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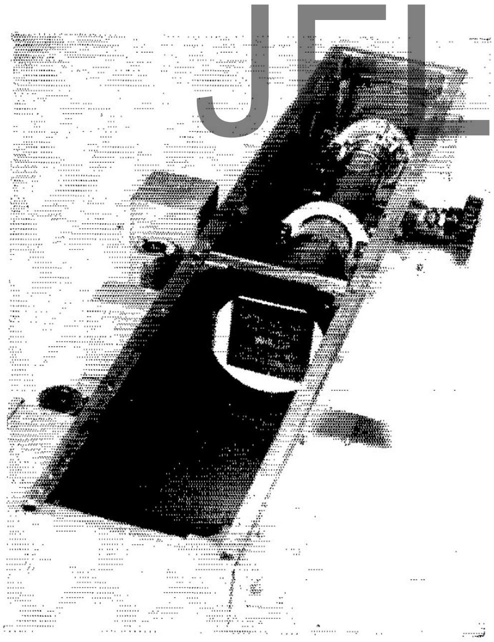

*In Two Parts**

Part II — Circuit and Construction Details

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Inside view of the flying-spot scanner, with slide in place. The knob at the rear actuates a cam arrangement for moving the cathode-ray tube back and forth so the face of the tube can be placed in contact with the photographic negative containing the subject to be transmitted. The outboard chassis at the left contains the subcarrier oscillator and modulating circuits. Inside the box in the foreground, but not visible in this photo, is the photomultiplier tube.

A New Narrow-Band Image Transmission System

PART I of this article described a low-cost method for transmitting images with conventional ham gear, a method which may be of interest to experimentally-inclined amateurs. The system, by combining television and facsimile techniques, permits a 120-line picture to be transmitted by almost any amateur phone transmitter and received on the station's communications receiver. The interested reader is referred to Part I for a discussion of the system's features and principles of operation. In this issue the actual circuitry will be described, with emphasis on the critical points, in order to help the reader who might like to build similar equipment make the most of his junk box.

> ***Here are the circuit details of the equipment described in outline in Part I of this article. The experimenter will find plenty of scope for trying out ideas of his own, since the basic system permits many variations. Discarded TV receivers and war-surplus c.r. indicator gear can be dug into for many of the components.***

Transmission Circuitry

The schematic of the combined transmission-reception apparatus is shown in Fig. 3. The cathode-ray tubes (V_2 and V_9) and the photomultiplier tube (V_1) require a high negative voltage for operation. A scope-type transformer with an electrostatically-shielded 2.5-volt filament winding for the V_2 heater is used in conjunction with a half-wave rectifier to develop approximately 2000 volts d.c. If the transformer (T_1) suggested in the parts list is used the rectifier should be a 2X2; other transformers may require a different tube. R_{20} should be selected to provide 1300 to 1500 volts across filter capacitor C_1, and will have a value of 1 or 2 megohms. Old scopes provide a fertile field for conversion to slow-scan use, but the available voltage should be at least 1500 for sufficient receiver cathode-ray tube brightness. The photomultiplier tube is quite sensitive to voltage changes so NE-2 neon bulbs were wired across the voltage-dividing resistors to regulate the dynode voltage at about 65 volts per dynode stage. The 450 volts B+ can be obtained from any supply capable of delivering approximately 200 ma. The +105- and −105-volt supplies were regulated by OC3/VR105 regulator tubes.

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**49 St. Mary's Place, Nutley, N. J.

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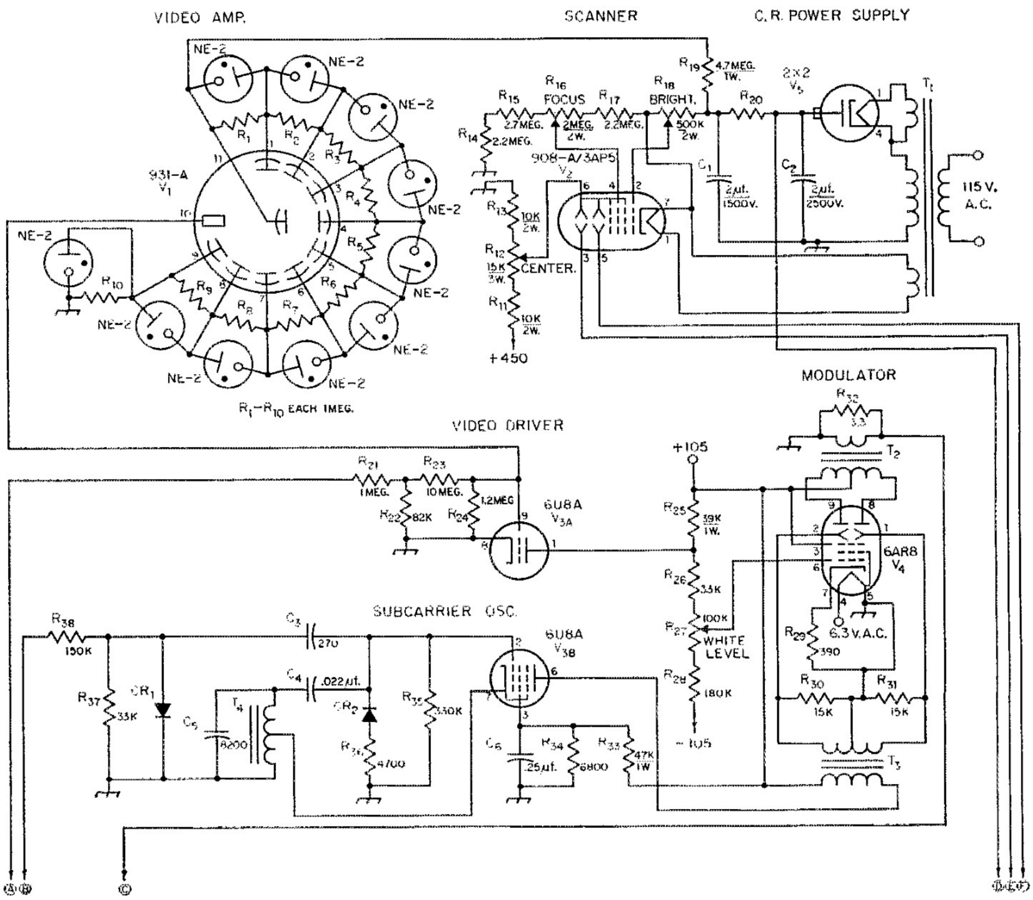
The grid resistor (R_{24}) of V_{3A} is also the photomultiplier anode load resistor; thus the grid of V_{3A} is at some negative potential whose actual value depends upon the setting of the V_2 brightness control (R_{18}) and the density of the picture being scanned. The large negative pulses coming from the sync-combiner diode (V_{12}) during retrace periods are attenuated by the R_{21}-through-R_{24} network but are still of sufficient amplitude to drive V_{3A} beyond cutoff. The voltage-dividing network in the V_{3A} plate circuit and V_4 grid circuit permits direct coupling of the video and sync signals to the balanced modulator.

The white-level control (R_{27}) should be adjusted so that the tone output of the balanced modulator [1] is close to zero during the scanning of white portions of the picture. A scope connected to the output jack (J_1) during transmis-

[1] This is not the conventional type of balanced modulator, the accepted definition of which is a modulator whose output contains side bands but no carrier. In the present case, a balanced circuit is used to produce an ordinary a.m. signal, but with the *modulating* signal balanced out in the output circuit. This is necessary because the modulating signal and carrier are so close in frequency. — *Ed.*

Fig. 3—Signal-generating and reproducing circuits for slow-scan picture transmission. Unless otherwise indicated, capacitances are in μμf., resistances are in ohms, fixed resistors are ½ watt, variable resistors are composition potentiometers, ½ watt. Capacitors marked with polarity are electrolytic; others may be paper, ceramic, or mica as available or convenient. With the exceptions listed below, component designations are primarily for text reference.

C_5—See T_4.
C_{10}—See text.
CR_1, CR_2—1N34 or equivalent.
J_1, J_2—Microphone-type connectors.
L_1—12 henrys, 20 ma. (Thordarson 20C52).
R_{20}—1 to 2 megohms, 1 watt (see text).
R_{x1}—Slider type resistor.
S_1—S.p.d.t. toggle or rotary.
S_2—2-pole 5-position rotary (Centralab PA-2019).
T_1—Scope transformer, to deliver approx. 2000 volts d.c.; see text (Thordarson 22R40; 1800 volts at 2 ma.; 2.5 volts at 2.2 amp. or 6.3 volts at 0.6 amp.).
T_2, T_5, T_6—Audio output transformer, push-pull plates to voice coil.
T_3—Audio interstage or small modulation transformer, single plate to push-pull grids, ratio not critical (Triad M-1X).
T_4—Autotransformer or tapped inductance; see text. C_5 may be varied to suit any available tapped coil to resonate at 2000 c.p.s.
T_7—6.3-to-6.3-volt isolation transformer, 1.2 amp. (Stancor P-8191).
V_5—2X2, or to suit filament voltage available on T_1.



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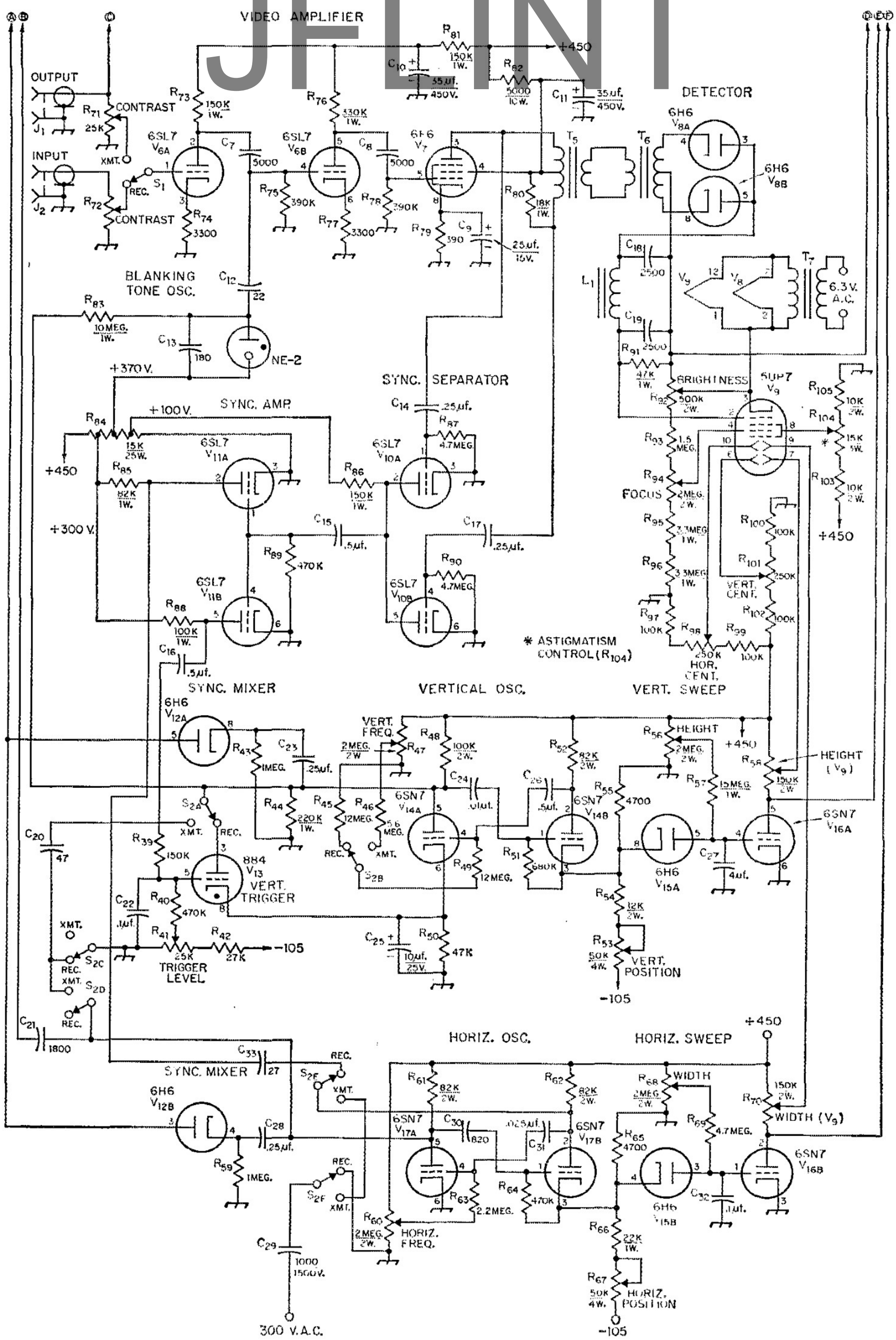
VIDEO AMPLIFIER
OUTPUT
INPUT
CONTRAST
DETECTOR
BLANKING TONE OSC.
NE-2
SYNC. SEPARATOR
SYNC. AMP.
BRIGHTNESS
FOCUS
VERT. CENT.
HOR. CENT.
* ASTIGMATISM CONTROL (R_{104})
SYNC. MIXER
VERTICAL OSC.
VERT. SWEEP
VERT. FREQ.
HEIGHT
HEIGHT (V_9)
VERT. TRIGGER
TRIGGER LEVEL
VERT. POSITION
HORIZ. OSC.
HORIZ. SWEEP
WIDTH
WIDTH (V_9)
HORIZ. FREQ.
HORIZ. POSITION
300 V.A.C.
6.3 V. A.C.
+450
-105
+370 V.
+100 V.
+300 V.

sion will permit this adjustment to be made, as well as setting the maximum black level at about 50-75 per cent of sync level with R_{18}. Fig. 4 illustrates the correct output wave form. No balancing control was provided in the balanced modulator, because the unwanted 0–1000 c.p.s. video was found to be 20 db. below sync level when checked on the scope with the 2000-c.p.s. carrier cut off.

The 2-kc. oscillator (V_{3B}) is an experimental circuit which permits the horizontal sync pulse to control the oscillations. It was felt that maintaining a constant time relationship between the sync pulses and individual cycles of tone might permit slightly more accurate synchronization than would be possible with a random relationship between the two. The results were inconclusive, however, with any advantage being a slight one. A standard oscillator circuit would probably serve just as well and would have a better output wave form. In the circuit used, T_4 is a high- to low-impedance headphone autotransformer. The CR_2-R_{36} combination improves the output wave form by limiting the negative grid-voltage swings so the tube is not driven to cutoff. This "gimmick" can also be applied to other types of oscillators. The oscillator output transformer (T_3) can be a small modulation transformer or single plate to push-pull grid interstage unit.

On "transmit" the horizontal multivibrator (V_{17}) is synchronized at a submultiple of the power line frequency by a voltage fed from the power transformer (external) through C_{29}. R_{60} controls the horizontal frequency and permits frequencies from 15 to 60 c.p.s. to be selected. The picture width is controlled by R_{68} which regulates the charging current of the sweep capacitor C_{32}. On retrace, V_{17B} is cut off and a heavy discharge current through V_{15B} pulls the grid voltage of V_{16B} to some negative value which depends on the setting of R_{67}. The charging rate during sweep is such that the grid never goes positive. A highly linear sawtooth wave, therefore, appears on the grid of V_{16B}; the tube amplifies this voltage, and it is fed directly to Pin 5 of V_2.

The vertical multivibrator has a sweep range of 1 c.p.s. to 1 cycle every 7 seconds, controlled by R_{47}. The oscillator receives a sync pulse from the horizontal oscillator through C_{20} during every horizontal retrace period. These pulses have no effect until the vertical oscillator approaches the triggering point, at which time one of the pulses triggers the oscillator. The rest of the vertical sweep circuit is similar to the horizontal, with R_{56} controlling flying spot scanner raster height, and R_{53} the vertical position. R_{12} is used to center the raster on V_2 and R_{16} focuses the flying spot.

The rectangular pulses developed during the multivibrator retrace periods are coupled to the cathodes of V_{12}, where they are combined to provide the video sync pulses fed to R_{21}. The sync pulse for the 2-kc. oscillator is coupled from V_{17A} through C_{21}.

Many substitutions can be made in the picture transmission circuits. While there is no inexpensive substitute for the 931-A, any cathode-ray tube with a P5 phosphor is suitable for V_2. The 5CP5 and 5JP5 are currently available on the surplus market. Miniature equivalents of the octal base tubes can be used, of course, and in some instances they cost less than the octal types used. Generally speaking, the R and C values in the sweep and sync circuits are noncritical; however, the time constants in the grid circuits of the multivibrators ($C_{24}R_{51}$, $C_{26}R_{49}$, etc.) should be adjusted for proper timing. Several balanced modulators were tried, but most failed to remain in balance over the wide range of control-grid voltage swing. The 6AR8 circuit was the most satisfactory in this respect, and it also provides plenty of output. If the output voltage from J_1 overdrives the first stage in the transmitter modulator, a pot or fixed pad may be installed to cut the gain.

Reception Circuitry

The audio from the communications receiver is fed into J_2 and is controlled in amplitude by con-

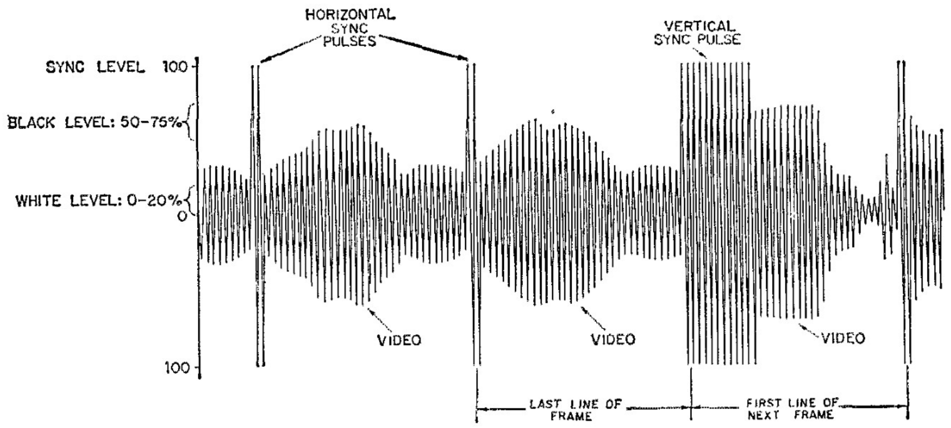

Fig. 4—Wave form of modulated 2000-c.p.s. tone. There are approximately 100 cycles of 2000-cycle carrier per line.

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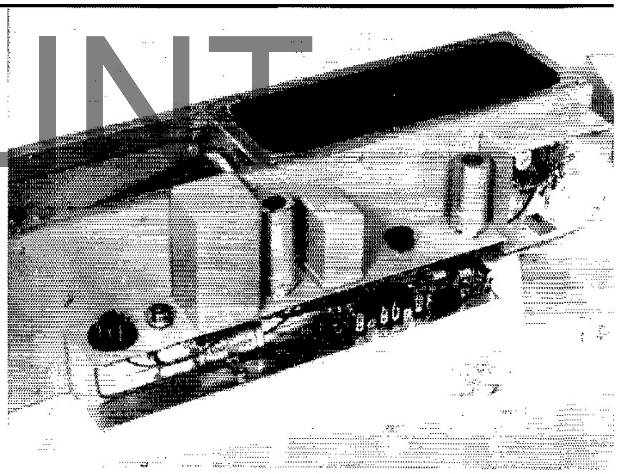


Side view of the scanner assembly with cover plates off the modulator chassis and 931-A socket shield. The 931-A socket, far right, has the dynode load resistors and neon-tube voltage regulators clustered about it. The tube immediately adjacent is V_3. Moving to the left, the components on top of the modulator chassis are the control knob for R_{27}, then T_3, V_4, T_2, the output connector for feeding the composite signal to the main chassis, and the power supply connector.

trast control R_{72}. During the monitoring of a transmitted image the contrast is controlled by R_{71}. These two controls can have a wide range of values from a few thousand ohms to half a megohm or more. The two small universal push-pull output transformers, T_5 and T_6, are connected to feed the amplified audio to V_8, the full-wave diode detector. The secondary of T_6 is at a potential of about -2000 volts d.c., but with the transformer mounted on small ceramic stand-off insulators there has been no trouble with insulation breakdown. Also at a high negative potential, and consequently mounted on stand-offs, is L_1. This choke is rated at 8 henrys at 40 ma. in its intended filter application, but it measures only 4.5 henrys at 2000 c.p.s. with no d.c. in the winding. Measuring the actual frequency response of the filter is the best check on performance. This filter should have no attenuation up to 1000 c.p.s., the point where a gentle roll-off starts.

In the cathode-ray tube circuit, R_{92} controls the brightness, R_{94} the focus, R_{98} the horizontal centering, R_{101} the vertical centering, R_{58} the vertical size, R_{70} the horizontal size, and R_{104} astigmatism. This last control is used to adjust the anode voltage to the point where optimum focus in the horizontal and in the vertical direction occurs at the same point on the focus control.

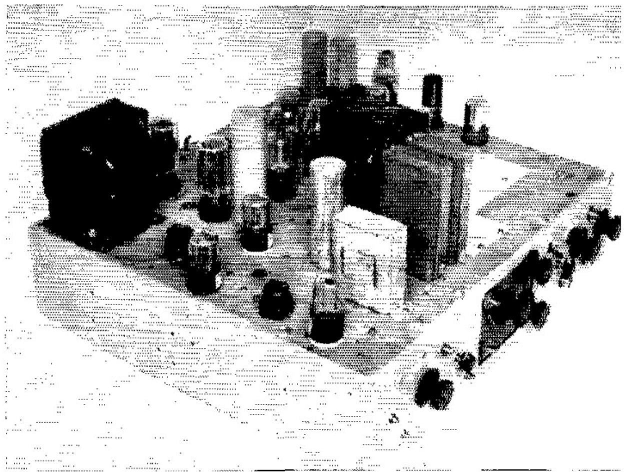
The sync pulses are separated from the composite video and sync signal in V_{10}. The pulses fed to the horizontal oscillator are amplified by V_{11A}. V_{11B} feeds the $R_{39}C_{22}$ integrating circuit which fires V_{13} when a vertical sync pulse charges C_{22} sufficiently. The firing level is controlled by R_{41}. Since the plate of V_{13} is directly connected to the plate of V_{14A}, the firing of the 884 will also trigger the vertical multivibrator. The $C_{25}R_{50}$ combination in the cathode circuit of V_{14A} is used to raise the bias on V_{13} after firing, until the bias on C_{22} has a chance to leak off. This is done so that noise or horizontal sync pulses soon after firing won't cause the tube to fire again. To operate properly, C_{25} should be in the neighborhood of 10 μf., not much larger.

The operation of the sweep circuits is the same during reception as during transmission. One additional event not previously mentioned is the triggering of the neon bulb blanking oscillator. During the sweep period, V_{14A} is cut off and the oscillator does not operate. However, during the conduction period the difference between the voltage at the plate of V_{14A} (about 50 volts) and the 370-volt return potential of the neon bulb is sufficient to allow the circuit to oscillate. The tone output is coupled to V_{6B} through C_{12}. The neon-bulb return voltage is a tap on R_{84}, which may be the bleeder resistor of the 450-volt power supply.

Several tubes may be substituted for the 5UP7; among them are the 3FP7, 5CP7, and 5ADP7, all of which are available on the surplus market. These tubes all have the post-deflection acceleration feature and can give a brighter picture than the 5UP7 if a high positive voltage is applied to the tube's third anode.

Mechanical Details

Physically, the equipment consists of three separate units. The largest of these is an old TV chassis upon which the power supply, sweep, sync, and receiver amplifier circuits are mounted. The important points here involve layout and insulation. In addition to the usual precautions in wiring the audio circuits, care must be exercised to reduce stray capacitive coupling between the two sweep oscillators. The steep wave forms in the horizontal oscillator are easily coupled to the vertical oscillator, where they may cause premature triggering. Several inches of separation between the two stages is recommended. The remainder of the layout is not critical. Adequate insulation should be used in the high-voltage



An old TV receiver chassis was used for the major portion of the circuitry. This assembly contains power supplies (built according to ordinary design methods) in addition to the circuits shown in Fig. 3.

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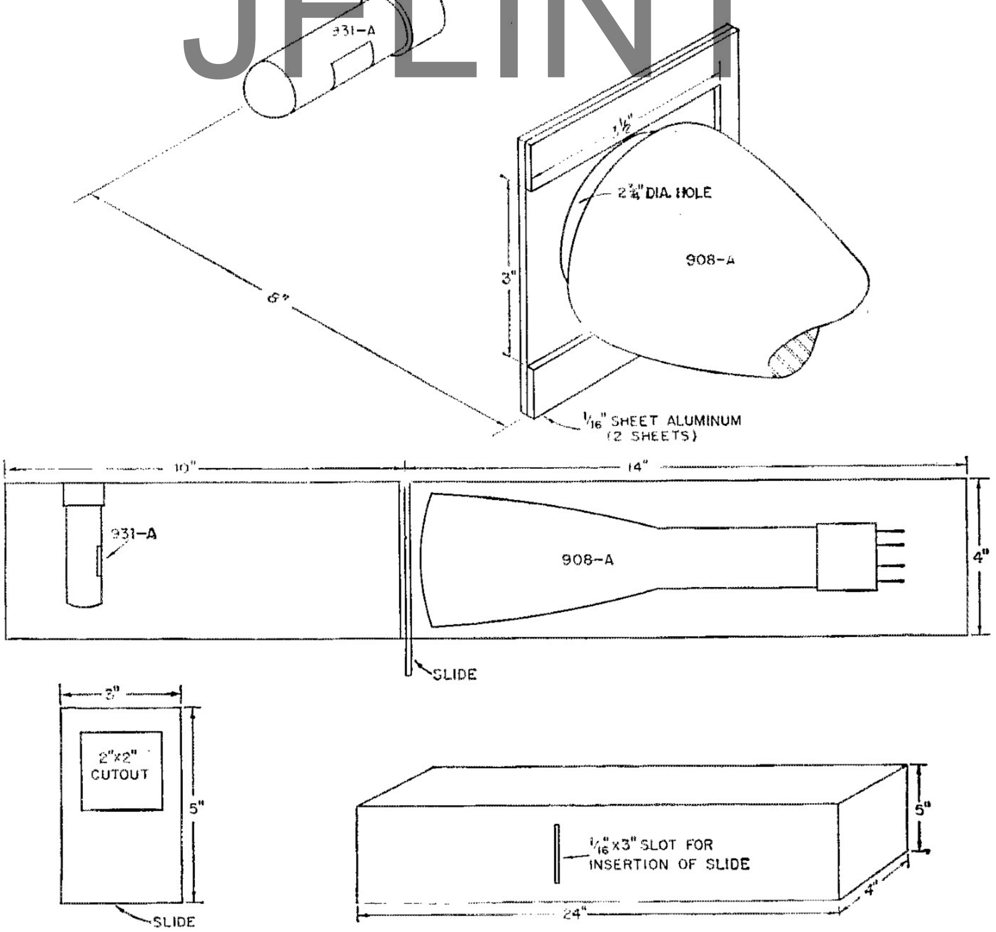

Fig. 5—Some mechanical details of the flying-spot scanner.

power supply, and the focus and brightness controls should be insulated from ground and connected to their knobs with insulated couplings.

The second unit contains the 5UP7 and the detector circuit. An ASB surplus radar indicator provided the chassis and mounting assembly for the 5UP7. Unfortunately, the magnetic shield which covered the 5BP1 originally used in the indicator was too narrow for the 5UP7 and had to be removed; the electron beam in the tube is therefore subject to deflection by stray magnetic fields. This may mean keeping the tube several feet away from power transformers.

The P7 phosphor is of the cascade type where the electron beam excites a short-persistence blue phosphor, which in turn excites a long-persistence yellow phosphor. The blue flash which accompanies the sweep is undesirable because of its extreme brightness and is therefore filtered out with a Wratten 15G gelatin filter which covers the face of the tube. Your photo dealer can obtain this filter for you.

The third unit, the flying-spot scanner, also has the 6U8, 6AR8, and voltage-regulating neon bulbs mounted on the back. The important constructional points are illustrated in Fig. 5 and in the photographs of the scanner. While this scanner has a framework of machined aluminum and sides of 1/16-inch thick aluminum sheet, equivalent results can be obtained with a much less elaborate arrangement. Actually, the first tests of the system were conducted with the scanner tube and photomultiplier in a cardboard box made light tight with masking tape, and with a negative taped to the face of the 908-A.

The aluminum scanner box was made as light tight as possible. A strip of felt covers the slot where the slide is inserted in order to reduce the amount of light entering here, and the interior is painted black to reduce reflection. Since it is desirable to have the negative directly against the face of the scanner tube during operation, the tube was mounted on a movable car-

(Continued on page 146)