The AEROVOX Research Worker

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Television Receivers

PART 5

By the Engineering Department, Aerovox Corporation

SYNCHRONIZATION

THE receiver section treated in this installment serves to sweep the cathode-ray beam both horizontally and vertically, doing this in synchronism with the sweep circuits in the transmitter. The action may be divided into several functions: (1) the synchronizing signals are separated from the video signal and amplified if necessary; (2) the horizontal and vertical synchronizing pulses are separated from each other; (3) these synchronizing pulses are applied to the proper sweep oscillators with correct polarity; (4) the resulting saw-tooth voltages are amplified. This is the system in use in most receivers. There is, however, a system which does not require sweep oscillators and which will be explained later.

THE "SYNC-SEPARATOR"

The synchronizing signals can be separated from the video signal by applying it to the grid of a tube which has been biased beyond plate current cut-off so that the square-topped synchronizing impulses alone cause plate current to flow. To do this, the signal must be applied to the grid of the separator tube or "clipper" tube in such a polarity that the synchronizing signals are the most positive part of the signal as in Figure 1A which is opposite to the polarity required at the picture tube grid, Figure 1B.

The separator tube might be biased from a voltage divider but then the incoming signal would always have to be of the same amplitude in order to get a correct separation. Therefore, grid-leak bias is resorted to. A practical circuit is shown in Figure 2; the tube has a low plate voltage. Under these conditions the grid-current passing through the grid-leak causes a large negative grid bias so that only the synchronizing signals appear in the plate circuit. These then appear as in Figure 1C, but upside down. There must then be another tube, an amplifier or inverter to bring the signal right-side up for application to the sweep oscillators.

There are both simpler and also more complicated systems of separation in use. Instead of a triode, the signal can be sent through a rectifier which acts the same as the grid and cathode in Figure 2. In some cases, the rectifier has an adjustable bias on the plate which would control the amplitude of the synchronizing signal and is marked "hold-control". The separating diode can be so arranged as to deliver the signal in the proper polarity if desired or it can be followed by amplifier stages, each of which inverts the signal.

A more complicated system occurs in the RCA receivers TRK9 and TRK 12. The original separator tube is followed by an amplifier which inverts the signal, bringing it back to the polarity it had at the separator grid. The amplifier is then followed by a second separator. This second separator is a tube with a high plate voltage but again with a grid-leak and condenser. Its function is to cut off the tops of the square waves in order to eliminate any irregular peaks caused by noise which might trigger the sweep oscillators at the wrong time. Essentially it is nothing but an amplifier tube with too low a bias to handle the signal which results in cutting off the tops of the waves and making them all equally high. The signal appears in the plate circuit again inverted and there must be another am-

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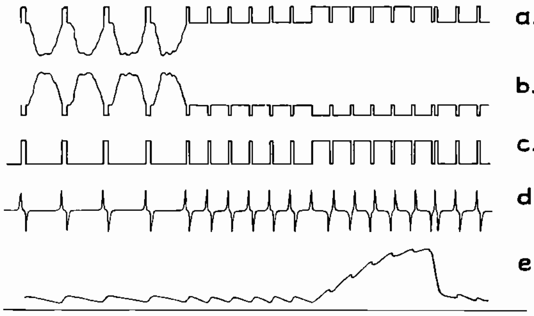


Fig. 1

plifier tube to right them. In the RCA receivers two amplifiers are used with their inputs in parallel. One delivers the signal to the vertical sweep circuit, the other to the horizontal sweep circuit. In this way there is no interaction between the two.

FUNCTION "TWO"

Now that all the synchronizing pulses are available in the proper polarity at the plate of the last amplifier, it is necessary to separate the horizontal synchronizing pulses from the vertical. The separation is accomplished by the use of resistance-capacity networks which discriminate against wave shape. This idea is superior to the use of tuned circuits which discriminate against frequency only because a change in the number of lines or frames would render such receivers inoperative while the other system still will work if the change is not too large.

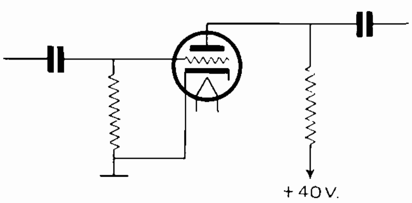


Fig. 2

The horizontal synchronizing signals are separated by means of a grid-leak and condenser or rather a condenser in series with a resistor which has a small time constant compared to the duration of the impulse. Examining this closer: as soon as the impulse starts and a voltage is suddenly applied at the input terminals of the separator, Figure 3, a current will flow through R so as to charge the condenser. This current will be a maximum at the start of the impulse and then decay according to the exponential law. Thus it will grow to its maximum very quickly, as rapidly as the very low inductance of the wiring allows. Due to the short time constant, the condenser reaches full charge before the pulse ends and the charging current through R has then stopped. When the pulse ends, just as suddenly, there is a discharge — current flowing through R in the opposite direction — having the same wave shape as the charge. The currents flowing through R cause voltage drops across it which have the same wave shape. The voltages across R then have the wave shape as shown in Figure 1D. Note that for every synchronizing square impulse there are now two peaked impulses, one positive and one negative. The positive one is the signal needed for setting off the sweep oscillator while the negative ones simply have no effect. Thus, instead of the whole square impulse, it is just the beginning or "leading edge" of each impulse which serves to synchronize the horizontal sweep circuit. This fact is utilized to receive horizontal synchronizing pulses while the vertical synchronizing signals are coming in. A careful study of Figures 1C and 1D will show this. The equalizing pulses sent at the end of a frame come at the wrong time to have any effect on the sweep oscillator. They serve to make each period at the end of a frame the same since the frame lasts 220½ lines.

The vertical synchronizing pulses are separated by a condenser and resistor in series with a time constant which is long compared to the synchronizing pulses. The short horizontal equalizing pulses charge C (Figure 4) and during the rest of the time it discharges through R. The discharge time is so much longer than the charging time that the condenser never has a chance to build up a charge except at the end of a frame. During the vertical synchronizing pulse, the charging time is longer and the discharge time very short. So a charge builds up across the condenser. The voltage across the condenser is as shown in Figure 1E and can now be applied to the vertical sweep oscillator for synchronization.

When both the circuits of Figure 3 and 4 are connected in parallel across a single source, such as the plate circuit of an amplifier tube, there must be some form of decoupling, usually by a series resistor.

OSCILLATORS

Most of the oscillators still in use will be familiar to readers who have studied the April 1939 issue of the Research Worker. Some sets are still equipped with the 884, the gas tube with its familiar circuit.

The second arrangement, used extensively, is shown in Figure 5. This was also described in the April issue.

A modification of the circuit in Figure 5 is shown in Figure 6 where a single tube is used both as blocking oscillator and discharge tube. The grid bias of the tube is below plate

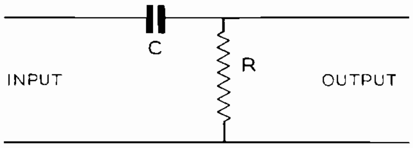


Fig. 3

current cut-off for the greater part of the time. The action is as follows: Suppose the grid has been blocked by the previous oscillation and the grid condenser C_1 is charged making the grid negative. This charge is leaking off through the grid-leak R_1. During this time no plate current flows and condenser C is being charged through R. The charge on C and the plate voltage is rising while the grid bias is becoming less negative. These two finally reach a combination of values when the tube resumes oscillation due to the coupling in the transformer. Then plate current flows, the condenser C is discharged and within one or two cycles C_1 is charged negative again so that the tube is blocked. The cycle then starts over again.

The frequency of the sweep is determined by the time constant of R_1 and C_1. If R_1 is made adjustable for precise control of the frequency it is called the hold-control. The values of R and C and the plate supply voltage determine the amplitude of the saw-tooth wave and its linearity. The higher the supply voltage and the larger R and C the greater is the linearity. The amplitude for any given supply voltage can be adjusted by varying R.

AMPLIFIERS

The sweep oscillators are followed by amplifiers to get a large enough signal for the deflection circuits. These amplifiers are of the resistance-coupled types but contain some special provision for the maintenance of the saw-tooth shape.

Some picture tubes are designed for magnetic deflection, others for electrostatic deflection. Both have their advantages; the magnetic deflection tube need not be equipped with deflecting plates which makes the tube more economical to manufacture. It also does away with the necessity of maintaining the output circuit at a high voltage. It is quite difficult to obtain a true saw-tooth wave at 60 cycles in an electrostatic deflection circuit and this is done easier with magnetic deflection. Against these advantages one should consider the disadvantages: The reduced cost of the tube is partly offset by the special yoke which becomes necessary. The amplifiers require output transformers and especially in the case of the horizontal amplifier they must end with power tubes while the electrostatic deflection type may work without output transformers and with voltage amplifier pentodes.

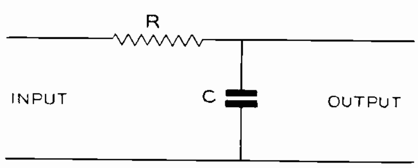


Fig. 4

In the case of magnetic deflection, the return stroke of the vertical sweep circuit represents a sudden collapse of current in a large inductance — the deflection coil. This sudden collapse will induce a high e.m.f. which might cause damage. A damping circuit, consisting of a diode across the yoke serves to short circuit the coil for voltages in this direction. During the forward stroke the impressed voltage is in the other direction so that the diode does not have any effect.

Since it is very difficult to maintain the saw-tooth wave at high frequencies, an auxiliary resistance and condenser are connected across the plate load of the horizontal sweep amplifier. The resistor is often adjustable and is then marked "horizontal peaking". See the article on sweep circuits (April 1939) and the November

	60 CYCLES	13230 CYCLES
R	2 Meg.	0.6 Meg.
C	0.25 Mfd.	0.001 Mfd.
R_1	0.22 Meg.	30000 Ohms
R_2	1.2 Meg.	27000 Ohms
C_1	3300 Mmfd.	820 Mmfd.

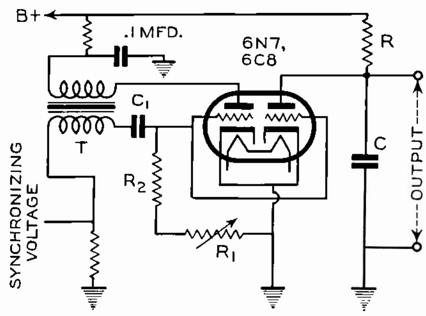


Fig. 5

1939 article on video-amplifiers for more information on this feature.

The electrostatic deflection circuits generally have to be made push-pull in order to keep the beam in focus at the edges of the picture. Hence we find inverter tubes used in such amplifiers. The coupling condensers to the deflection plates must be able to withstand the high voltage of the cathode-ray tube because the deflection tubes are at the same potential as the anode.

THE DRIVEN SYSTEM

Some receivers have been constructed which do not require a sweep oscillator. Instead they contain a discharge tube which works similar to the second half of the 6N7 in Figure 5 but instead of a blocking oscillator, the synchronizing impulse itself initiates the discharge. The synchronizing impulse does not last long enough to effect a complete discharge when a vacuum tube is used, therefore these receivers are equipped with a gas discharge tube, similar to the 884. The grid is at a fixed bias which prevents the firing of the tube until the synchronization impulse arrives. Such a system cannot get out of synchronism and cannot fail to interlace perfectly so long as the synchronizing signals are coming in.

ADJUSTMENTS

The section of the receiver discussed above contains several controls. There are two "hold-controls", two amplitude controls and a horizontal peaking control. Keeping the system in synchronism is done by careful adjustment of the hold controls. These determine the speed or frequency of the sweep circuits should the synchronizing impulses fail to arrive due to fading or any other cause.

If the horizontal sweep frequency is too high, for instance, the synchronizing impulse comes too late to do any good and there will be several lines before the discharge tube is made to fire at the right time again. A somewhat too low frequency would do less harm.

Interlacing troubles are caused by improper adjustments of the hold control. The horizontal sweep being either slightly fast or slow at the end of a frame will result in the next lines not falling exactly in the middle of the lines in the previous frame but off center.

When a figure which should be a circle looks like an egg on the screen the trouble is due to non-linearity in the sweep circuits. Adjust the horizontal peaking control. Perhaps the bias on an amplifier tube should be changed or the value of the resistance in the discharge tube should be higher.

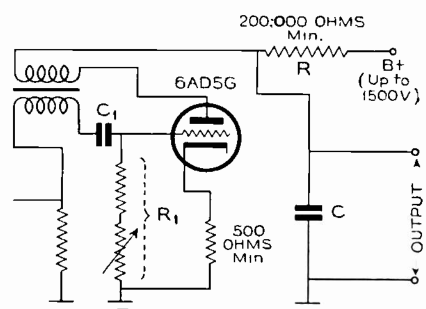
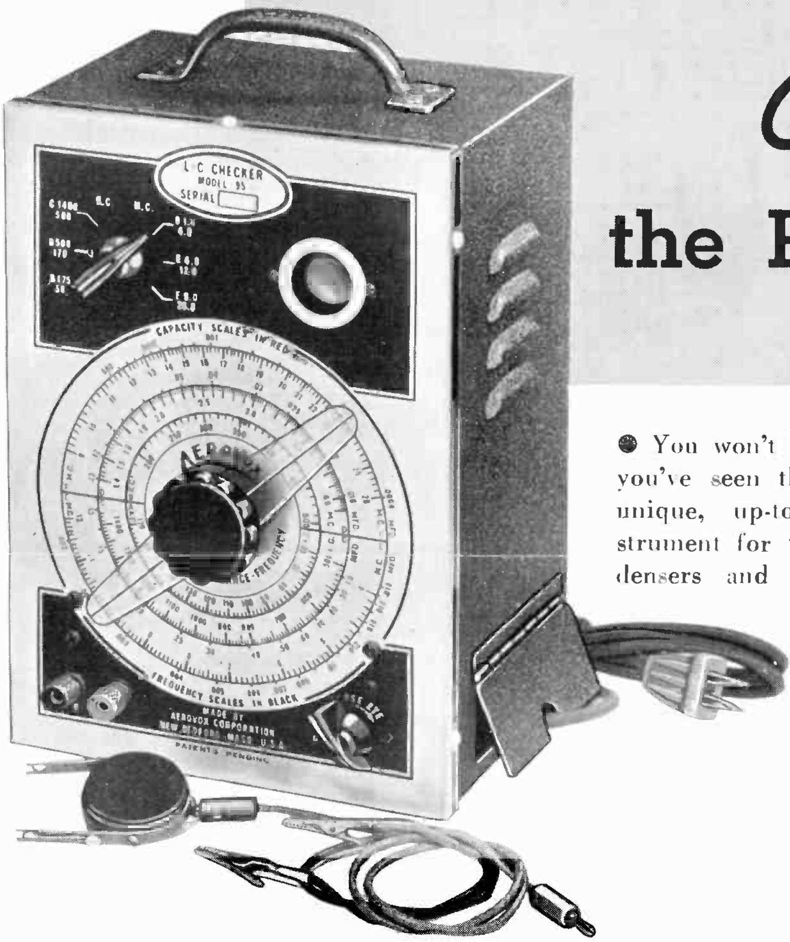


Fig. 6

Hum in the sweep amplifiers or the deflection apparatus shows up as a warped picture with vertical sides in the shape of an S.

Another trouble to look for is microphonic tubes. Since the signals are not made audible such tubes are sometimes hard to detect in the deflection amplifiers and the video amplifiers. The result is, of course, complete ruin of the picture.

Checking the RADIO Way



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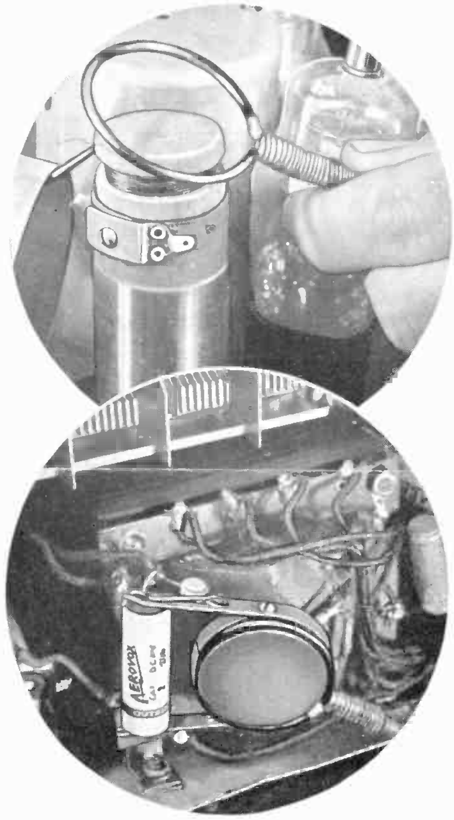

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