Remember the thrill of your very first QSO? Remember the kick you got from your first real DX contact? And, if you have photography as an allied hobby, remember the excitement you felt when you finished that first print and the picture details began to appear? Put them all together and you have some idea of what is in store when the new ham television camera is fired up for the first time — bring up the Ike bias a hair, a final touch to the focus — and there's the first image beginning to take form on the monitor! There *is* something new in the old game of ham radio.

Television Camera-Modulator Design for Practical Amateur Operation

Combining Economy, Mobility and Reliability in a Compact Tripod-Mounted Assembly

BY JAMES J. LAMB, W1AL*

The new seeing era in amateur communication has been made not only possible but eminently practical by the introduction of the amateur type 1847 Iconoscope, described in June 1940 *QST*, along with the evolution of circuit simplifications which were published for the first time in May 1940 *QST*. The practicability of this combination has been well demonstrated by the experimental equipment described in the latter article; and the fact that the laboratory design lends itself to adaptation in a form even more suitable for practical amateur use has been proved by experience with the set-up which is the subject of the present article.

Although the circuit might seem unduly complex at first glance, a little section-by-section study shows that the whole breaks down into elements that are relatively simple and fully within the scope of amateur understanding. For instance, the video amplifier-modulator chain is nothing more than a straightforward resistance-coupled amplifier of familiar type. Actually, it represents little more complexity than the speech-input end of an amateur 'phone transmitter. The Iconoscope and monitor circuits are found to be no different from what we have already met in the conventional cathode-ray oscilloscope, with the minor exceptions that we find signal voltages as well as d.c. bias applied to the monitor and "Ike" control grids, and an extra connection from the signal plate at the front end of the Iconoscope tube. While the pulse generator introduces us to something we have

The complete tripod-mounted television assembly is conveniently rolled into operating position on a simple dolly made of three pieces of 1 x 2 wood and three 10-cent casters. Plug in the line cord of the power supply (bottom) and connect the concentric line from the camera (top) to the r.f. transmitter — and you're on the air. The unit immediately below the camera is the pulse generator. The tripod, with "tilt" and "pan" head, is part of an old 16-mm. standard home-movie outfit.

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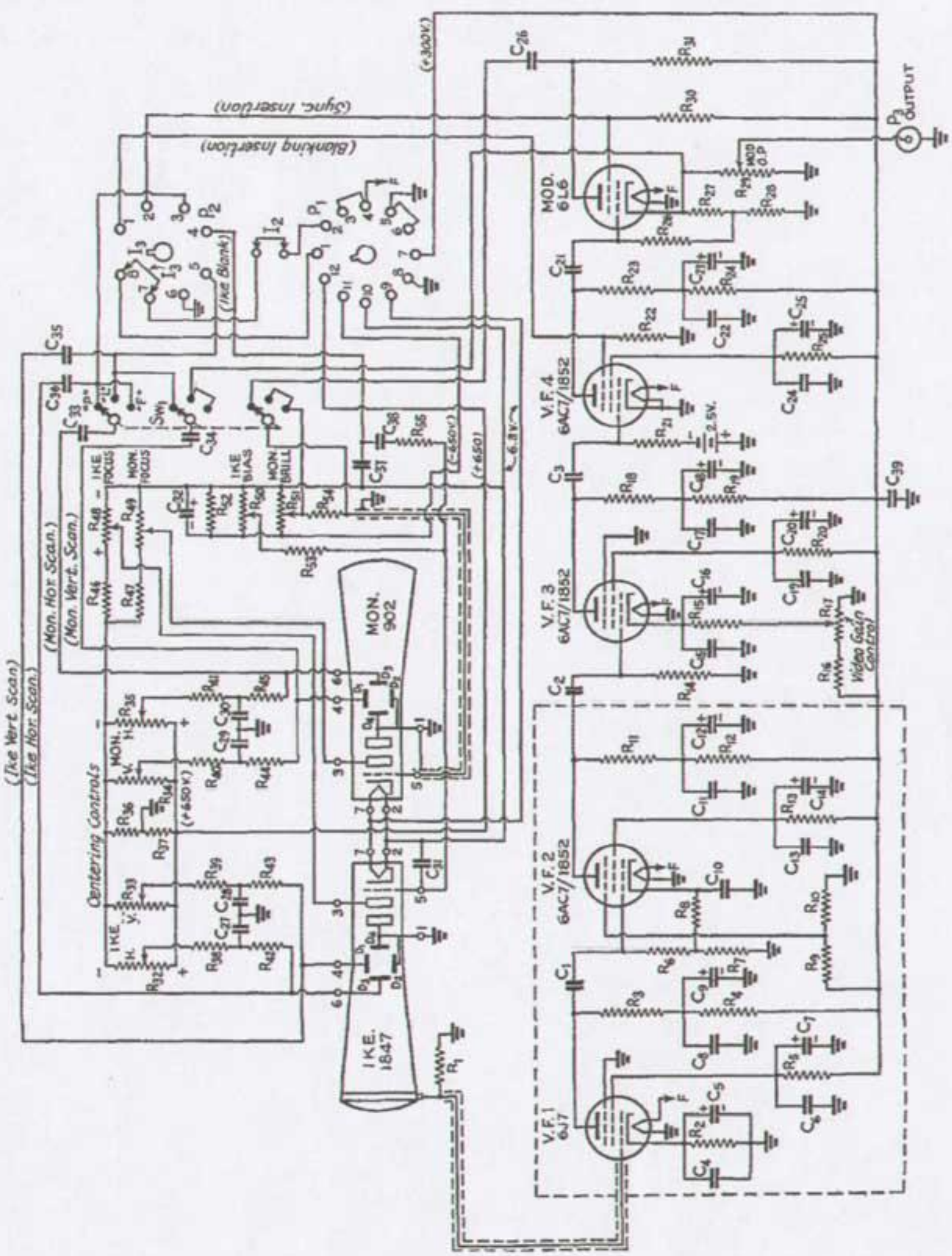

(Ike Vert. Scan)
(Ike Hor. Scan.)
(Mon. Hor. Scan.)
(Mon. Vert. Scan.)
Centering Controls
(Sync. Insertion)
(Blanking Insertion)
(Ike Blank)
(+300V.)
MON. 902
IKE. 1847
V.F. 1 6J7
V.F. 2 6AC7/1852
V.F. 3 6AC7/1852
V.F. 4 6AC7/1852
MOD. 6L6
Video Gain Control
OUTPUT

Fig. 1 — The camera-modulator circuit diagram.

R_1 — 0.5 meg., ½ w. (Ike coupling).
R_2 — 800 ohms, ½ w. (Cathode bias).
R_3 — 10,000 ohms, ½ w. (Plate coupling).
R_4 — 50,000 ohms, ½ w. (Plate filtering).
R_5 — 0.25 meg., ½ w. (Screen dropping).
R_6, R_{14}, R_{21} — 0.1 meg., ½ w. (Grid coupling).
R_7 — 4000 ohms, ½ watt (Cathode degeneration).
R_8, R_{15} — 160 ohms, ½ w. (Cathode bias).
R_9 — 50,000 ohms, ½ w. (Suppressor divider).
R_{10} — 150,000 ohms, ½ w. (Suppressor divider).
R_{11}, R_{18} — 10,000 ohms, 1 w. (Plate coupling).
R_{12}, R_{19} — 10,000 ohms, 1 w. (Plate filtering).
R_{13}, R_{20}, R_{26} — 60,000 ohms, ½ w. (Screen dropping).
R_{16} — 0.1 meg., 1 w. (Gain control divider).
R_{17} — 5000-ohm wire-wound potentiometer (Video gain control).
R_{22} — 20,000 ohms, ½ w. (Blanking insertion coupling).
R_{23} — 7500 ohms, ½ w. (Plate coupling).
R_{24} — 50,000 ohms, 1 w. (Plate filtering).
R_{25} — 1 meg., ½ w. (Grid coupling).
R_{27} — 1000 ohms, 1 w. (Cathode bias).
R_{28} — 2000 ohms, 2 w. (Cathode loading).
R_{29} — 3000-ohm wire-wound pot. (Mod. output control).
R_{30} — 6000 ohms, 10 w. (Sync. insertion coupling).
R_{31} — 1000 ohms, 10 w. (Mod.-monitor coupling).
R_{32}, R_{33}, R_{34}, R_{35} — 1-meg. potentiometers (Beam centering controls).
R_{36}, R_{37} — 20,000 ohms, ½ w. (Centering voltage divider).
R_{38}, R_{39}, R_{40}, R_{41} — 1 meg., ½ w. (Deflection filtering).
R_{42}, R_{43}, R_{44}, R_{45} — 2 meg., ½ w. (Deflection plate coupling).
R_{46}, R_{47} — 0.2 meg., ½ w. (Focus voltage dropping).
R_{48}, R_{49} — 0.25-meg. pots. (Focus controls).
R_{50}, R_{51} — 0.1-meg. pots. (Bias and brilliance controls).
R_{52} — 0.1 meg., ½ w. (Bleeder).
R_{53} — 50,000 ohms, ½ w. (Ike grid coupling).
R_{54} — 0.5 meg., ½ w. (Monitor grid coupling).
R_{55} — 1000 ohms, ½ w. (Ike blanking feed).
C_1, C_2, C_3 — 0.004-µfd., 400-v., mica (High-frequency video coupling).
C_4, C_6, C_9, C_{10}, C_{11}, C_{13}, C_{17}, C_{19}, C_{22}, C_{24} — 0.002-µfd., 400-v. mica (High-frequency by-pass).
C_5, C_{16} — 25-µfd., 25-v. electrolytic (Cathode by-pass).
C_7, C_8, C_{12}, C_{14}, C_{18}, C_{20}, C_{25} — 4-µfd., 450-volt electrolytic (Screen and plate filtering).
C_{15} — 0.01-µfd., 600-v. paper (Cathode by-pass).
C_{21} — 0.1-µfd., 600-v. paper (Low-frequency video coupling).
C_{23} — 16-µfd., 450-v. electrolytic (Plate filtering).
C_{26} — 0.05-µfd., 1000-v. paper (Monitor coupling).
C_{27}, C_{28}, C_{29}, C_{30} — 0.1-µfd., 400-v. (Deflection filtering).
C_{31} — 0.05-µfd., 600-v. paper (Ike grid by-pass).
C_{32} — 4-µfd., 450-v. electrolytic (Bias filtering).
C_{33}, C_{34}, C_{35} — 0.25-µfd., 600-v. paper (Deflection coupling).
C_{36} — 0.05-µfd., 600-v. paper (Deflection coupling).
C_{37} — 0.1-µfd., 600-v. paper (Ike blanking stabilizer).
C_{38} — 0.05-µfd., 1000-v. paper (Ike blanking coupling).
C_{39} — 0.1-µfd., 600-v. paper (Main B-supply by-pass).
SW_1 — Triple-pole triple-throw non-shorting circuit selector switch (Mallory-Yaxley 3243J, one circuit-section not used).
P_1 — 12-contact power supply chassis-type connector (Amphenol No. PO12F, used with No. 012 cable connector).
P_2 — Standard ceramic octal socket (National CIR-8, used with Amphenol PM8-11 octal plug on pulse generator connecting cable).
P_3 — Co-axial cable chassis connector (Amphenol No. 93-C, with No. 93-M cable connector; or Amphenol No. PC1M, with No. MC1F cable connector).
I_2 — Interlock, standard plug and receptacle (Amphenol No. 61-F1 receptacle mounted on chassis, No. 61-M1 standard plug on base plate).
I_3 — Pulse cable interlock (Jumper between pins 7 and 8 in pulse generator cable plug).
Bias battery — Two 1½-volt Mallory bias cells. Two 1½-volt flashlight cell may be used instead.
Chassis — 7″ x 13″ x 2″ or 2½″ deep. Base plate fitted with tapped bushing to take tripod-head screw. Camera cover case, 7″ x 13″ x 8″ high (James Millen Mfg. Co.).

not met in exactly the same form previously, the certainty of obtaining proper results automatically by the simple process of faithfully following the diagrams and specifications eliminates any reason for doubt on this score. The power supply required is entirely conventional, so much so that many amateurs will find that they already have one that may be used with little or no modification.

The complete camera-modulator unit, it is interesting to note, contains about the same number of tubes and circuits as the better type communication receivers now so universally used. But there are no coils to wind, nor are there any tricky tuned-circuit adjustments to be made. The same comparison may be made with regard to cost. The total bill for everything included in the three units shown, not excepting the cables and all tubes, is $142.42. That's less than the price of the top-flight single-signal superhets now on the market. Of interest to 'phone operators is the additional comparison of the cost of the Iconoscope tube and the cost of a good quality crystal microphone of the type widely used by amateurs. They are practically the same.

A functional description of the amateur television circuit has been given in the May *QST* article describing the first experimental laboratory camera-modulator assembly; therefore, only a general résumé will be necessary here. The camera-modulator proper includes the Iconoscope which picks up the picture focused on its mosaic by a simple lens. The video output of the Iconoscope is amplified through the chain consisting of four 1852's and a 6L6. This last tube is designated the modulator, since its output is at a sufficiently high level to be used to grid-modulate a suitable tube in the u.h.f. final stage of the transmitter. The camera unit also contains the monitor which is nothing more than a 902 cathode-ray tube serving as a miniature television Kinescope, using part of the video output of the modulator. This is an especially unique feature since it permits the operator to see just what he is picking up, right at the camera position, so that he knows exactly what is being put on the air, both as to subject matter and quality.

The pulse generator, which in this design is a separate unit, furnishes vertical and horizontal saw-tooth scanning voltages for both the Iconoscope and the monitor, making scanning in both these tubes automatically synchronous. The pulse generator also furnishes vertical and horizontal blanking pulses for two purposes. A part of the full output of the blanking amplifier is applied to the control grid of the Ike, biasing its grid negative during the fly-back time of both horizontal and vertical scanning cycles so that there is no output from the Ike during the line and frame return traces. These combined blanking voltages are also applied at full amplitude to the suppressor grid of the fourth video stage, thus impressing the blanking pulses on the output for conveyance to the receiver on the radio frequency

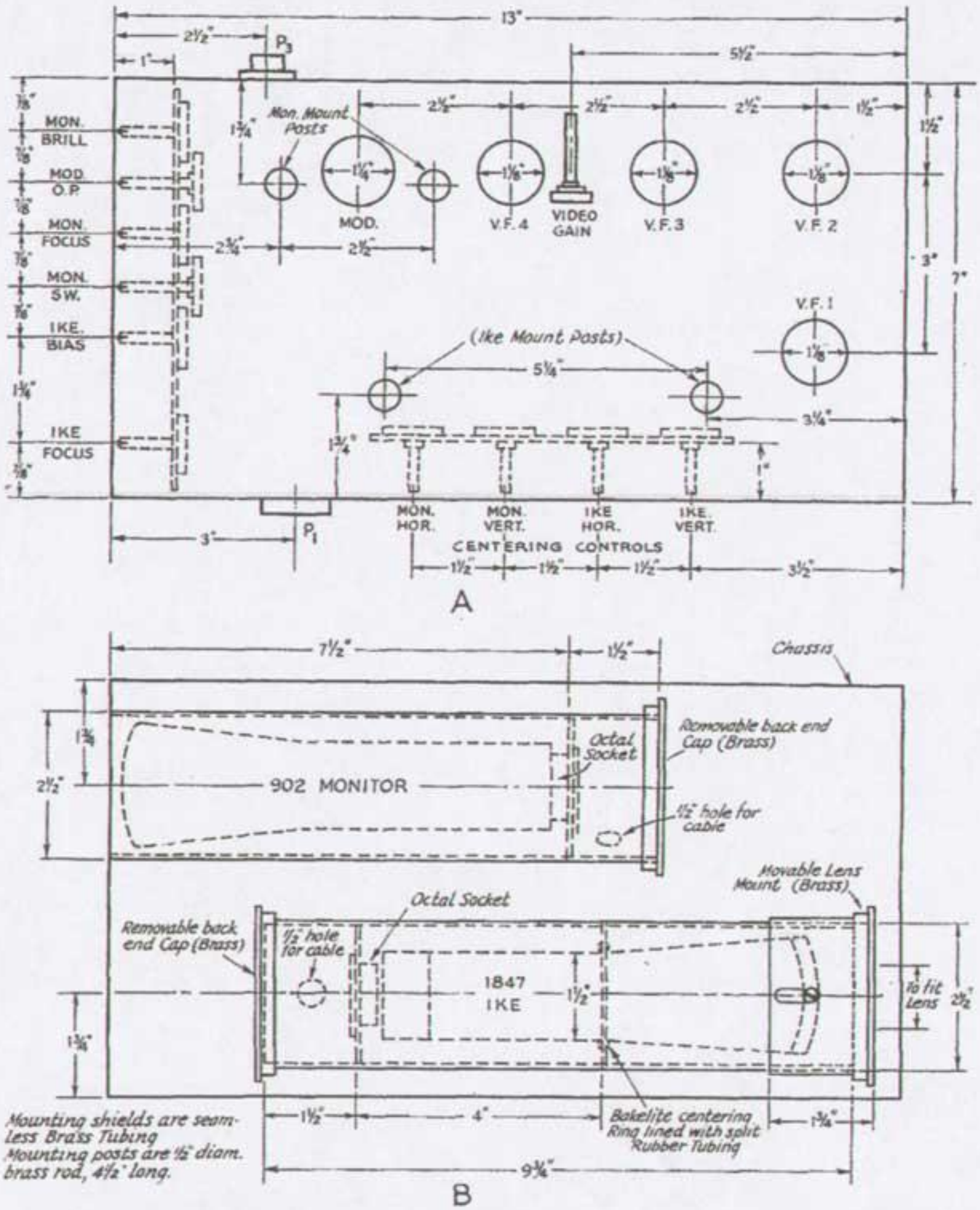
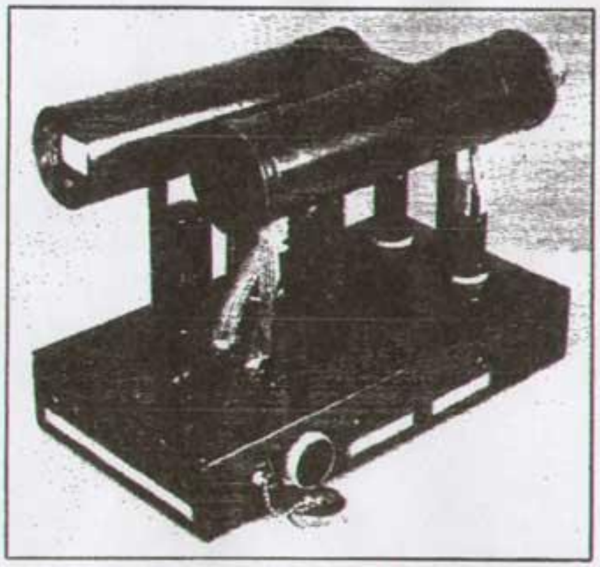


Fig. 2 — Layout plan of the camera-modulator unit. "A" shows the location of tubes and gain control on top of the chassis, with components underneath indicated by dotted lines. "B" gives the dimensions and constructional details of the Iconoscope and monitor mounts.



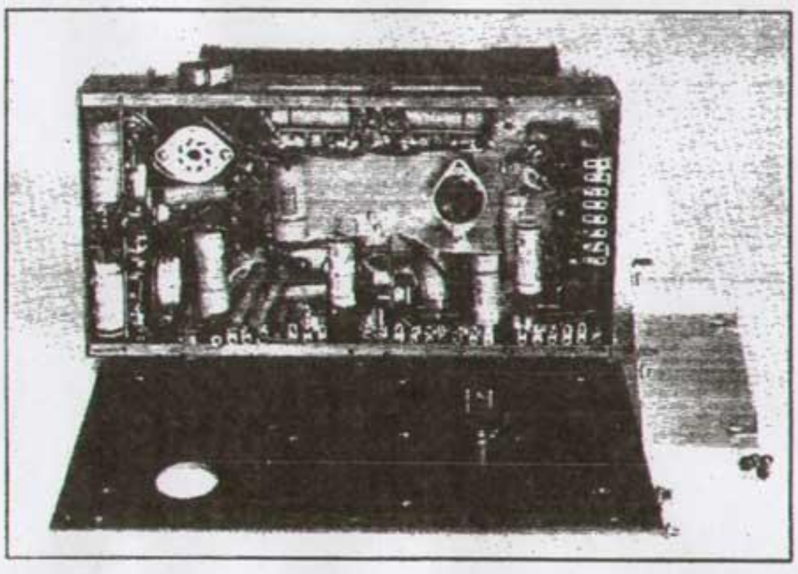
The compact camera unit, here viewed from the rear, includes the video amplifier and modulator circuits, as well as the Iconoscope (facing forward) and monitor (facing rear) mounted in separate shield assemblies. Constructional details are shown in Fig. 2.

carrier wave. There they are used to cut off the scanning beam of the Kinescope during the return trace intervals between frames and between the lines of each frame. If this were not done, during fly-back the return traces of the scanning beam would show up and spoil the picture reproduction. These blanking pulses are of square-top wave form and are of relatively short duration as compared to the scanning time.

In addition to these blanking pulses which operate in effect to stop picture pick-up and reproduction between frames and between the lines of each frame, the pulse generator also supplies narrower synchronizing pulses which have no function in the transmission system but which are of prime importance at the receiver. These pulses are sent along with the transmitted signal during the blanking time and are applied to the emitted carrier by modulation of the screen-grid of the 6L6 output tube. The synchronizing pulses are considerably narrower than the blanking pulses and are characteristically sharp-peaked "pips" which show up riding on top of the blanking pulses in an oscillogram of the modulator output.

Although this pulse combination might seem extremely complex and difficult of attainment, both timing and polarity are automatically taken care of in the design of the circuits. Since the vertical and horizontal oscillators each serves as the primary source for the respective vertical and horizontal pulses of the several types, their respective frequencies are taken care of without any special adjustment. The polarity is determined by the sequence of phase reversals in passage through the various amplifying stages. For instance, the blanking pulses are applied with negative polarity to the suppressor of the fourth video stage. Thus they come out with positive polarity in the plate circuit of this tube and in the cathode circuit of the modulator from which the composite signal applied to the carrier is taken. On the other hand, the synchronizing pulses are

Below the camera chassis, with base plate (in foreground) and shielding enclosure of first two stages (right) removed. Note that control shafts do not extend beyond the chassis, but are adjusted by the removable tuning tool shown in another illustration. This eliminates unauthorized knob twiddling and accidental misadjustment.



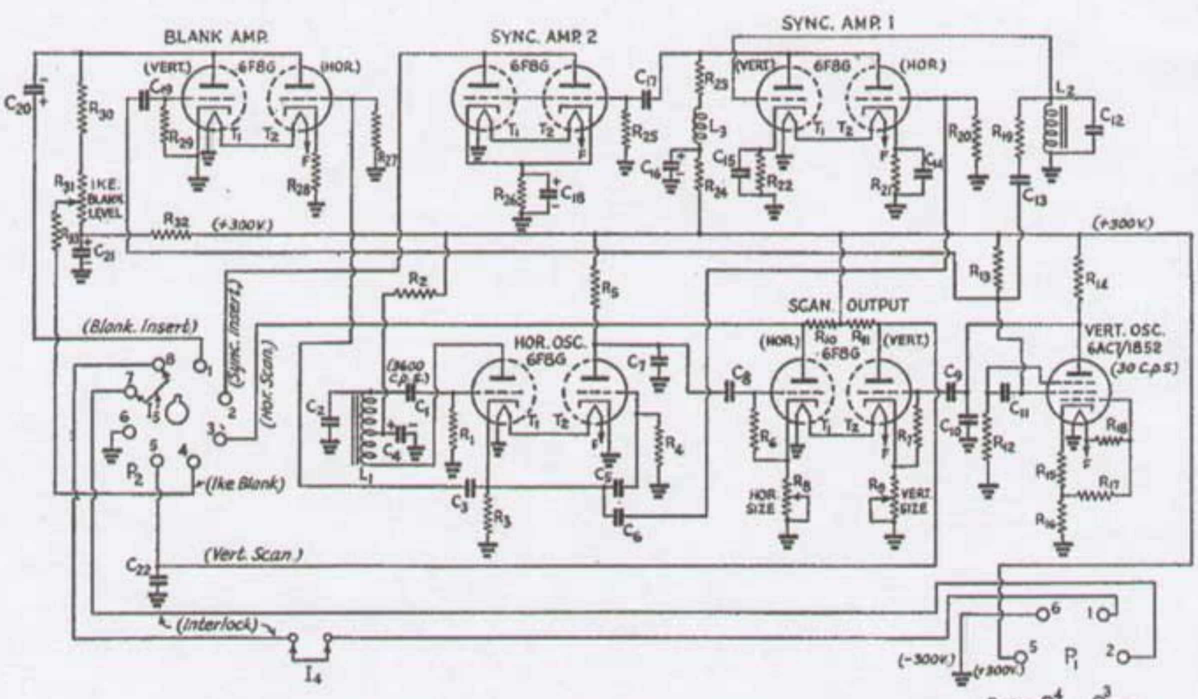
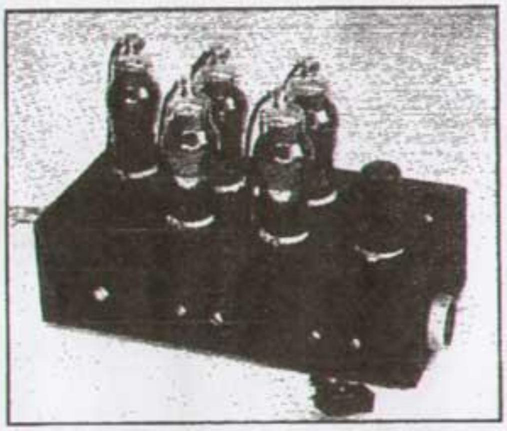


Fig. 3 — Circuit diagram of the pulse generator unit.

R_1 — 70,000 ohms, ½ w. (Horizontal osc. grid leak).
R_2 — 5000 ohms, ½ w. (Horizontal osc. plate filter resistor).
R_3 — 1000 ohms, ½ w. (Horizontal osc. cathode resistor).
R_4 — 1 meg., ½ w. (Hor. saw-tooth generator grid resistor).
R_5 — 1 meg., ½ w. (Hor. saw-tooth generator plate resistor).
R_6, R_7 — 10 meg., ½ w. (Scan. amp. grid resistors).
R_8, R_9 — 50,000-ohm pots. (Scan. amp. cathode-bias (size) controls).
R_{10} — 0.1 meg., ½ w. (Hor. scan. amp. plate).
R_{11} — 0.15 meg., ½ w. (Vert. scan. amp. plate).
R_{12} — 5 meg., ½ w. (Vert. osc. suppressor).
R_{13} — 0.2 meg., ½ w. (Vert. osc. screen).
R_{14} — 1 meg., ½ w. (Vert. osc. plate).
R_{15} — 500 ohms, ½ w. (Vert. osc. grid bias).
R_{16} — 5000 ohms, ½ w. (Vert. osc. cathode drop).
R_{17} — 25,000 ohms, ½ w. (Vert. osc. 60-cycle sync. feed).
R_{18} — 1 meg., ½ w. (Vert. osc. 60-cycle sync. feed).
R_{19} — 1 meg., ½ w. (Vert. sync. amp. grid feed).
R_{20} — 1 meg., ½ w. (Hor. sync. amp. grid leak).
R_{21}, R_{22} — 4 meg., ½ w. (Hor. and vert. sync. amp. cathode bias).
R_{23} — 30,000 ohms, ½ w. (Sync. amp. plate load).
R_{24} — 0.1 meg., ½ w. (Sync. amp. 1-plate filter).
R_{25} — 2 meg., ½ w. (Sync. amp. 2-grid coupling).
R_{26} — 250 ohms, ½ w. (Sync. amp. 2-cathode bias).
R_{27} — 2 meg., ½ w. (Hor. blank. amp. grid coupling).
R_{28} — 1000 ohms, ½ w. (Hor. blank. amp. cathode bias).
R_{29} — 5 meg., ½ w. (Vert. blank. amp. grid leak).
R_{30} — 20,000 ohms, 1 w. (Blank. amp. plate load).
R_{31} — 1000-ohm pot. (Ike blank. level adjustment).
R_{32} — 20,000 ohms, 1 w. (Blank. amp. plate filter).
R_{33} — 1000 ohms, ½ w. (Ike blank. feed).
C_1 — 0.002-μfd. mica (Hor. osc. grid blocking).
C_2 — 0.006-μfd. mica (Hor. osc. tuning).
C_3 — 0.002-μfd. mica (Hor. blank. grid coupling).
C_4 — 4-μfd., 450-v. electrolytic (Hor. osc. plate filter).
C_5 — 0.01-μfd., 600-v. paper (Hor. saw-tooth amp. grid).
C_6 — 0.01-μfd., 600-v. paper (Hor. sync. amp. 1 grid).
C_7 — 0.001-μfd. mica (Hor. saw-tooth amp. plate).
C_8 — 0.01-μfd., 600-v. paper (Hor. scan. amp. grid).
C_9 — 0.1-μfd., 600-v. paper (Vert. scan. amp. grid.)
C_{10} — 0.25-μfd., 600-v. paper (Vert. osc. plate).
C_{11} — 0.006-μfd., 600-v. mica (Vert. osc. time constant).
C_{12} — 0.001-μfd. mica (Vert. sync. pulse delay).
C_{13} — 0.01-μfd., 600-v. paper (Vert. pulse coupling).
C_{14} — 0.01-μfd., 600-v. paper (Hor. sync. amp. cathode by-pass).
C_{15} — 0.05-μfd., 600-v. paper (Vert. sync. amp. cathode by-pass).
C_{16} — 4-μfd., 450-v. electrolytic (Sync. amp. plate filter).
C_{17} — 0.1-μfd., 600-v. paper (Sync. amp. 2-grid).
C_{18} — 50-μfd., 25-v. electrolytic (Sync. amp. 2-cathode by-pass).
C_{19} — 0.1-μfd., 600-v. paper (Vert. blank grid coupling).
C_{20} — 4-μfd., 450-v. electrolytic (Blank. output coupling).
C_{21} — 20-μfd., 450-v. electrolytic (Blank. amp. plate filter).
C_{22} — 0.002-μfd. mica (Vert. scan. h.f. by-pass).
L_1 — Hor. osc. coil to tune to approx. 3600 c.p.s. Primary of open-mounted type audio output transformer with part or all of core laminations removed — such as RCA No. 7852 with keeper (separate laminations across one end) removed. See text.
L_2 — 1080-h., 0.5-ma. audio choke, vert. sync. pulse differentiator (Thordarson T-29C27).
L_3 — 60-mh. r.f. choke, peaking h.f. components of hor. sync. pulse.
P_1 — 6-contact chassis connector for power supply (Amphenol Type PO6F, used with type O6M cable connector).
P_2 — Standard ceramic octal socket for pulse output connection to camera unit (National CIR-8, used with Amphenol PM8-11 octal plug on connecting cable).
I_4 — Base-plate interlock (Amphenol No. 61-F1 standard receptacle mounted on chassis, No. 61-M1 standard plug on base plate).
I_5 — Pulse cable interlock (Jumper between pins 7 and 8 in pulse generator cable plug).
Chassis — 5″ x 10″ x 3″ deep, with cover and base plate (Parmetal No. DF-5510).



Top view of the pulse generator chassis. The tuning tool for adjustment of the various controls is at the right.

applied with positive polarity to the screen of the modulator so that they also come out of this tube's cathode circuit with positive polarity. It is therefore important that no changes should be made in the number of stages, either in the camera-modulator unit or in the pulse generator, without provision for preservation of this proper relationship in polarity of the pulses.

The same requirement applies to the polarity of the video signal from the Ike. Since transmission with *negative* polarity of video modulation is intended in this system, and since the output of the Iconoscope is characteristically negative, there should be an even number of amplifying stages ahead of the modulator when the signal output is taken from the cathode of this last stage. It is understood, of course, that negative video polarity means that black gives maximum output and white gives minimum output. Maximum upward modulation of the carrier by a video component occurs with scanning of a dark part of the picture while minimum modulation occurs with scanning of a bright part of the picture. Of course positive polarity of video modulation could be used (and is used in some foreign television systems) provided both the transmitter and the receiver were designed for it. However, the American commercial practice is to use negative modulation (for technical reasons which we need not go into here) and accordingly it has been adopted for our amateur system.

The design of this equipment, like that of the amateur experimental television assembly previously described, is for 30 frames (pictures) per second, and approximately 120 lines per picture. It should be made clear that there is no rigorous relationship between the number of lines per picture and the number of pictures per second. Although the frame (picture) frequency is synchronized by the 60-cycle supply, the number of lines (which is determined by the frequency of the horizontal oscillator) need not be exactly 120 per picture. However, since the intention is to use a 3-inch Kinescope for reception, a greater number of lines than 120 or so is not justified in view of the fact that the band width required increases with the number of lines very rapidly — and we haven't any too much channel space, even on the 112-Mc. band. In experimenting with this equipment a wide range of horizontal oscillator frequencies has been tried, giving from less than 100 lines to over 400 lines per picture. At 60 lines (1800-cycle oscillator frequency) the line structure is very coarse and quite unsatisfactory. But above 120 lines the line structure does not show up in the received picture noticeably and no appreciable improvement is evident with a greater number of lines. (The number of lines is readily determined by simply dividing the horizontal oscillator frequency by 30, the number of frames per second, since in this system "straight" scanning is used with no interlacing.) The horizontal oscillator frequency was finally left at 3750 cycles, where it happened to land with the *LC* combination most convenient. This corresponds to 125 lines per picture.

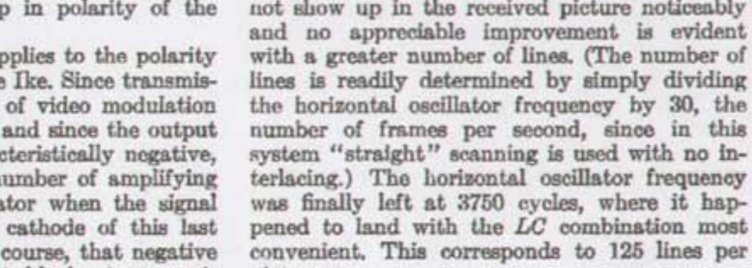
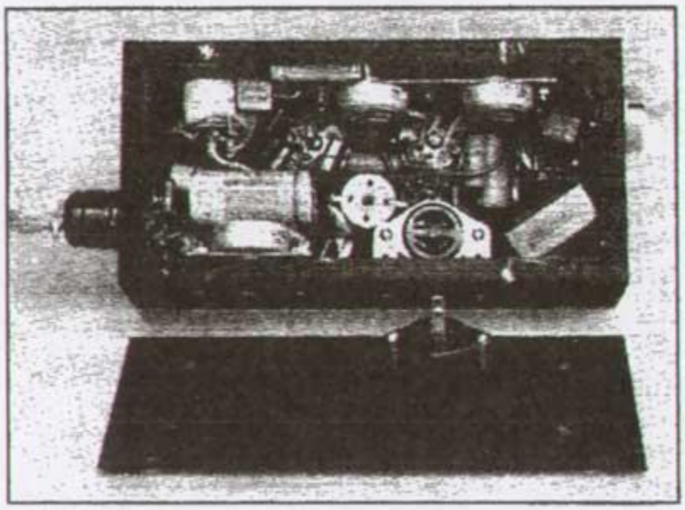


Fig. 4 — Location plan of the pulse generator chassis. Components underneath are indicated by dotted lines.



Showing the components inside the pulse generator unit chassis. Details are given in Fig. 4.

Camera Unit Construction

One of the objectives in the design of the camera-modulator unit was to make it of practical size and proportions for easy handling with tripod mounting. This could not be done with the video and pulse-generator circuit on the same chassis. Accordingly, the pulse generator was made a separate unit with a short cable carrying the pulse voltages to the Iconoscope, monitor and video circuits. This arrangement has the additional advantage of keeping the vertical and horizontal oscillators, with their amplifiers, physically isolated from the sensitive video amplifier circuits and thus minimizes stray coupling of undesired pulse voltages into video circuits where they do not belong.

Although the camera chassis may seem rather crowded underneath, separate shielding of the first two stages and proper attention to the placement of the various components results in good circuit stability with short connections in video circuits, and freedom from hum modulation and cross-talk between deflection circuits, etc. Important dimensions and locations of the principal components are shown in Fig. 2. As a further aid in identification of the parts, the general functional purpose of each item is given in the list accompanying the circuit diagram. In placing the tube sockets of the video stages, the grid and plate terminals (which are opposite each other in the 1852) should be lined up to give the shortest possible coupling connections from one video amplifier to the next. The modulator socket is spaced ¼-inch below the chassis top. In wiring, the filament connections should be made first, one side of each heater being grounded immediately at the socket. The single wire interconnecting the ungrounded sides should run from stage to stage in the corner of the chassis, and should be kept well away from grid leads and terminals. The grid coupling condensers should be dressed away from the chassis to minimize capacitance to ground. The screen by-pass condensers should be laid across the sockets between the grid and plate terminals to serve as shields between input and output. Plate and cathode by-pass condensers are tucked in as convenient, usually between the sockets and the adjacent side of the chassis. A line of terminal lug strips near the edge of the chassis makes for convenience in soldering connections and in supporting the resistors and some of the smaller condensers.

When the video amplifier has been completely wired it is a good idea to check the circuit elements for continuity and resistance values by means of an ohmmeter. Caution: Do not connect a voltmeter or other closed-circuit instrument across the grid circuit of V.F.4 if Mallory bias cells are used. If a signal generator is available an operating test also can be made. A good test frequency is 10,000 cycles. Output of approximately 25 volts peak should be shown on a c.r. oscilloscope with an input of 100 microvolts or so to the grid of the first stage, the output being taken off across the cathode circuit of the 6L6.

When the video section has been completed, the next step is to assemble the components and to wire up the Iconoscope and monitor circuits inside the chassis. The two small sub-panels, one carrying the centering controls and the other the bias and focus controls, go in first. The centering control panel, at the bottom in Fig. 2-A, is made of 1/16-inch aluminum sheet, 6 inches by 2¼ inches with ⅜ inch bent over for fastening to the chassis with a couple of machine screws. After cutting off the potentiometer shafts and filing them "half-flat" to accommodate the tuning tool (this is a 2-inch length of ¼-inch diameter copper tubing with solder run in one end along a cut-off piece of aluminum control shafting to make a half-round, after which the shafting is removed; the other end is fitted with a knob). The resistors are assembled on the sub-panel. To make the best use of available space, the four deflection filtering condensers, C_{27}, C_{28}, C_{29} and C_{30}, are located on the front of this sub-panel and are supported on insulated terminal lugs near the edge at the center and near the bottom on the right and left sides. These terminal connections also support the deflection filtering resistors, R_{38}, R_{39}, R_{40} and R_{41}, which connect to the centering controls.

In connecting to the potentiometer terminals, it is recommended that the polarity indications of the schematic diagram be followed so that full right-hand rotation of the control is "plus" in each case. The polarity indications also should be observed in connecting the electrolytic condensers. The video gain control R_{17} should be connected with its right-hand terminal to ground. This control, which is above the chassis, is mounted on an individual bracket and connected into the cathode circuit of V. F. 3 by insulated flexible leads through holes in the chassis top.

The sub-panel carrying the focus and bias controls is similar, except that it is 6⅞ inches wide. In addition to the controls, condensers C_{31}, C_{32}, C_{37} and C_{38} are also carried on this sub-panel, utilizing the space between it and the chassis.

Behind this sub-panel, with shafts projecting between adjacent controls, are next placed the monitor switch, Sw_1, and R_{39}, the modulator output control, mounted on individual brackets. Before proceeding further the remaining leads should be soldered to the power-supply connector terminals (P_1), leaving lengths sufficient for each to reach its ultimate connection. The pulse-generator connecting octal socket, P_2, should then be located. This socket is supported on two 1½-inch pieces of ½-inch tubing tapped for 6-32 screws at the ends. The four deflection-coupling condensers, C_{33}, C_{34}, C_{35}, and C_{36}, are grouped in the space remaining at this end of the chassis. Connections are made to the monitor and Iconoscope leads by means of insulated terminal strips. The monitor coupling condenser, C_{28}, is also fitted in this area.

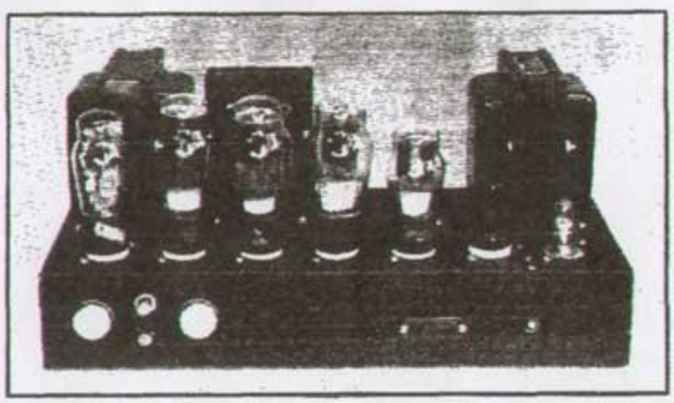
Monitor and Iconoscope Mounts

Dimensioned details of the monitor and Iconoscope mounts are given in Fig. 2-B. The general idea is to place the mountings on the chassis so that the front end of the Ike points forward and the screen end of the monitor faces the rear of the camera. The sockets for these two tubes are centered in thin aluminum discs which are held in place within the mounting by three 6-32 screws tapped into "ears" 120 degrees apart around the periphery of each disc. Each disc has peripheral slots for the socket-mounting screws to allow rotation of the socket plus and minus 10 degrees for exact alignment of the scanning area or "raster." The monitor socket is mounted with pins Nos. 3 and 7 in a vertical line, with pin 3 above 7. The Iconoscope socket is located so that pins No. 3 and No. 6 are in a horizontal line with the key of the base centering pin upward. Note that the socket terminal numbers are indicated on the schematic diagram of Fig. 1.

The rear covers of the Ike and monitor mounting tubes are removable to give access to the socket mounting screws for rotation adjustment and also to facilitate removal of the 902 and 1847 by pushing against the base centering pin with a small dowel rod or a lead pencil.

Terminal No. 1 of each socket is connected directly to the shielding within the mount. The grid lead (No. 5) of the monitor is separately shielded within the cable which runs down to the chassis. The collection of leads to each of these tubes is run in a braided shield which is grounded at each end and is secured at the chassis by a small cable clamp. The cable leads are flexible wire with rubber and cotton braid insulation. The leads terminate underneath the chassis on insulated terminal strips between the modulator and pulse cable sockets, except for the monitor grid lead which goes to the switch and the Iconoscope grid lead which goes to a terminal on the rear sub-panel.

The top cover for the camera unit is 8 inches high above the chassis and has a 2-inch diameter hole in the front and another in the back for the camera lens and for viewing the monitor. Centered on the monitor port in the back is 2½-inch diameter flange over which is slipped a "shadow-box" or visor which is necessary to shield off external light when viewing the monitor. This flange is made from a National type J30 coil shield cut off ¾-inch from the bottom. It is fixed to the camera case by four self-tapping screws.



The power supply with its top cover off. In the Millen ceramic tube sockets (spaced 2¼" between centers) are (left) the time delay relay, then the 5Z3 main rectifier, two 2A3 regulator tubes, the 80 rectifier, 6SJ7 regulator control and, finally, the 991 neon tube (right). Behind, in the same order, are T_3, T_2 and L_1. The power switch and extractor end of the fuse mounting are between the pilot light "bull's eyes" at the left, on the front of the chassis; the voltmeter tip jack strip and output voltage adjustment (R_8) are at the right.

The outside of the chassis, the bottom plate and the Iconoscope and monitor mounts are painted with dark gray Duco lacquer to give a uniform appearance. Before applying the paint, scotch tape was wrapped around the tube sockets extending above the chassis and around the power and output cable connectors for protection during the painting process. The scotch tape was left on until the paint had dried.

Pulse Generator Construction

The circuit of the pulse generator unit is given in Fig. 3 and the layout plan of its chassis is shown in Fig. 4. The information given in these two diagrams is almost completely self-explanatory, but a few additional suggestions may be helpful. The circuit is essentially the same as that given in Mr. Sherman's description of the experimental camera-modulator unit in May 1940 *QST*, with two minor exceptions. In the vertical oscillator, the time-constant determining capacitor, C_{11}, connected between the screen and suppressor grids, is 0.006 μfd. instead of 0.004 μfd. It was found that the lower capacitance gave insufficient time constant with the result that the oscillator attempted to run at an indeterminate frequency between 30 and 60 cycles per second. Although this capacitance is not especially critical, the value of 0.006 μfd. was found to be more satisfactory with condensers of usual commercial tolerance. The other minor modification is in the resistance of R_{31}, the Iconoscope blanking level adjustment. Here a resistance of 1000 ohms was found to give a somewhat higher maximum out-

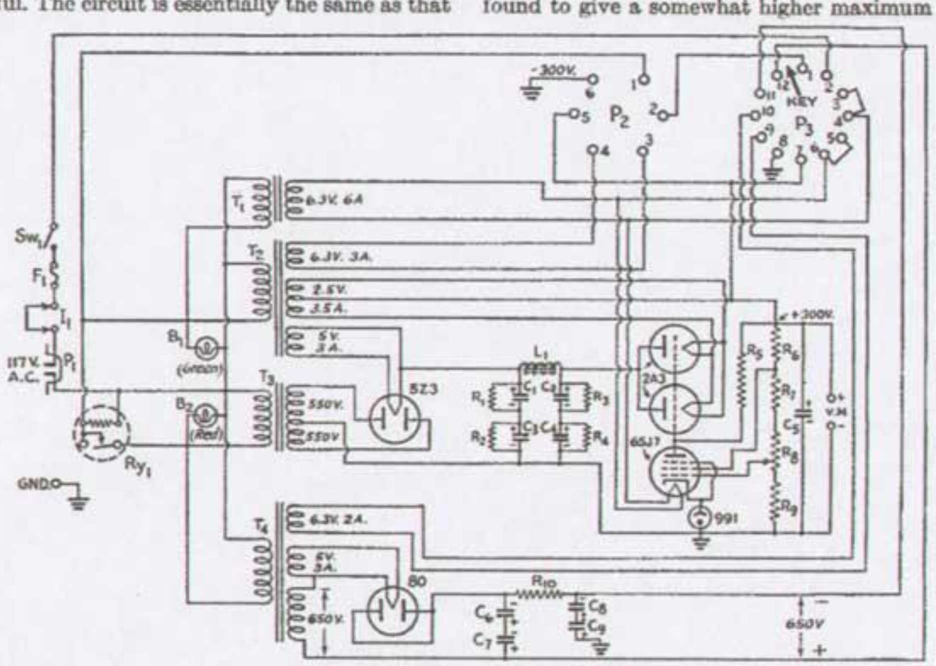


Fig. 5 — Power supply circuit diagram

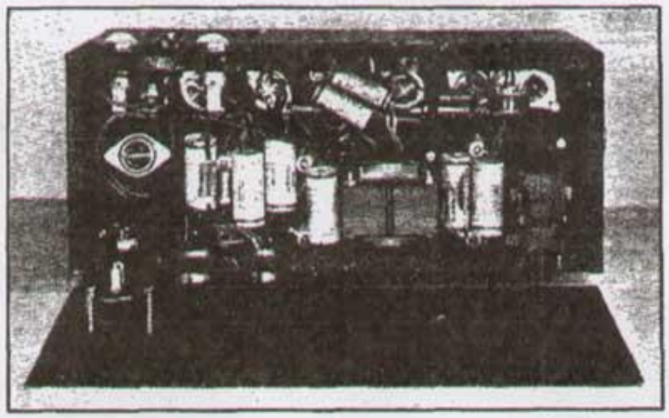
T_1 — Camera filament transformer (Thordarson T-19F98).
T_2 — Pulse rectifier and regulator fil. trans. (Thordarson T-79F84).
T_3 — 1100-v., 250-ma. plate transformer (Thordarson T-19P55).
T_4 — Iconoscope- and monitor-supply transformer (Thordarson T-13R11).
L_1 — 13-h., 250-ma. filter choke (Thordarson T-75C51).
C_1, C_2, C_3, C_4 — 20-μfd., 450-v. electrolytic filter cond.
C_5 — 8-μfd., 450-v. elec. filter cond.
C_6, C_7 — 4-μfd., 450-v. elec. filter cond.
C_8, C_9 — 20-μfd., 450-v. elec. filter cond.
R_1, R_2, R_3, R_4 — 100,000 ohms, 2 w. (Condenser Voltage equalizing).
R_5 — 0.5 meg., ½ w. (Regulator-control plate).
R_6 — 15,000 ohms, 1 w. (Regulator-control divider).
R_7 — 25,000 ohms, 1 w. (Regulator-control divider).
R_8 — 10,000-ohm potentiometer (Output voltage adjustment).
R_9 — 5,000 ohms, 1 w.
R_{10} — 50,000 ohms, ½ w. (Filter resistor).
Ry_1 — Thermal time delay relay, circuit-closing type (Millen No. 51006).
P_1 — Motor-type male connecting plug (Amphenol 61M10, used with No. 61-F11 receptacle on line cond.).
P_2 — 6-contact chassis-type connector (Amphenol PO6F, used with Type O6M cable connector).
P_3 — 12-contact chassis-type connector (Amphenol No. PO12F, used with No. 012-M cable connector).
I_1 — Interlock, standard plug and receptacle (Amphenol No. 61-F1 receptacle mounted on chassis, No. 61-M1 standard plug mounted on base plate).
F_1 — Fuse (Littelfuse extractor type fuse mounting with 3-amp. fuse).
SW_1 — Double-action push switch (Hart & Hegeman Type 80710).
B_1, B_2 — 110-v. pilot lights, with jewel colors as indicated (Drake No. 75).
V.M. — Moulded bakelite twin tip jacks marked "+" and "−" (For d.c. voltmeter connection).
Chassis — 7″ x 17″ x 3″ deep, with base-plate and cover (Parmetal No. DF-717).

put blanking voltage to take care of critical conditions for which the originally specified 500-ohm value proved to be inadequate.

In this unit individual shields are not provided for the glass tubes because of the metal enclosure which is provided for the top of the chassis. If this enclosure is omitted, individual shielding of the tubes should be used.

The Power Supply

The power supply illustrated and diagramed in Fig. 5 is designed to give regulated output of 200 ma. at 300 volts d.c. as well as the necessary filament power for the video and pulse generator tubes, and the anode and filament supply for the Ike and monitor.



Transformers T_4 and T_1 (right) are mounted underneath the power supply chassis. Note that filter condensers connected in series are supported on stand-off insulators.

It includes a thermal time-delay relay which turns on the main B-supply and the supply for the c.r. tubes approximately 25 seconds after the filaments of the video amplifier and pulse generator tubes have been switched on. It is not necessary to use a supply incorporating all of these features, of course, and the simpler type described by Mr. Sherman in May 1940 *QST* could be used. However, the additional features of regulation of the full B-supply output and the time delay are well worth the extra cost. This supply, incidentally, is also well adapted to other purposes. The regulated output may be taken frοm the volt-meter pin-jack terminals for the operation of a receiver or the low-power stages of a transmitter requiring 250 or 300 volts at times when the equipment is not used with the television camera-modulator. The additional filtering provided by the regulator gives B-supply of exceptionally low hum content. The construction of the power supply is adequately shown by the circuit diagram and photographs, and is entirely conventional.

Preliminary Testing

Before attempting to put the complete outfit into operation, a few preliminary tests are advisable to determine the approximate adjustment settings of the various controls and to check the operation of the separate sections. Having first determined that the amplifier is in operating condition, as previously suggested, the next check should be made on the pulse generator unit. This will be greatly simplified if a separate cathode-ray oscilloscope is available, particularly the type having a horizontal sweep oscillator that can be externally synchronized. The preliminary checks on this equipment were made with an RCA type 122-B oscilloscope.

Inter-connecting cables all should be plugged in and the base plates of the power supply and camera unit should be on to close the interlock circuit. The base-plate of the pulse generator is left off, however, and a shorted dummy plug is inserted in the interlock receptacle. The 80 rectifier in the power supply should be removed to prevent application of anode voltage to the c.r. circuit. The power supply should be switched on and the main B-supply voltage adjusted to exactly 300 volts by means of R_8.

The ground side of the external oscilloscope should be connected to the pulse-generator chassis. A test lead with a blocking condenser of approximately 0.1 μfd. in series is connected to the high side of the vertical deflection input. If the oscilloscope contains a vertical amplifier, this is switched off. The sweep oscillator of the oscilloscope should be on and, for the time being, 60-cycle internal synchronization may be used.

Operation of the vertical oscillator in the pulse generator is checked by connecting the test lead to the screen of the 1852. With the oscilloscope sweep properly adjusted, the pattern of the square-topped pulse shown in Fig. 2, page 34, May 1940 *QST* should appear. With the test lead connected to the plate of the vertical oscillator tube a saw-tooth wave of relatively small amplitude should result. An enlarged version of this same saw-tooth with reversed polarity is obtained by connecting the test lead to pin No. 5 of the pulse generator output socket. A sharp narrow pulse should be obtained by connecting to the plate of vertical Sync. Amplifier 1 or the grid of Sync. Amp. 2. Much greater amplitude and opposite polarity of the same wave form should obtain with connection of the test lead to pulse cable socket pin No. 2. The horizontal synchronizing pulses will also appear in these oscilloscope patterns of the vertical sync. pulse, although they will be fainter and probably not stationary. Test lead connection to the plate of the blanking amplifier should show a square-top pattern with a

(Continued on page 94)

Amateur Television

(*Continued from page 81*)

straight base instead of the 60-cycle ripple base obtained with connection to the screen of the vertical oscillator.

To check the frequency of the horizontal oscillator, the output of a variable frequency audio beat-frequency oscillator should be connected to the horizontal deflection-plate terminals of the oscilloscope. The test leads for the vertical deflection plates should be connected across the cathode of the first section (T_1) on the horizontal oscillator. The beat-frequency oscillator frequency should be varied until it is the same as that of the horizontal oscillator as indicated by a single cycle on the oscilloscope. If no audio signal generator is available, the frequency tone may be heard by connecting a headset across the horizontal oscillator cathode resistor, R_3, through a small coupling condenser of approximately 100-$\mu\mu$fd. capacitance. The pitch of the audio tone should be approximately the same as that of the top black note on a piano.

To examine the wave-form of the various horizontal oscillator pulses, the external synchronization terminals of the oscilloscope should be connected across the horizontal oscillator cathode resistor through a small-capacitance coupling condenser. With the vertical deflection test lead connected across the same resistor, a narrow vertical pulse pattern like that shown in Fig. 4, page 34, May 1940 *QST*, should appear. A saw-tooth wave form should be obtained with the test lead connected to the plate of T_2 of the horizontal oscillator, or the grid of T_1 of the scanning output amplifier. A saw-tooth of the same pattern but of enlarged amplitude and opposite polarity should be obtainable at the plate of the scanning output amplifier.

A narrow peaked pulse should result with connection to the plate of Sync. Amplifier 1, and a similar pulse of greater amplitude and opposite polarity should result with connection of the test lead to the plate of Sync. Amp. 2. A square-topped pulse should appear with connection to the plate of the blanking amplifier. A similar pulse but of much smaller amplitude should appear with connection to pin No. 4 of the pulse generator output socket when the Iconoscope blanking level control, R_{31}, is fully advanced.

With external synchronization obtained by a connection of the oscilloscope's horizontal input to the Ike blanking terminal of this socket, and the oscilloscope sweep amplifier synchronized with the vertical (30-cycle) pulse, connection of the vertical deflection test lead to the modulator output terminal of the camera should give a pattern like that shown in Fig. 3, page 34, May 1940 *QST*. This shows the vertical blanking pulse with the synchronizing pulse superimposed. A similar picture of the horizontal blanking and synchronizing pulses should result with the horizontal sweep oscillator of the oscilloscope synchronized with the horizontal oscillator frequency.

It should hardly be necessary to mention that additional capacitance should be connected across L_1 of the horizontal oscillator if its frequency is too high. If the frequency is too low, less capacitance may be used for C_2, or more iron should be removed from the core of the transformer coil if there is any left. As has been stated previously, it is not necessary that the frequency of this oscillator be exactly 3600 cycles per second. Any frequency between 3600 and 3800 or even 3900 will do.

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Even without a separate oscilloscope to make the foregoing tests, the over-all performance of the pulse generator may be checked on the monitor of the camera unit. With switch Sw_1 of Fig. 1 in the "Frame" position (designated "F" in the circuit diagram) a picture like that of Fig. 5, page 35, May 1940 *QST*, but with a straight base line and no video "haze," should appear. With this switch in the "Picture" (P) position, and with the monitor bias properly adjusted, a rectangular illuminated area should appear on the screen. The width and height of this area are adjusted to occupy a desired part of the total screen surface by manipulation of the vertical and horizontal size controls of the pulse generator unit. This scanning area (raster) should be centered on the screen by adjustment of the monitor horizontal and vertical centering controls on the side of the camera unit. This rectangle should have straight sides with fairly sharply defined edges when the monitor focusing adjustment is properly set. If the top and bottom edges do not line up horizontally, the monitor tube socket should be slightly rotated by loosening the socket mounting screws and moving the socket one way or the other, from the back.

When the monitor operation has been checked as just described, the monitor tube should be removed and placed in the Iconoscope socket. A scanning area of the same size should appear with adjustment of the Iconscope bias control. The approximate setting of the focus control also should be checked for adjustment for sharpest definition of the edges of the scanning area. In this case the scanning area will be rotated 90 degrees because of the differences in socket connections characteristic of the Iconoscope.

When these preliminary tests have been made and the approximate control settings have been noted, the monitor tube should be replaced in its own socket and the Iconoscope should be placed in its socket. The Iconoscope output connection to the grid of the first video amplifier is made through a small ceramic bushing (Millen No. 32150) pushed through a ¼-inch diameter hole in the bottom of the Ike mount immediately below the signal tab and held in place by softening the lead collar on the inside. Braided shield over the grid lead is carefully soldered to the lead flange on the outside and grounded to the grid shield of the first video amplifier tube. The tinned flexible lead extending through the bushing is bent over and carefully soldered to the signal tab of the Iconoscope. Prior to this, of course, the Ike coupling resistor, R_1, will have been soldered to the exten-

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sion of this lead through the bushing and to the head of the front *Ike* mount support screw, as indicated in the schematic of Fig. 1.

Before putting the complete outfit into operation with the lens in place, the Iconoscope bias control should be turned all the way negative (to the left). With the lens in the approximately correct position as previously determined from knowledge of its focal length, the camera should be aimed at a suitable test pattern illuminated with one or two No. 2 Photoflood lamps. For this test pattern, a large "X" made of strips of black paper about 1 foot long and 1 inch wide pasted on white cardboard is suggested. This should be placed 3 or 4 feet in front of the camera with the photoflood lamps, say one on either side, about 1 foot away. In the present rig, a simple f3.5-2-inch focal-length camera lens has been used successfully. This lens was picked up second-hand for $3. Focusing adjustment as well as a diaphragm are included in the lens mounting, so additional provision for these is not required.

It is absolutely essential that adjustment of the Iconoscope controls be made very slowly and carefully. The grid bias adjustment is especially critical and the focusing is almost as critical. It either is slightly off the correct setting, nothing resembling a picture of the object being televised will appear on the monitor. There is some interlocking between the monitor brilliance and the Iconoscope bias adjustment, so each should be reset when the other has been changed. However, a little practice will make the operator familiar with these minor peculiarities and ultimately bring realization of the full capabilities of the equipment.

One peculiarity that will be noticed when a pattern containing a black object extending horizontally over about half the picture width (against a light background) is the appearance of white "shadows" at either end. The converse occurs with white against a dark background. This is the result of the restricted low frequency response and is the only major point on which this television system merits adverse criticism. However, in practice actual scenes which contain subject matter of this type are seldom encountered, especially in close-up views, so it is not a particularly important deficiency.

In closing this story, the prospective constructor is warned that he is in for many hours of absorbing activity in exploring the many facets of amateur television, using just the equipment described in this story and without putting a signal on the air at all. The many seeming complexities of television theory rapidly become familiar elements of relative simplicity, and more is learned in a few hours of practice than all one's previous reading and theorizing ever promised.

And it's fun.