A New Electronic Television Transmitting System for the Amateur

The Complete Modulator Including Iconoscope Camera and Monitor Units

BY J. B. SHERMAN*

This article describes all of the equipment necessary to furnish a complete television signal for modulating the r.f. amplifier of an amateur transmitter. For convenience, all of this equipment will be referred to as the "modulator."

Reviewing very briefly, it will be recalled that a complete television signal contains the picture intelligence, horizontal and vertical synchronizing signals, and horizontal and vertical blanking signals.[1] The synchronizing signals cause the lines and frames of the received picture to be started at their proper times; and the blanking signals extinguish the receiving Kinescope spot during the intervals between lines and between frames, so that no retraces appear on the screen.

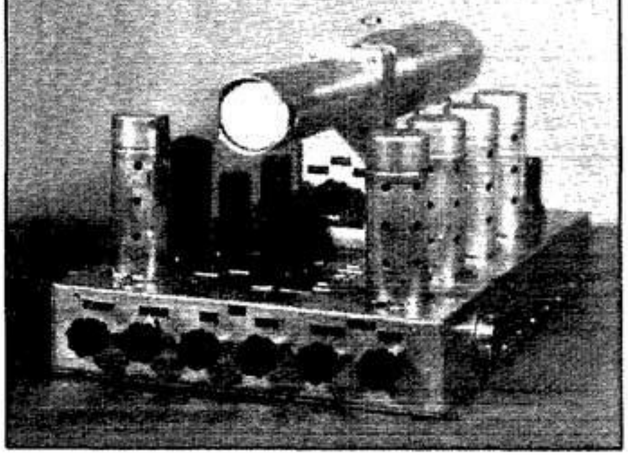
The essential equipment for producing this composite signal comprises an Iconoscope, or picture pick-up tube, with a video amplifier capable of raising the initial signal to a level sufficient for modulation; a monitor Kinescope on which to observe the picture as picked up; scanning circuits for the Iconoscope and monitor; blanking and synchronizing signal generators, and means for mixing these signals with the video signal; high-voltage supply for the Iconoscope and monitor; and low-voltage regulated supply.

* Formerly with RCA Mfg. Co., Inc., Harrison, N. J.

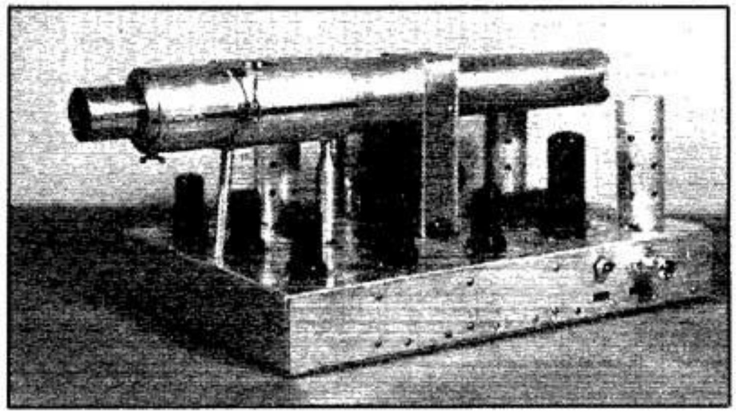
[1] "Introduction to Modern Cathode-Ray Television Reception," by Marshall P. Wilder. *QST*, Dec., 1937. — EDITOR.

The Iconoscope used in this outfit is a simplified small-size version of the type in current commercial use. The mosaic is translucent; the picture is projected on one side and the scanning is performed from the other side. Unlike the larger commercial type, the mosaic lies in the same plane as both the image and the scanning raster, which makes it possible to use simple rectangular scanning. Further simplifying steps are the use of electrostatic scanning, and the omission of direct connection to the signal plate. Instead of a direct connection through the bulb, a conducting coating on the inside provides a capacitive coupling to an external band on the tube. This series capacitance means that the video signal will consist of high frequencies alone. The picture thus produced is very acceptable and material advantages result in the design of the video amplifier, as will be pointed out later.

The system to be described is based on a picture of 120 lines, which gives adequate definition in small pictures. The scanning frequencies are 30 frames per second and 3600 lines per second. The video channel width thus required is about 200 kc., which of course means 400 kc. on the air with double-sideband modulation. Inasmuch as the entire 2½-meter amateur band, for which this



The controls are readily accessible to the operator viewing the image on the monitor from this end of the chassis. The location plan of the tubes and controls is shown in Fig. 6.



The camera-modulator unit as viewed from the Iconoscope end.

equipment is intended, is only 4 megacycles wide, it is evident that the channel and hence the picture definition must be restricted to minimize interference. This is especially evident when it is considered that the channel required varies as the square of the number of lines in the picture.

The Video Amplifier

By building the entire modulator into a single unit the necessity for an Iconoscope pre-amplifier and transmission line is avoided. Likewise, none of the scanning or power connections need be carried to another unit. Referring to circuit diagram of Fig. 1, it will be seen that the video amplifier contains a 6SJ7 in its first stage, 6AC7/1852's in the second, third, and fourth stages, and a 6L6 in the output stage. The blanking signals are inserted by suppressor modulation of the 6AC7/1852 in the fourth stage, and the synchronizing signals are inserted by screen modulation of the 6L6. The blanking signals drive the 6AC7/1852 to cut-off; hence no video signal passing through the amplifier can have a greater amplitude than the blanking level. The sync signals appear in the output with the same polarity as the blanking and with approximately 25% greater amplitude. This is a true "super-sync"; that is, no adjustment of picture level can interfere with the sync signals.

In order to obtain adequate signal output from the Iconoscope, a high load resistance (0.5 megohm) is used. This arrangement means that the higher frequencies will suffer because of the shunting effect of the tube and circuit capacitances. To compensate for this effect the cathode circuit of the second video stage is made degenerative by inserting the large resistor R_7 in addition to the bias resistor. The small condenser C_5 then "peaks" the high frequencies only. The values given for R_7 and C_5 are correct for the input capacitance of this particular setup; R_7 at least should be adjusted for a different arrangement. This adjustment is readily made by focussing the Iconoscope on a subject having vertical lines offering good contrast to their background, increasing R_7 until white or black shadows appear after the lines as seen on the monitor and then decreasing R_7 until the shadows just disappear. Optimum high-frequency response is then being obtained.

The first three video stages need pass only the frequencies actually contained in the video signal, and freedom from hum and microphonics is thus attainable by using high-pass interstage couplings. However, the 30-cycle blanking and sync

Practical two-way amateur communication was envisioned when the first articles on modern electronic television were presented to amateurs in the program inaugurated in these pages over two years ago and since that time we have sought continuously for a way to simplify the standard commercial technique in picture pick-up. If that could be done, the rest would be easy. Earlier in this program several manufacturers coöperated by furnishing experimental picture pick-up tubes, but none was obtained that had the requisite sensitivity along with simple scanning requirements — and low enough cost. What we wanted was a low-cost camera tube that would require a minimum of auxiliary pulse-generating and video amplifying apparatus, no critical correction circuits for reshaping a "keystone" raster into a rectangle, and which would be satisfied with an inexpensive lens system. This called for optical focusing and electronic scanning along the same axis, with a short focal-length lens system and a pretty good order of photo-sensitivity.

These once-impracticable general specifications at last have been met by a new type of miniature Iconoscope. A developmental model of this tube is the heart of the purely amateur television transmitting system described by Mr. Sherman in the accompanying article. Complete details of the new tube, including ratings and constructional description, are scheduled for an early issue. — EDITOR.

MODULATOR FOR AMATEUR TELEVISION TRANSMITTER

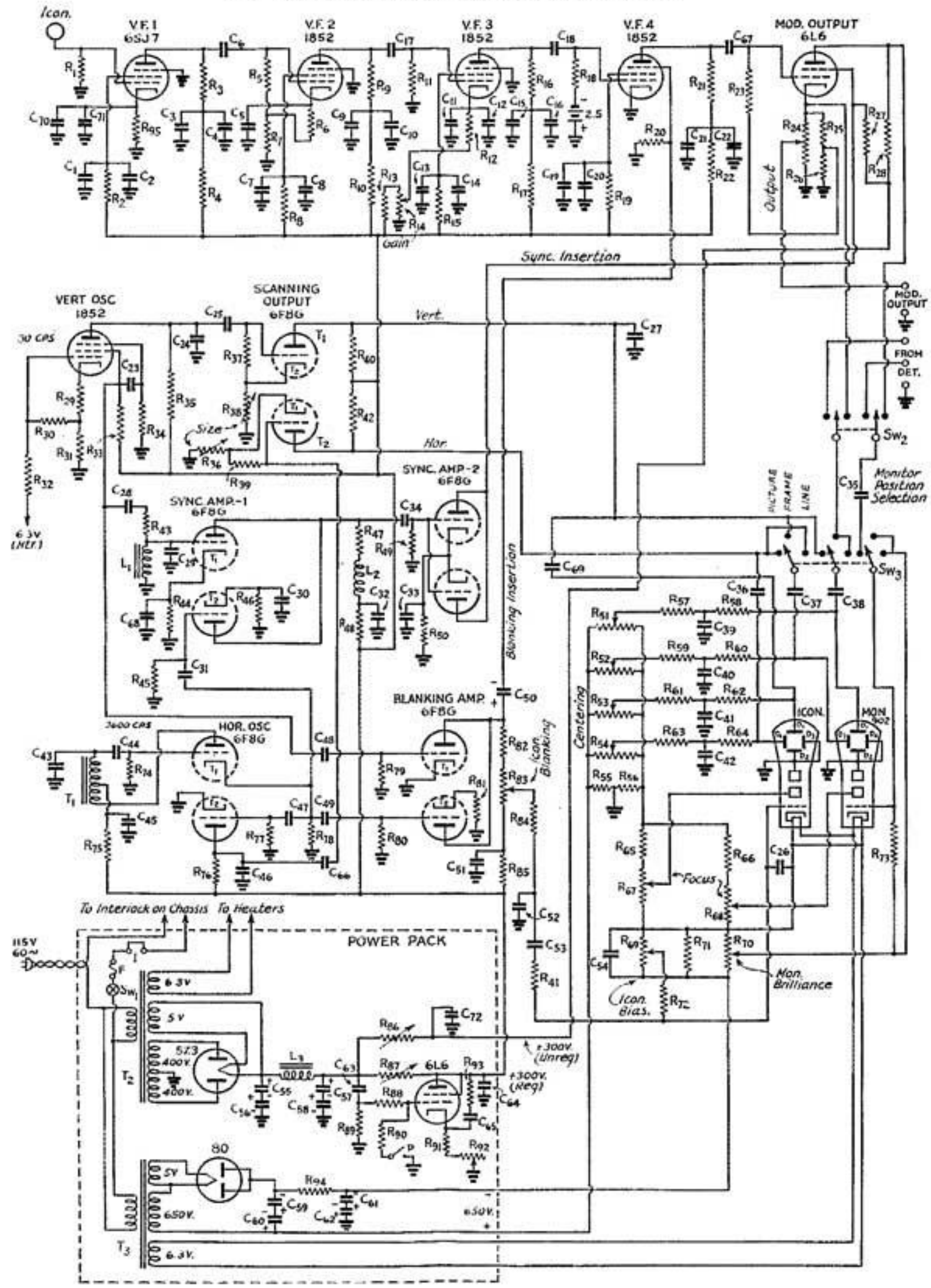


Fig. 1 — Circuit of the complete television modulator and power supply units.

R_1, R_{73} — 0.5 meg., ½ w.
R_2 — 0.25 meg., ½ w.
R_3 — 10,000 ohms, ½ w.
R_4, R_{88}, R_{94} — 50,000 ohms, ½ w.
R_5, R_{11}, R_{18}, R_{42}, R_{48}, R_{71} — 0.1 meg., ½ w.
R_6, R_{12} — 160 ohms, ½ w.
R_7 — 4000 ohms, ½ w.
R_8, R_{15}, R_{19} — 60,000 ohms, ½ w.
R_9, R_{10}, R_{16}, R_{17} — 10,000 ohms, 1 w.
R_{13} — 0.1 meg., 1 w.
R_{14} — 5000-ohm pot.
R_{20}, R_{55}, R_{56} — 20,000 ohms, ½ w.
R_{21} — 7500 ohms, ½ w.
R_{22} — 50,000 ohms, 1 w.
R_{23}, R_{32}, R_{35}, R_{43}, R_{45}, R_{57}, R_{59}, R_{61}, R_{63}, R_{76}, R_{77} — 1 meg., ½ w.
R_{24} — 3000-ohm pot.
R_{25} — 1000 ohms, 1 w.
R_{26} — 2000 ohms, 2 w.
R_{27} — 6000 ohms, 10 w.
R_{28} — 1000 ohms, 5 w.
R_{29} — 500 ohms, ½ w.
R_{30} — 25,000 ohms, ½ w.
R_{31}, R_{75} — 5000 ohms, ½ w.
R_{33}, R_{65}, R_{66} — 0.2 meg., ½ w.
R_{34}, R_{79} — 5 meg., ½ w.
R_{36}, R_{38} — 50,000-ohm pot.
R_{37}, R_{39} — 10 meg., ½ w.
R_{40} — 150,000 ohms, ½ w.
R_{44}, R_{46} — 4 meg., ½ w.
R_{47} — 33,000 ohms, ½ w.
R_{49}, R_{58}, R_{60}, R_{62}, R_{64}, R_{80}, R_{89} — 2 meg., ½ w.
R_{50} — 250 ohms, ½ w.
R_{51}, R_{52}, R_{53}, R_{54} — 1 meg. pot.
R_{67}, R_{68} — 0.25-meg. pot.
R_{69}, R_{70} — 0.1-meg. pot.
R_{72} — 50,000 ohms, ½ w.
R_{74} — 70,000 ohms, ½ w.
R_{78}, R_{81}, R_{84}, R_{90}, R_{41} — 1000 ohms, ½ w.
R_{82}, R_{85} — 20,000 ohms, 1 w.
R_{83} — 500-ohm pot.
R_{86}, R_{87} — 5000 ohms, 25 w., slider type.
R_{91} — 1000 ohms, 5 w.
R_{92} — 1000-ohm pot.
R_{93} — 100 ohms, ½ w.
R_{95} — 800 ohms, ½ w.
C_1, C_3, C_5, C_7, C_9, C_{13}, C_{15}, C_{19}, C_{21}, C_{27}, C_{44}, C_{49}, C_{70} — 0.002-μfd. 400-v. mica.
C_2, C_4, C_8, C_{10}, C_{14}, C_{16}, C_{20}, C_{32}, C_{45}, C_{50}, C_{54}, C_{59}, C_{60} — 4-μfd. 450-v. elec.
C_6, C_{17}, C_{18} — 0.004-μfd. 400-v. mica.
C_{11}, C_{28}, C_{30}, C_{31}, C_{47}, C_{66} — 0.01-μfd. 600-v. paper.
C_{12}, C_{71} — 25-μfd. 25-v. electrolytic.
C_{22} — 16-μfd. 450-v. elec.
C_{23} — 0.004-μfd. 400-v. mica.
C_{24} — 0.25-μfd. 600-v. paper.
C_{25}, C_{34}, C_{48}, C_{52}, C_{67} — 0.1-μfd. 600-v. paper.
C_{29} — 0.001-μfd. 200-v. mica.
C_{33} — 50-μfd. 25-v. elec.
C_{35}, C_{53} — 0.05-μfd. 1000-v. paper.
C_{36}, C_{68}, C_{26} — 0.05-μfd. 600-v. paper.
C_{37}, C_{38}, C_{69} — 0.25-μfd. 600-v. paper.
C_{39}, C_{40}, C_{41}, C_{42} — 0.1-μfd. 200-v. paper.
C_{43} — 0.006-μfd. 400-v. mica.
C_{46}, C_{65} — 0.001-μfd. 400-v. mica.
C_{51}, C_{55}, C_{56}, C_{57}, C_{58}, C_{61}, C_{62}, C_{64}, C_{72} — 20-μfd. 450-v. elec.
C_{63} — 1-μfd. 600-v. paper.
T_1 — RCA output transformer No. 9852 with keeper removed from core. Only primary used.
T_2 — Thordarson power transformer No. T-13R16.
T_3 — Thordarson power transformer No. T-13R11.
L_1 — Thordarson choke No. T-2927, 1080-henry.
L_2 — 60-mh. choke.
L_3 — 20-henry, 200-ma. filter choke.
SW_1 — S.p.s.t. toggle switch.
SW_2 — D.p.d.t. toggle switch.
SW_3 — Yaxley switch, single-deck three-position.
F — Fuse.
I — Interlock.
P — Pushbutton, normally open.
2.5-volt grid-bias battery of V.F.-4 consists of two 1.25-volt Mallory bias cells in series.

Actual-size unretouched photograph of the 120-line image appearing on the 902 monitor screen.

signals require excellent low-frequency amplifier response. This requirement is satisfied by the coupling systems in the fourth and output stages.

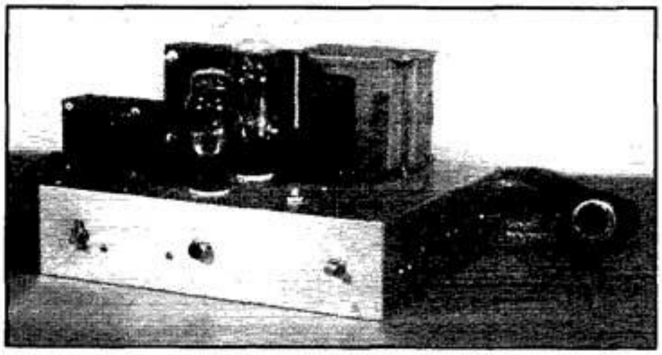
The modulator output is taken from the cathode of the 6L6. About 30-volt peak is the maximum available signal. The outfit is specifically intended for grid modulation of an 829, one of the few tubes suitable for 2½-meter operation. Since this requires a modulating signal of about 20-volt peak value the modulator output is ample. The maximum output can be increased or decreased, without changing the amount of sync, by either increasing or decreasing R_{21}, which varies the blanking level.

It is intended that an increase in carrier level shall represent a decrease in illumination of the received picture, in accordance with usual American practice. Hence in the modulator output the blanking, sync and "dark" video appear in the positive direction. If applied directly to the grid of a Kinescope receiving tube, this would produce a negative picture; that is, a picture in which the light and dark values are interchanged. Therefore, in order that the monitor may show the original scene correctly, it is operated from a load in the plate circuit of the 6L6, where the picture polarity is opposite to that in the cathode circuit.

The video gain control consists of a cathode bias adjustment on the third video stage.

Vertical Scanning, Blanking, and Sync

In the interest of simplicity, blanking and sync signals are derived from the same oscillators which supply scanning to the Iconoscope and monitor. The vertical oscillator is a simple relaxation oscillator of the negative transconductance type and uses a 6AC7/1852. This circuit is synchronized with the 60-cycle supply and operates reliably at 30 c.p.s. without the necessity of a speed control. The oscillogram of Fig. 2 shows



The power-pack chassis carries the main regulated 300-volt supply and a separate 600-volt supply for the Iconoscope and monitor tubes, along with the necessary filament-heating windings.

the form of the vertical oscillator voltage appearing at the screen of the 6AC7/1852. It will be observed that this is a straight-sided impulse at 30 c.p.s., plus a 60-c.p.s. sine wave from the synchronizing source.

The plate circuit of the 6AC7/1852 contains the condenser C_{24} which is charged from the 300-volt supply through R_{35}, and discharged each time the screen impulse occurs because of the resulting low plate resistance. Thus a saw-tooth wave appears across C_{24} at 30 cycles. This saw-tooth wave is amplified in one-half of a 6F8G double triode and applied to the vertical deflection plates of the Iconoscope and of the monitor.

The screen impulse is clipped and amplified in one-half of a 6F8G so that it appears in the plate circuit with negative polarity and no longer has the 60-cycle ripple base. This is the vertical blanking signal, which is applied to the suppressor of the fourth video stage.

The same screen impulse is applied to the choke L_1, which "differentiates" it; that is, produces from the rectangular wave two narrow impulses of opposite polarity. These impulses are applied to one-half of a 6F8G which clips off all of the negative impulse and most of the positive one so that the plate circuit contains a small, narrow, negative signal. This is then amplified in another 6F8G and becomes a large, narrow, positive signal which is applied to the screen of the 6L6 modulator to produce the vertical synchronizing impulse. It is desirable to have this impulse start slightly after the beginning of the blanking period, so that at the receiver the edge of the scanning raster will be darkened. This is accomplished by placing the small condenser C_{29} across L_1, which delays the sync impulse. It is also desirable to have the vertical sync impulse narrow enough so that a large part of the blanking period remains after the impulse. The reason for this is that the horizontal sync signals are interrupted for the duration of the vertical sync pulse; for smooth operation of the horizontal oscillator in the receiver the horizontal sync pulse should commence before the beginning of the new frame. The oscillogram of Fig. 3 shows the vertical blanking and synchronizing pulses, and the horizontal sync pulse also can be seen.

Horizontal Scanning, Blanking, and Sync Pulses

In order to have a stable source of horizontal scanning, blanking and sync pulses, without the necessity of synchronizing or making speed adjustments, a sine-wave oscillator is used. One half of a 6F8G is employed, with grid-leak and cathode-resistor bias so adjusted that the operating angle is short; that is, plate current flows for only a small portion of each cycle. The oscillogram of Fig. 4 shows the form of the impulse voltage appearing across the cathode resistor under these conditions.

This positive impulse is applied to the grid of the other half of the same 6F8G, the plate circuit of which contains the time constant combination C_{46}-R_{76}. Condenser C_{46} is charged through R_{76} and is discharged by the low plate resistance of the tube each time its grid is driven positive. Hence a saw-tooth wave appears across C_{46}, which is amplified in the other half of the same 6F8G used for vertical scanning, and applied to the horizontal deflection plates of the Iconoscope and of the monitor. Cathode degeneration controls R_{36} and R_{38} make excellent scanning-size controls.

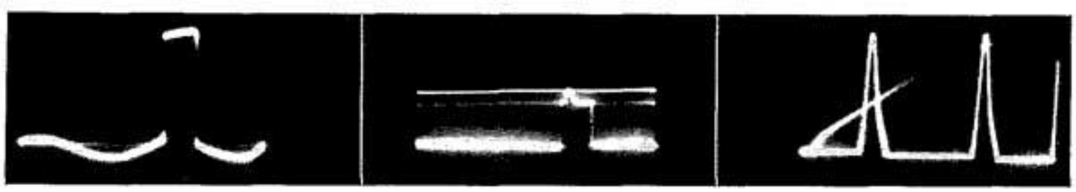


Fig. 2 (left) — Oscillogram of the vertical oscillator impulse. *Fig. 3 (center)* — Oscillogram of the vertical blanking and sync pulse. *Fig. 4 (right)* — Horizontal oscillator impulse oscillogram.

The horizontal oscillator cathode impulse is also applied to the other half of the same 6F8G used for vertical blanking, is amplified, and appears with the vertical blanking in the common plate circuit. In this manner the suppressor of the fourth video stage receives both horizontal and vertical blanking pulses. The width of the horizontal blanking pulse can be varied by changing the value of R_{31}. By changing the value of R_{33} in the vertical oscillator, the vertical blanking time can be varied.

Returning again to the horizontal oscillator cathode impulse, the tip of this signal is selected by clipping action in the other half of the first sync amplifier and appears in the common plate circuit with the vertical sync. To maintain the high-frequency components in the horizontal sync, L_2 is added to this plate circuit. The shape of the horizontal sync pulse can be changed by varying R_{47}. Both horizontal and vertical sync pulses are applied to the second sync amplifier, and then to the screen of the 6L6.

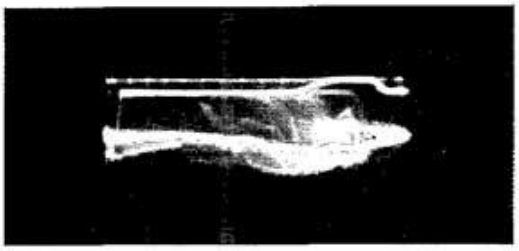


Fig. 5 — Content of one frame as seen on the monitor with SW_3 in "Frame" position.

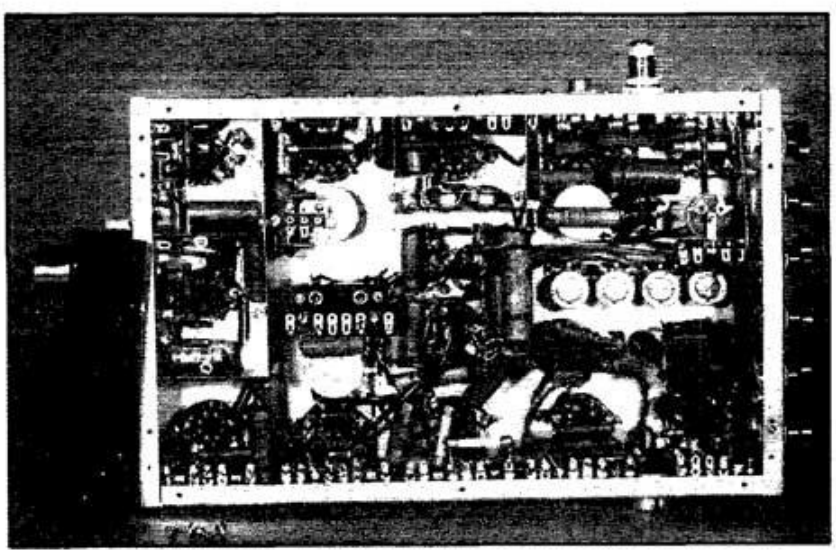
It should be noted that when the unit is to be operated near the transmitter, the 6F8G glass tubes and their grid leads must be shielded to prevent r.f. pickup.

The Monitor

The monitor is an important part of the equipment, since by showing the actual final picture it gives a check on every adjustment, including optical focus. A type 902 2-inch cathode-ray tube is used for this purpose. To avoid a contrast control for the monitor picture, it is desirable to apply to the 902 grid sufficient video voltage to give a good picture when the signal reaches the blanking level; that is, when the "pedestal" is filled. It may be desirable to vary R_{28} somewhat to accomplish this.

The usefulness of the 902 is increased by a switching arrangement which permits it to be used as an oscilloscope as well as a Kinescope, so that the video, blanking, and synchronizing signals can be observed. By switching the horizontal scanning voltage to the horizontal deflection plates, the modulator output to the vertical plates, and no signal to the grid, the content of one line appears on the monitor. Likewise, by applying the vertical scanning voltage to the horizontal plates, the modulator output to the vertical plates, and no signal to the grid, the content of one frame appears on the monitor. Since the blanking period and sync signal occur as the oscilloscope spot returns, the sync pulse appears across the top to an expanded scale, in the reverse direction. Fig. 5 shows this monitor oscillogram.

It is desirable to be able to monitor the signal leaving the antenna, as well as the modulator output. Hence another switch is provided for connecting to an external detector arranged to pick up and rectify the transmitted signal. For direct comparison of this signal with that leaving the modulator, either as picture or oscillogram, it is desirable to have both polarities available from the detector. This can be done readily by using a 6H6 double-diode for the detector.



Bottom view of the camera-modulator unit with base cover removed and shield of first two video stages opened. The locations of the principal components are shown in the chassis plan of Fig. 6.

Power Supplies

The Iconoscope and monitor tubes operate at 600 volts from a common supply. In order to keep the Iconoscope's video output circuit near ground potential, the positive side of this supply is operated at approximately ground potential. Long time-constant filtering is used as an aid in obtaining freedom from line fluctuation difficulties.

The low-voltage supply is regulated, using as regulator a 6L6, triode-connected. Because of the large grid resistor used, there is a slight possibility of occasional blocking. Should this occur, pressing the button *P* briefly will restore the regulator operation. The modulator output and second sync amplifier receive unregulated voltage; the rest of the 300-volt requirements are obtained from the regulator output.

Physical Layout

Fig. 6 shows the layout of parts on the modulator chassis. The Iconoscope and monitor are mounted in line so that the chassis can be moved around as desired and the picture observed on the monitor. The controls are all conveniently available to the operator watching the monitor.

The Iconoscope has the same bulb size as the 902, and therefore lends itself to the symmetrical layout. The Iconoscope shielding must be thorough on account of the high gain in the video amplifier. The shield should clear the bulb by at least ¼ inch in order to reduce capacity to the output connection. It will be noted that a draw tube carrying the lens has been fitted to the fixed shield, so that optical focussing is accomplished by moving the sliding tube in and out.

It is desirable to use a large-aperture lens, but it is not necessary that it be of camera quality. A projection lens is entirely satisfactory. In this outfit, a 35-millimeter projection lens of *f*2.3 and 3-inch focal length has been used with good results.

In the photograph of the underside of the modulator chassis it will be noted that the first two video stages are enclosed in separate shielding to prevent any possible pickup. The chassis and power pack are connected by a single cable carrying all the power leads and covered with grounded copper braid. It is advisable to run several wires in parallel for each of the filament leads in order to minimize voltage loss. (This does not apply to the Iconoscope and monitor filaments.) The filaments should not be grounded at the power pack, but at the chassis. One side of each filament goes to ground at the socket. The bottom covers of the modulator chassis and power pack carry pin-jack interlocks which disconnect the a.c. supply when either bottom is removed.

The Iconoscope and monitor should be biased off when the outfit is turned on, so that there will be no stationary spot before the scanning starts. There have very recently appeared on the market inexpensive thermal relays and it is suggested that one of these connected to the 80 rectifier supply would delay the application of the high voltage until after the scanning had started.

In operation it will be found that there is a certain range of Iconoscope bias over which the signal output increases with decreasing bias without hurting the picture quality. Above and below this range, although the picture level may be kept constant by readjusting the gain control, the quality will suffer.

It will be found that there is little need for an iris on the lens. No provision is made on the present outfit for stopping down the lens; it has been used on scenes ranging from sunlight to interior illumination, with adjustment of gain the only necessary change. However, there is one advantage to be gained from stopping down the lens, and that is the improved depth of focus.

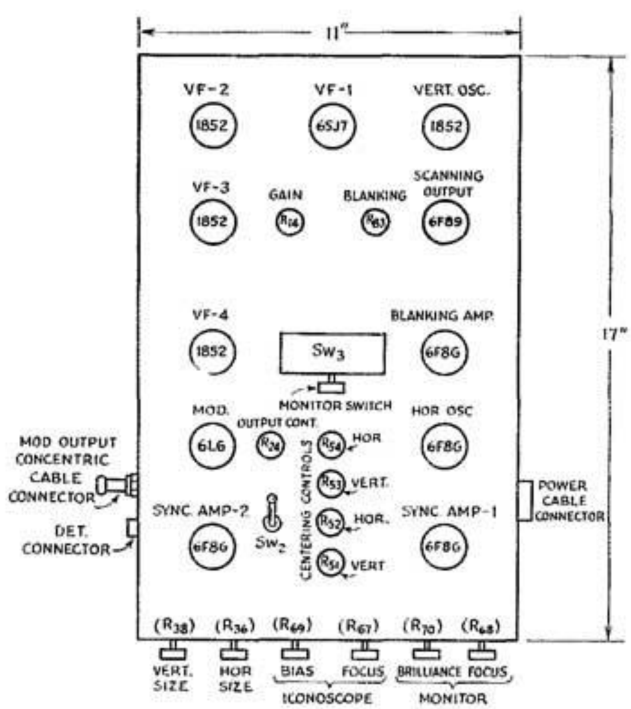


Fig. 6 — Chassis layout plan showing relative positions of the tubes and operating controls. The chassis depth is 3 inches.

Editor's Note. — Subsequent articles in this series will describe the receiver and transmitter which complete the new amateur television system, the former by Mr. Sherman and the latter by Mr. L. C. Waller, W2BRO, another well-known *QST* contributor.