which is applied to such a stage is such that only the synchonizing portion of the signal succeeds in driving the grid up into that range where plate current will flow, thus the output of such a stage consists only of synchronizing signal, the picture and blanking portions having been discarded.

The signal thus obtained contains both horizontal and vertical scanning frequency components. These components must be further separated in order to control the motion of the beam in the kinescope. There are several means of accomplishing this separation, and of utilizing the separated signals. In order to avoid undue confusion, one of the more common arrangements will be considered here. In the case of the horizontal utilization circuit, the synchronizing signal is passed thru an *RC* network which differentiates the impulses. This is simply a resistor and a condenser connected as shown in Fig. 1A, and whose time constant is very small. The impedance of the condenser at the higher frequency harmonics which go to make up the larger part of the steep leading and trailing edges of the impulses, is negligible, but its impedance at the lower frequency harmonics and fundamental is so great that these components are, for all practical purposes, lost in the process. The resultant wave form is as indicated in Fig. 1C. It will be noted that the configuration of the vertical synchronizing signal is such that there are impulses occurring during the entire vertical synchronizing period, which are in phase with the regular horizontal impulses. This explains then, the reason for the slots during the 60 cycle vertical synchronizing signal. This differentiated signal may then be used to "trigger" a relaxation type of oscillator. This may be, as is usually the case, a blocking oscillator or it may be a multivibrator, or other similar device. The fundamental or undriven frequency of the blocking oscillator should be adjustable over a narrow range and should normally be operated at a frequency only slightly below the required scanning frequency in order that it may be adequately controlled or "triggered" by the incoming signal. Since its fundamental frequency is approximately the desired scanning frequency, it is immune to the intermediate double frequency impulses which immediately precede and follow the vertical synchronizing signal. The blocking oscillator or multivibrator as used here, is a dual purpose device. When there is no synchronizing signal present to trigger the oscillator, it continues to operate at its natural frequency and thus provides a source of deflection voltage which keeps the kinescope scanning beam in motion. Were the beam to remain stationary for any appreciable length of time, a burned spot would appear on the fluorescent coating of the kinescope. Also, the oscillator acts as an amplifier in that it provides an output signal of sufficient amplitude to adequately drive the saw-tooth generating or discharge tube, although the input synchronizing signal may be of very low amplitude. The saw-tooth voltage is then amplified and applied to the deflection yoke of the kinescope in such a manner as to cause a saw-tooth current to flow in the coils of the deflecting unit.

In order to accurately reproduce the original scene, the rate at which the scanning beam moves across the face of the kinescope must be absolutely uniform. In other words, the linearity of the saw-tooth must be good. Considerable attention must be given this point in the horizontal output stage because in most cases an appreciable amount of power must be delivered by this tube to the yoke. In order to develop this required amount of power, a fairly large amplitude of saw-tooth voltage must be applied to the grid of the output stage. As is frequently the case, the amplitude of this signal may well swing the grid of the output stage beyond the limits of the straight portion of the characteristic curve. Various means have been suggested and used for improving linearity, one of which consists of an unbypassed resistor in the cathode circuit of the output stage, which, although it reduces somewhat the output voltage of the tube, does tend to straighten the tube characteristic; or the cathode resistor may be bypassed with a small condenser in order to peak the high frequency end of the pass band of the tube. In other cases, various *RC* networks are used in the grid circuit of the output tube or in series with the discharge condenser. Another serious cause of non-linearity of horizontal scanning is that due to the collapse of the electromagnetic field in the yoke. As this field collapses a damped oscillatory effect occurs. Obviously, such a condition would cause the rate of motion of the beam being controlled by the coil to be other than linear with respect to time. In order to eliminate this effect a damping or squelch tube is used. This is a rectifier tube which is usually connected across the secondary or output side of the horizontal deflection output transformer in such a manner that it draws current only on the negative swing of voltage which is present as the magnetic field collapses. The tube type which is used for this purpose and the resistance in series with it determines the voltage point at which it will conduct and thus absorb the back-kick from the yoke. In this way, the voltage impulse which is required in order to pass a saw-tooth current through the deflecting coils is retained as an impulse, with little or no damped oscillation following it, with the result that the scanning linearity may be maintained more accurately

*Returning now to the output of the* synchronizing separation tube, another branch circuit goes to the vertical synchronizing utilization circuits. Again, there have been several methods proposed for making use of the vertical synchronizing signal, but this discussion will be limited to one of the more common methods. In this circuit, the synchronizing signal is passed through a series of integrating circuits which consist of resistance and capacity as shown in Fig. 1B. In this case, it will be seen that the shunt capacities will bypass the higher frequency components of the synchronizing signal, thus the horizontal impulses will be almost, if not entirely, lost in the process. The vertical impulses, however, last for a considerably longer period of time, and contain an appreciably greater amount of energy. This greater energy content charges the condensers successively until the end of the last section of the vertical signal, when they discharge and are thus prepared for the vertical signal for the succeeding field. This process is indicated in Fig. 1D. This integrated signal then controls a blocking oscillator which in turn drives a 60 cycle saw-tooth generator or discharge tube. Following this tube are suitable amplifier stages and an output stage to feed the components. This is contrary to transmitting equipment where it is desirable, in order to transmit a signal with an absolute minimum of hum components, to use well regulated power supplies. It is well known that any common impedance between two circuits provides a convenient path for cross-talk between these two circuits. Any power supply whose output voltage does not remain constant over its entire working range has, by definition, an appreciable internal impedance. By the addition of suitable d.c. amplifier regulating circuits to this power supply, which will maintain its voltage absolutely constant over the range of current drains demanded by the equipment which it supplies, its internal impedance can be reduced to such a low value that any cross-talk which may occur due to the fact that it is common to different circuits having widely different signal amplitudes, will be negligible. In the case of ordinary home receivers, however, such rigorous treatment of the power supply problem is not mandatory if the power handling capabilities of the plate voltage supply system are adequate and are well filtered.

The high voltage power supply may be a conventional transformer, high voltage rectifier, and filter. Since the current drain from this particular supply is extremely low, in the order of 500 microamperes, very low capacity filter condensers will suffice. Due to this low current requirement there are, however, other means of developing the high voltage required by the kinescope than with ordinary 60 cycle transformers. These include simple r.f. oscillators operating at frequencies of 100 to 500 kc. The voltage developed across the oscillator coil at the resonant frequency may be very high depending upon the "Q" of the oscillator circuit. By means of additional windings on the oscillator coil form, power for lighting the filament of a rectifier tube may be obtained as well as high voltage to be rectified by this tube, filtered, and applied to the second anode of the kinescope. Such a power supply is capable of delivering only a very small amount of power, and any demand for a greater amount of power such as would occur were the load circuit to be touched with the finger would cause the voltage to drop to a point where it would neither harm the person touching the supply, nor would it provide the accelerating potential for the kinescope. Another method of obtaining high voltage at very low power capacity is by amplification of the horizontal deflection voltage, either by tubes or transformers or a combination of both, to the point where the peak voltage obtained will be sufficient to provide the required d.c. potential for the kinescope after rectification. Both of these latter methods are safe power supplies from the standpoint of shock, but both of them require a certain amount of

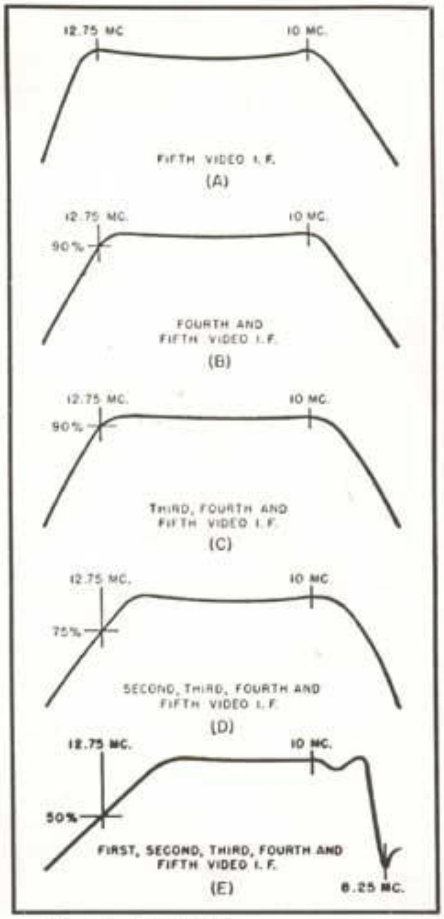


**Fig. 3. Typical i.f. response curves for a receiver having five stages of i.f. amplification. The lower curve shows the effect of the sound rejector.**

shielding in order to avoid cross-talk into the picture.

A slight amount of hum component from the power supplies is not objectionable in most cases. This is due to the fact that at the transmitting station the vertical deflection frequency is synchronous with the local power supply hence any hum components from the receiver power supply will result in faint stationary bars across the picture. Since these light and dark bars are stationary they will normally not be offensive; however, in those areas where the received signal originates in a power service area other than that which supplies the receiver, these hum bars may drift slowly up and down across the picture, in which case they may be extremely objectionable if the amount of hum involved is very great. The presence of power supply hum in the high voltage supply may cause bulging of the sides of the picture due to the alternate stiffening and softening of the beam of electrons as the voltage increases and decreases, and at the same time there may be a tendency for out-of-focus bands to appear across the picture, coincident with the bulges and valleys in the sides.

In any television work, whether it be with studio transmitting equipment or with receivers, the test pattern is probably the most useful, as well as the most used tool. In standard audio broadcasting practice, tone runs provide a means of checking the performance of amplifiers; a simple 1000 cycle tone is used for routine gain measurements, and the engineer's ear (subject to checking with a CRO) detects serious distortion. The use of the test pattern provides a quick and convenient means of checking all of these conditions in a television system, as well as many others. A typical test pattern is shown in Fig. 4.

The large, heavy circle in the test pattern of Fig. 4 is so proportioned that when the scanning amplitude is adjusted so that the inner circle is tangent to the top and bottom of the picture, and the outer circle is tangent to the sides, the required 3 by 4 ratio exists. This same procedure of setting the scanning amplitude, or height and width controls, so that the inner circle is tangent to the top and bottom of the mask, and the outer circle is tangent to the sides, should be followed in the case of the receiver, otherwise the subject matter in the picture may be out of proportion.

The four tapering wedges which converge toward the center target provide a measure of the resolving power of the system. The two vertical wedges which are at right angles to the horizontal scanning lines, provide an indication of the high frequency response of the video amplifiers. That point at which the individual lines of the wedge can no longer be distinguished from each other represents the upper limit of horizontal resolution. What this resolution is, in terms of lines, may be indicated by numbers adjacent to the wedge, by concentric circles, or by dots placed along the wedge. The width and spacing of the lines in the wedge, i.e., their physical dimensions with respect to the over-all dimensions of the test pattern, are not necessarily uniform in the patterns used by all broadcasters, hence, unless the numbers appear on the pattern itself, an effort should be made to determine just what the resolution indications of a given pattern are before quoting numbers. There are indications on some test patterns which, given certain assumptions, indicate the upper limit of the pass band in terms of megacycles. A "fuzziness" or lack of sharpness of detail in the wedges, shows inadequate high frequency response. A narrow white line or transient down the right side of each of the black lines indicates excessive high frequency response or improper phase characteristic, or both. A series of short vertical lines extending off to the right of a small portion of the wedge indicates a peak within the useful range of the pass band characteristic along with attendant phase shift.

The wedges which lie in a horizontal position are used to determine vertical resolution. Obviously, the vertical resolution could never be greater than


Fig. 4. Conventional type test pattern.

the number of lines in the picture (525 lines under present standards). Actually, it is invariably less since some 8% of the lines are blanked out during the vertical retrace time. An additional loss of vertical resolution may occur due to less than perfect interlace, plus the fact that there is always some doubt as to whether the position of the scanning lines with respect to the finer portion of the wedges is precisely that which will show the highest resolution. This last item, however, is not apt to seriously detract from the general picture quality.

The shading target in the center of the pattern gives an indication of saturation in the system. The center spot is black, the outer circle or the background is white, and the intermediate concentric circles represent even steps of grey between black and white. If these steps do not appear to be of uniformly increasing or decreasing density, there is saturation existing somewhere in the system.

A black or a white smear, usually following (to the right) but sometimes preceding, either a black or white object indicates improper mid-frequency response. A bas-relief effect indicates a lack of low frequency response. A second image displayed a little to the right of the main image indicates a reflection which may be in the r.f. path, or it may be due to a long unterminated cable. Egg-shaped or flattened circles indicate a lack of linearity of scanning. It will be seen that a wealth of information can be obtained from a test pattern picture, although a certain amount of experience is necessary in order to properly evaluate each of the symptoms which may appear.

The proper adjustment of a television receiver is very often misunderstood. Certain precautions are taken in the transmission of television signals to ensure the desired effect at the receiver, but in many cases, unless the receiver is properly adjusted, these effects may go wholly unnoticed or they may be distinctly disturbing to the viewer. On many receivers the controls for the adjustment of scanning amplitude, the centering of the picture within the mask, and the distribution or linearity controls, are screw driver adjustments since they normally do not require adjustment other than when repairs are made or when tubes are changed. The horizontal and vertical speed or synchronization controls may or may not be knobs within reach of the user. In general, these knobs need but little adjustment under ordinary conditions. The contrast and brightness knobs are the most misused of all the controls.

With the station selector knob tuned to the desired station, the contrast control should be turned fully counter-clockwise, then the brightness control should be turned slowly from a clockwise position until illumination of the screen almost disappears. Then advance the contrast control until the picture appears at its best. A slight further reduction of brightness is usually desirable. The contrast control turned too far clockwise causes blurring. In addition to this effect, if the contrast control is turned up too high, an intentional reduction of blanking amplitude at the transmitting station such as would occur during a night scene will cause the screen of the receiver to go completely black. Conversely, if the contrast knob is not high enough there will appear to be a milky haze over the picture. It will appear somewhat "washed out." The common misconception in this respect is that the higher the contrast, the brighter the picture with no limitations. This is not true. The brightness of the picture, as it is usually referred to, but which is more accurately described as the contrast range of the picture, is a function of the fluorescent material in the kinescope screen and how long it has been used, as well as the accelerating voltage which is applied to the kinescope. With a given kinescope and a given accelerating voltage, the maximum contrast is limited and any increase of signal applied to the grid of the kinescope beyond this value will do no more than cause saturation and attendant loss of detail in the blacks, or the whites, or both. Proper operation of the receiver by the user is, therefore, of considerable importance if the final result is to be as intended by the producer and engineers at the broadcasting studio.