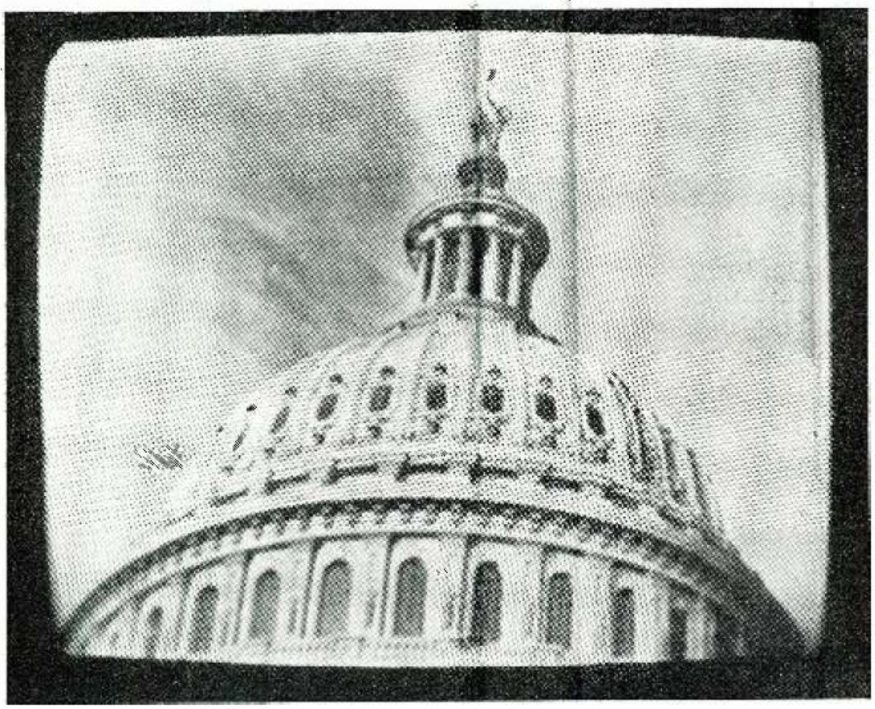


An example of perfect frequency separation—a perfect tele-picture.

FREQUENCY SEPARATOR

by M. W. THOMPSON
Television Engineer, Chicago, Illinois

A television signal is complex, containing many things besides the actual picture. Separating these components gives us the tele-picture.

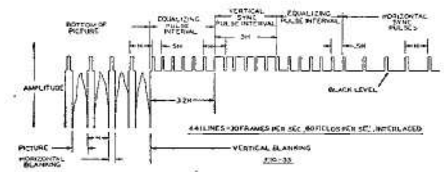
Lesson 5 of the Television Series.

AS previous articles have carried our discussion of television reception through transmission standards and channels (February issue), the Iconoscope and its amplifiers (March), antennas and u-h-f circuits (April), then intermediate amplifiers and second detectors (May), it seems desirable at this point to present a block diagram that will show the operations still to be performed.

The video amplifier, in effect, replaces the audio amplifier of a sound receiver, the C-R tube is substituted for a speaker, and the A. G. C. is similar in operation to an A. V. C. The items Sync Separator, Frequency (sweep) Separator, and Vertical or Horizontal Sweep Oscillator are definitely new and different. It is the duty of the Sync Separator to take a combination of video and complex synchronizing signals, and eliminate the former, then pass on pulses which can be further separated and then used to control the line and field frequency oscillators.

The section designated as Frequency Separator then takes the three types of pulses—Horizontal, Vertical and Equalizing—separates the first from the other two, and so provides the timing which keeps the scanning of our picture tube synchronized with that of the Iconoscope (camera tube) at the transmitter.

Since it is necessary to move the electron beam in the Kinescope in two directions, vertically and horizontally, an electronic-scanning receiver must have *two* sets of sweep or scanning circuits. Each consists, essentially, of an oscillator (relaxation, blocking or multi-vibrator) whose frequency can be held under control by the pulses from the Frequency Separator, and an amplifier which may be either "pull" only, or push-pull. If the Kinescope contains two pairs of parallel plates, these amplifiers are connected to them and electrostatic deflection of the



beam is employed. Some types of cathode-ray tubes do not include these plates but are designed for a "yoke" to be slipped over the neck of the tube and moved forward close to the point where the conical shape begins. This yoke contains two coils, to which the sweep amplifiers are connected, and electromagnetic scanning is said to be in use.

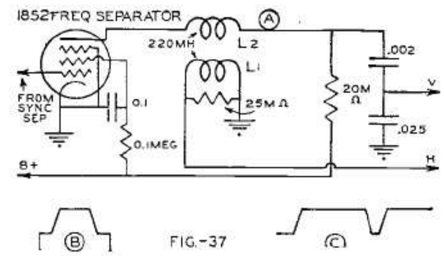
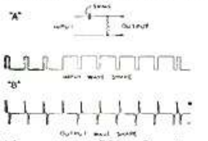


FIG.-37

Having thus mapped the courses to be taken by the video and synchronizing components of the television transmission, we can go back to where we left our composite signal last month—at the second detector. Due to space limitations, it was impossible to go into the subject of "polarity of shading" in which the detector plays a very important part.

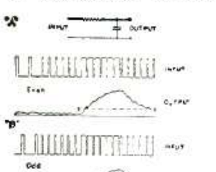
Television stations use movie technique in making titles and fade-ins.

A most confusing point in television is to find that one writer states that a receiver *must* have one or three video amplifier stages, while another says, with equal positiveness, that you either feed the Kinescope's grid directly from the video detector or two stages must be employed.



This all goes back to the fact that, with present RMA standards, modulation amplitude *increases in black* portions of the picture and *decreases in white* areas, and is said to have *negative* transmission polarity. It is essential, therefore, that video signals reach the Kinescope grid with correct polarity of shading, otherwise (1) the image will resemble a photographic negative (blacks are white and vice versa), and (2) the "blanking pedestals" will not be at full black amplitude and may bias off the Kinescope during the return trace of the beam.

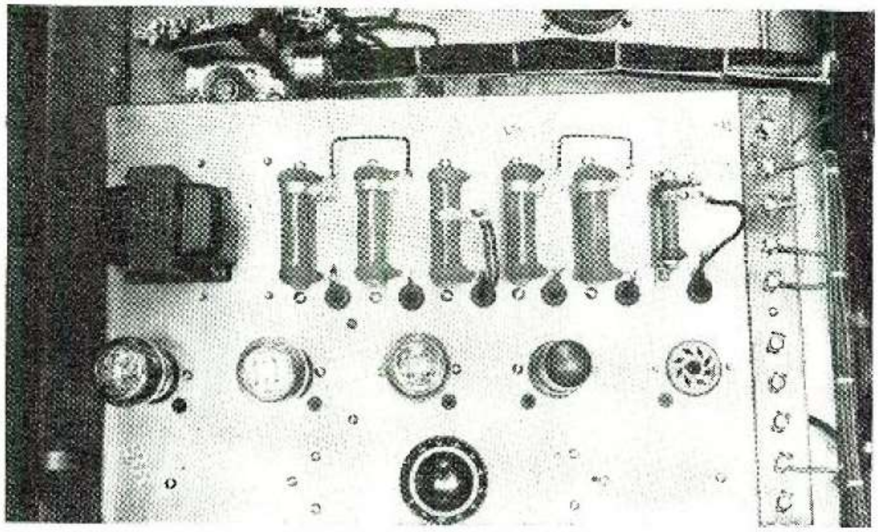
Each video amplifier stage produces a complete reversal of polarity of shading and the last stage must feed the picture tube grid with video signal and blanking periods at *negative* polarity.



Now, strange to say, the proponents of *both* odd and even numbers of video stages can be right if each would only add—and this is important —"with my detector hook-up."

Three methods of inserting a 6H6 diode are shown in Figure 32. When the "high" end of the input circuit is connected to the plate of the diode, as in 32a, and the output filter network is connected to the cathode, the output polarity of shading is "positive"

The British Televisors use this type of antenna for receiving.



The scanning source for live "pick-up" used and built by Don Lee. of W6XAO.

and must be reversed by either one or three video stages. If, as in 32b, the "high" input terminal goes to the cathode, and our output network connects to the diode's plate, we get "negative" polarity of shading and this output can be fed (if strong enough) directly to the grid of the Kinescope or put through a 2-stage amplifier. The circuit of Fig. 32c, seldom used, also requires 2 stages.

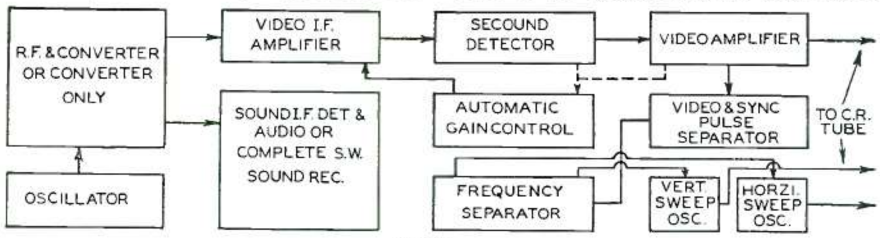


FIG.-31

This matter of polarity of shading must be watched carefully when feeding other circuits from the detector output filter. There may be as many as three circuits to be attached —the first video amplifier, a sync

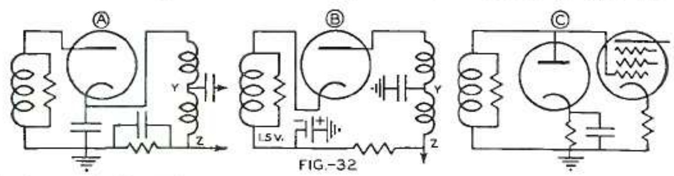


FIG.-32

it at "Y" for the video grid lead, and hook-on the sync separator or amplifier at "Z." If an A.G.C. amplifier is also to be operated from this filter, add it at "Y." However, do not think it unusual if, on examining the many circuits coming out, you find only the video amplifier connected to the detector's output. Many set and kit designers believe it preferable to take Sync Separator and A.G.C. current from the output of either the first or second video amplifiers, which pro-

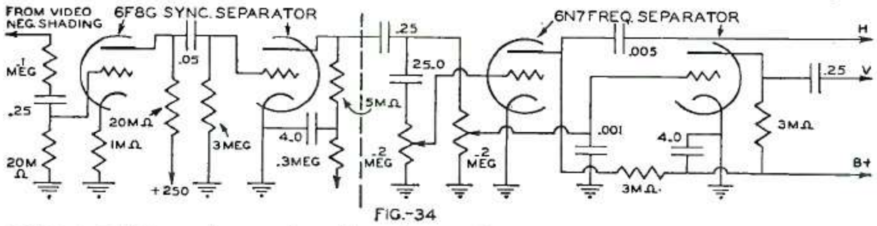
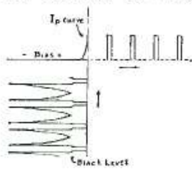


FIG.-34

pulse amplifier and an automatic gain control (A.G.C.). The total of the tube and wiring capacities of these circuits may be somewhat large and it would be unwise to attach them all to the point "Z" which would be regarded as the logical output terminal.



The filter will be less upset, for example, if we tap

vides much stronger components and for some designs, a more advantageous polarity of shading.

Before going into separation of the

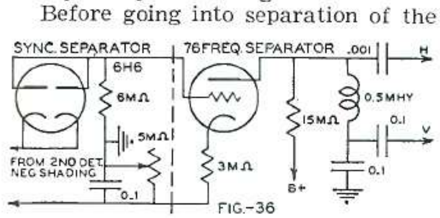
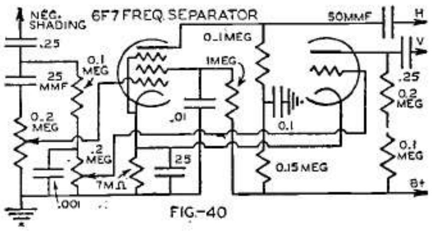


FIG.-36

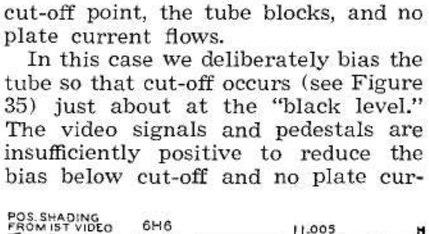
synchronizing signals from the video current, let's refresh our memory of the complete television signal that has been brought in on the carrier and which appears as shown in Figure 33. The time interval chosen is at the end of one field and includes four picture



lines, equalizing pulses, a vertical pulse and horizontal pulses. What we must do is split this television signal into that portion above the "Black Level" and that part below, which means elimination of the video current.

One of the most frequently used methods is that shown in Figure 34, and which uses a type 6F8G double-triode. A few moments' study of this diagram will show that the first triode of the 6F8G is a straight resistance-coupled amplifier. It serves two purposes—first to amplify, which makes separation easier, and second, to reverse the shading polarity so that signals reach the second triode with "positive" polarity. This "separation" triode is grid-leak-biased much like an audio second detector. If you overload such a detector, bias reaches the cut-off point, the tube blocks, and no plate current flows.

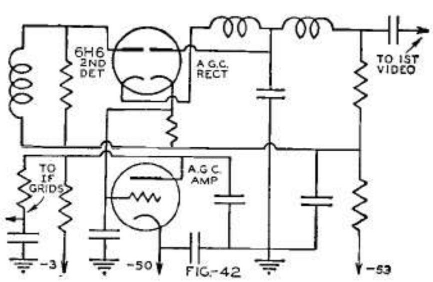
In this case we deliberately bias the tube so that cut-off occurs (see Figure 35) just about at the "black level." The video signals and pedestals are insufficiently positive to reduce the bias below cut-off and no plate cur-



rent flows; the sync pulses are, however, and, as each reaches the sync separating triode's grid, the negative bias drops and a pulse occurs in the plate circuit. The amplitude of these output pulses will remain constant, regardless of variations of the video signal, if the incoming pulses not only swing the bias below cut-off but also to zero. While only a series of horizontal sync pulses are shown in Figure 35, the equalizing and serrated vertical pulses go through in the same way, since all are above the "black level" and of the same amplitude.

Another method of separating the sync and video signals that you will encounter, although less frequently, is that shown in Figure 36, and here a 6H6 diode is set-up to pass the former and reject the latter. It is essential here that the plates be biased very slightly negative with respect to the cathode, and this bias is obtained from the current flowing in the cathode circuit of the following tube, the Frequency Separator. Current cannot flow in the 6H6 under these conditions. This bias is so adjusted that the amplitude of the sync pulses above the "black level" is sufficient to swing the plates positive, and current will flow; the amplitude of the video current is insufficient to do this and no current is passed to the Frequency Separator during the picture trace periods.

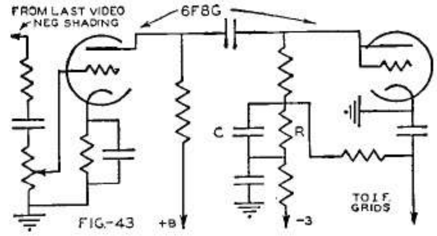
There are several methods of Frequency Separation, of which the four you are most likely to meet are here presented. One thing they all have in common—they make use of the *difference in pulse length.* If you will glance at Figure 33, you will note that



horizontal pulses are short, equalizing pulses are even shorter, while the six pulses in the vertical pulse interval are, comparatively, very long indeed. A factor, also, in this separation operation is the narrowness of the serrations between vertical pulses.

The first method to be considered is that shown in Figure 37a. The successful functioning of this circuit relies on the fact that the sides of pulses (37b) and serrations (37c) are *not straight up and down,* but have a slight and very definite slope. When a current is passing through an inductance which is coupled to a second inductance, any *changes* in that current will be reflected in the second inductance (transformer action). When current such as that produced by pulses and serrations (37b and 37c) is present in the plate circuit of 37a, each slope represents a *variation* of current in coil L1 and a voltage pulse will appear in L2. The front edges of the horizontal, equalizing and six vertical pulses cause positive voltage pulses, and all back edges cause negative voltage pulses (see Figure 38B). It is the *positive* pulses which are utilized for horizontal timing and a little study will show you that this timing is constantly maintained — right through vertical pulse intervals and equalizing pulse intervals. It is true the off-beat equalizing pulses show up also, but they may be disregarded because the oscillator to which they go is not susceptible to pulses which occur that far "out of step" with it.

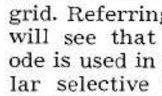
Because of the length of the vertical pulses and the short time interval between them, we can insert a pulse-collector or "integrator" which will build up a higher voltage and hold it there during the entire vertical pulse interval. This consists of the 20,000-ohm resistor and the .002 mfd. conden-



ser, and the action is indicated in Figure 39B. It will be noticed that the insertion of equalizing pulses causes a much finer saw tooth formation than would be the case were they not there —both just preceding the vertical pulse and throughout its rise and fall. It is this smoothing action which makes the vertical pulses of alternate fields so alike that there is no difficulty securing proper interlace.

Only the front face of the first saw tooth in the vertical pulse (below line t-t) is utilized. Either the tube fed from the integrator is arranged to clip the pulse at "t-t" or the timing of the vertical oscillator is adjusted to respond to this pulse only on the first small saw tooth.

The type of Frequency Separator which will probably be the most utilized is that shown in Figure 40. What it really provides is a pair of *selective input* filters; and a pentode line frequency amplifier and a triode field frequency amplifier. Figure 38A presents a "high pass" resistance-capacity filter and 38B gives the action. In Figure 40, this R-C combination is the 25 mmfd. condenser and the 200,000-ohm variable resistance, from which a lead goes to the pentode grid. In Figure 39A we have a "low pass" filter, together with the integrating action (39B), and its counterpart in Figure 40 is composed of the .001 mfd. condenser, a 100,000-ohm fixed resistor and the 200,000-ohm variable from which a wire connects to the triode grid. Referring back to Figure 34, you will see that a type 6N7 double-triode is used in the same way, and similar selective filters show up in the input circuits to the two grids.



While Figure 36 illustrates a type of sync separator, it has also been drawn to illustrate a method of Frequency Separation. Here a type 76 triode functions (1) as an amplifier, (2) as a polarity-changer, so that positive pulses will be delivered to the sweep generators, and (3) as a frequency separator, with selective circuits in the output. The 13,230 brief line-pulses-per-second find an easy road through the small .001 mfd. con-

(*Televise further on page* 51)

Lesson 5. Television
(*Continued from page 12*)

denser, but the 0.5 H inductance is an obstacle. The 60-per-second groups of vertical (field) pulses, each considerably longer than a line pulse, find the .001 mfd. condenser a bit small and so build up in the 0.5 H inductance to discharge through the 0.1 mfd. condenser.

The fourth method of frequency separation, shown in Figure 41, is a development of Marshall P. Wilder, W2JKL. Its action is, apparently, something like this: The No. 1 diode is so adjusted that the plate is slightly negative to cathode. The No. 2 diode is similarly adjusted but the bias is somewhat greater. As the short line pulses hit the plate of the first diode, they are just sufficiently positive to cause current to flow; and corresponding pulses appear at the "horizontal" output point. The longer field or vertical pulses not only pass diode No. 1, but build up a voltage sufficiently positive to offset the higher negative bias on the second diode's plate, and a powerful pulse appears at "vertical" output. The difference in the sizes of the output condensers materially aids in this discrimination.

Automatic Gain Control is not absolutely essential to the successful building and operation of a tele-ceiver but it is so easy to add, costs so little, and offers so many advantages, I personally feel that the odds are all in favor of including it.

For example, A.G.C. will hold signals at a constant level at the video detector despite wide variations in strength at the first tube. While u.h.f. signals vary but little from the phenomena we call reflected-wave fading, there may be considerable variation from swaying of the antenna or its transmission line; also because of movement of nearby large metallic objects, as discussed in article three. No manual readjustment of controls is necessary when switching from one station to another if an A.G.C. is operating. Consistent performance of the Frequency Separator is assured if constant signal level at the video detector is maintained.

The counterpart of A.G.C. in sound receivers is the A.V.C., which we have been accustomed to operating from the d.c. drop across a diode resistor. It thus operated on average carrier amplitude, and its function is to maintain a constant level at the 2nd detector. In present-day television transmission the average carrier amplitude does not remain constant through various scenes and subjects because it shifts with the average amounts of black and white in the subjects being televised. As between a scene that is largely white in background, and one that is very dark, the average carrier level varies as much as 4 or 5 to 1.

The one factor that *does* remain constant in the complex stream of video signals, blanking periods, pulses and pedestals is the sync pulses. Though the intervening video signals stay at low amplitude for awhile because of a preponderance of white in the picture, or climb close to the blacker-than-black level because of shadows or lack of light in the scene, the peaks of the sync pulses always reach the same amplitude. They thus form a reference point for proper operation of the Automatic Gain Control.

An excellent circuit for gain control is shown in Figure 42, where a 6H6 is used as both video detector and A.G.C. rectifier, with any suitable triode as the gain amplifier. The action here is that the rectifier is so operated that it draws current from the detector's load resistor only at moments of high amplitude (the pulse peaks), and this current charges the condenser in the A.G.C. rectifier's cathode circuit to a d.c. value equal to the top amplitude of the sync pulses. The cathode resistor is so chosen that it approximately maintains the charge at this level between line sync pulses. As this potential is always proportional to the amplitude of the peaks of the pulses, rather than to the varying average carrier, it is amplified in the triode and utilized to control the gain of the first two I.F. amplifier tubes.

Figure 43 illustrates another method of securing A.G.C. Here a dual-triode tube, type 6F8G, is used, and so connected that it functions as amplifier and diode. The result is that the amplified signals from the triode (both video and sync) are rectified by the diode to build up a charge in capacity "C." The resistor "R" is so selected that it maintains this charge close to the d.c. potential produced by the sync pulse peaks, and this current is filtered for use in controlling the bias of i.f. stages or a combination of r.f. and i.f.

Should one prefer, for any reason, to omit A.G.C. when planning his receiver, the connections of Figure 44 are employed. The grid returns of the second and third i.f. stages may be connected to a fixed bias of negative 2 or 3 volts. The grid return leads from the converter and 1st i.f. are brought to a 50,000-ohm potentiometer which permits a variation of from zero to 20 volts negative bias to these tubes. If this plan is utilized, it will be unnecessary to incorporate a Contrast Control later on, which would otherwise be essential.

The final steps in the conversion of vision-modulated radio signals into a living, moving, enjoyable image, portraying events as they happen, will be covered in the next issue. Either of these two important elements—video amplifiers or sweep generators—is, in itself, a fascinating study.

Reference Reading
Scanning Sequence and Repetition Rate of Television Images

R. D. Kell, A. V. Bedford and M. A. Trainer

"Television" Volume I.—RCA Institute Press, New York.