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A Simple Solid-State Flying Spot Scanner For Slow-Scan Television

A flying spot scanner is a device which uses a raster on the face of a cathode ray tube to produce high quality television pictures from either photographic slides or prints and drawings. It is usually more economical to build and easier to adjust than a vidicon camera, a factor which makes the flying spot scanner (FSS) an ideal first camera construction project for the newcomer to SSTV. The ease of operation and picture fidelity of a well designed FSS unit also makes it a valuable station accessory even when a vidicon camera is available. Using the FSS to televise most routine picture material reduces the total operating time on the SSTV camera vidicon, an important factor considering the difficulty in obtaining the special 7290 slow-scan vidicons.

The flying spot scanner which I developed to take the load from my own transistorized camera consists of three separate units:

1. The normal station SSTV monitor, which, in addition to displaying the picture output, provides both operating and deflection voltages for the FSS scanning module.
2. An SSTV test generator which supplies a signal to trigger the sweep in both the monitor and scanning module, a sub-carrier oscillator which is modulated by the scanning module output to produce the picture, and a variety of useful test outputs which are completely independent of the scanning module.
3. The scanning module which consists of a scanning CRT whose deflection plates are slaved to those of the monitor CRT, a 931 photomultiplier, and an FET dc amplifier for boosting the photomultiplier output to a suitable level for driving the test generator sub-carrier oscillator.

How it Works

Figure 1 shows a block diagram of the entire system. With no signal from the scanning module, the test generator produces a composite slow-scan signal consisting of one 30 ms vertical sync pulse of 1200 Hz repeated every eight seconds, 5 ms horizontal sync pulses of 1200 Hz at a 15 Hz rate, and a video tone (between sync pulses) of 1500 Hz. The sync pulses cause a square 120 line slow-scan raster to be produced on the monitor screen which is black due to the 1500 Hz video tone. Since the scanning module CRT has its plates slaved to the CRT in the monitor, a raster is produced on this tube as well. Since the scanning CRT is unaffected by

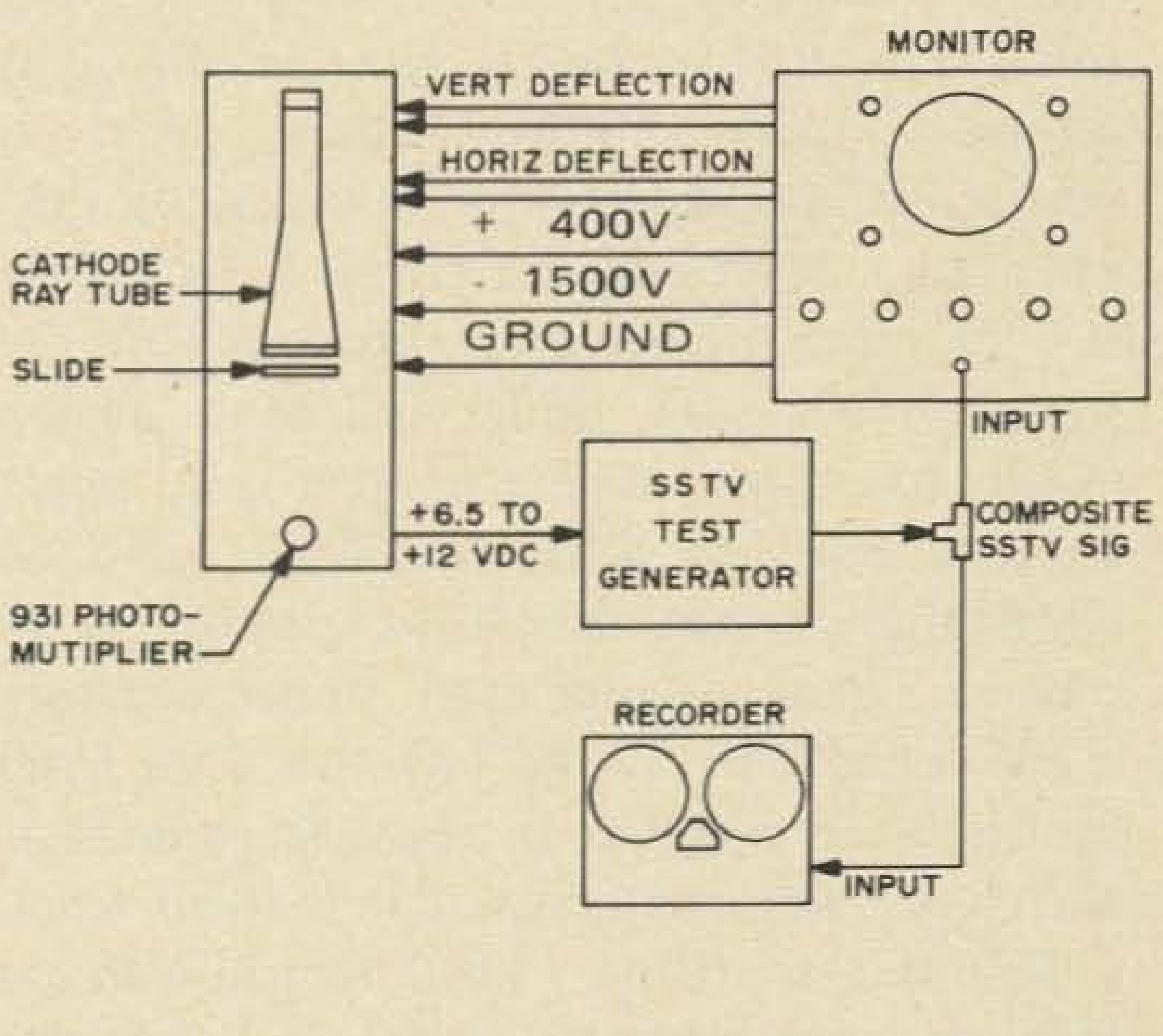

Fig. 1. Block diagram of the solid-state flying spot scanner system.

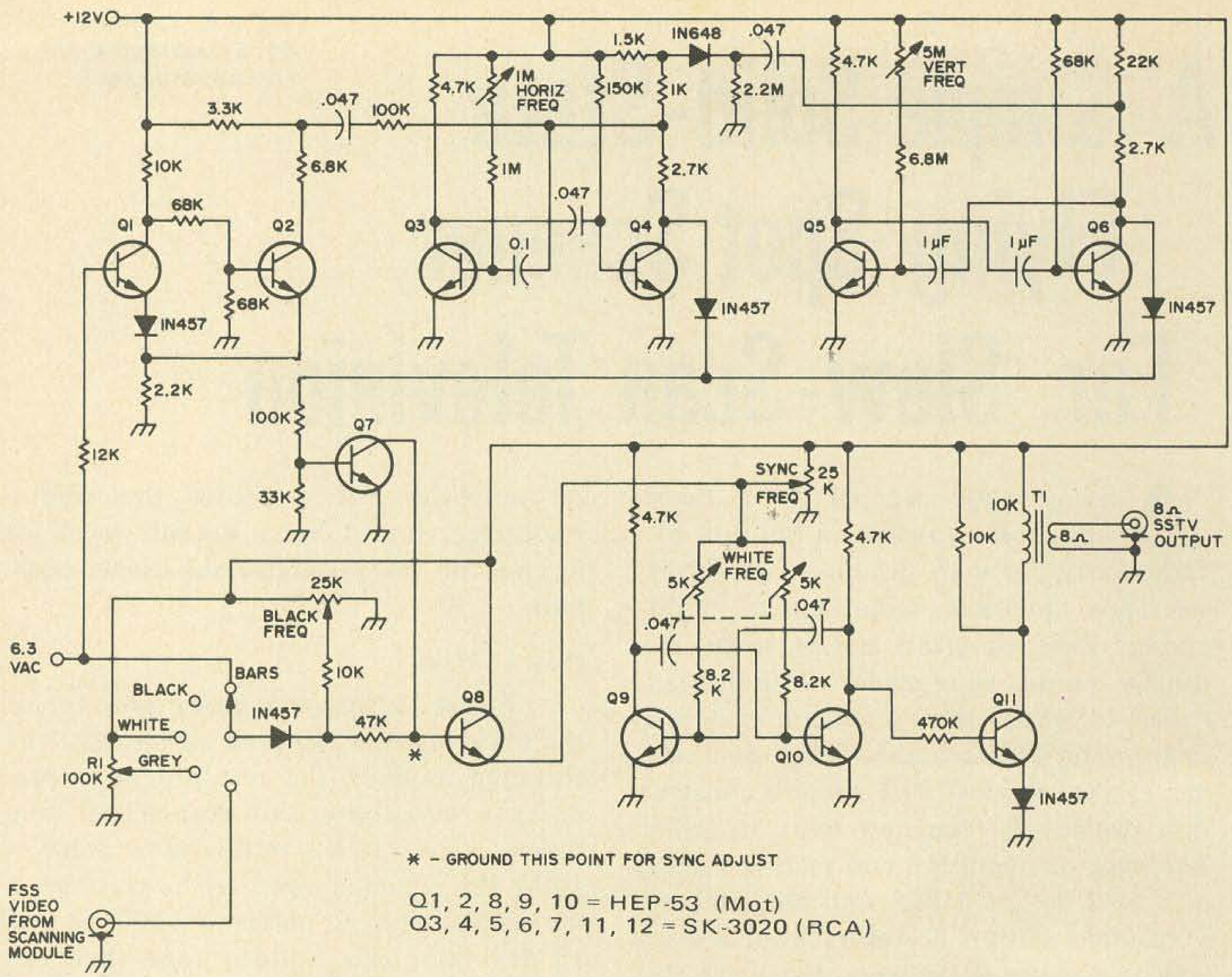

Fig. 2. The SSTV test generator circuit from a circuit described by K7YZZ[1].

the video tone, it can be independently set for a moderately bright raster. A photographic slide is placed over the face of the scanning CRT so that the light from the raster, actually a fast-moving spot of light, must pass through the slide before reaching the 931 photomultiplier tube. The 931 converts the varying light intensity to a minute voltage which is internally amplified by the photomultiplier to a level ranging from −.3V under no illumination (black portions of the picture) to −3.0V under full illumination (white portions of the picture). A single FET is used as a dc amplifier with an adjustable output threshold, producing an output signal ranging from approximately 6.5V (black) to 12.0V (white). This total range, when applied to the test generator, shifts the sub-carrier oscillator from black (1500 Hz) to white (2300 Hz) in a linear fashion, resulting in a replica of the original slide being reproduced on the monitor screen. This video information in no way affects the sync pulses, and since there is no video interconnection between the scanning CRT and the monitor, the picture will remain until the slide is removed from the scanning module CRT face. The brightness control on the scanning module CRT functions as the system contrast control and can be varied to produce the proper light level for good contrast. A T or Y connector is used at the SSTV output jack of the test generator to record the picture output for later playback. The use of the monitor to supply scanning and operating voltages for the scanning CRT and 931 photomultiplier not only reduces cost, but simplifies construction as well.

Construction

Monitor. Very little needs to be done with the monitor to fit it into the system. An auxilliary socket should be installed on the rear apron to make deflection and operating voltages avail-

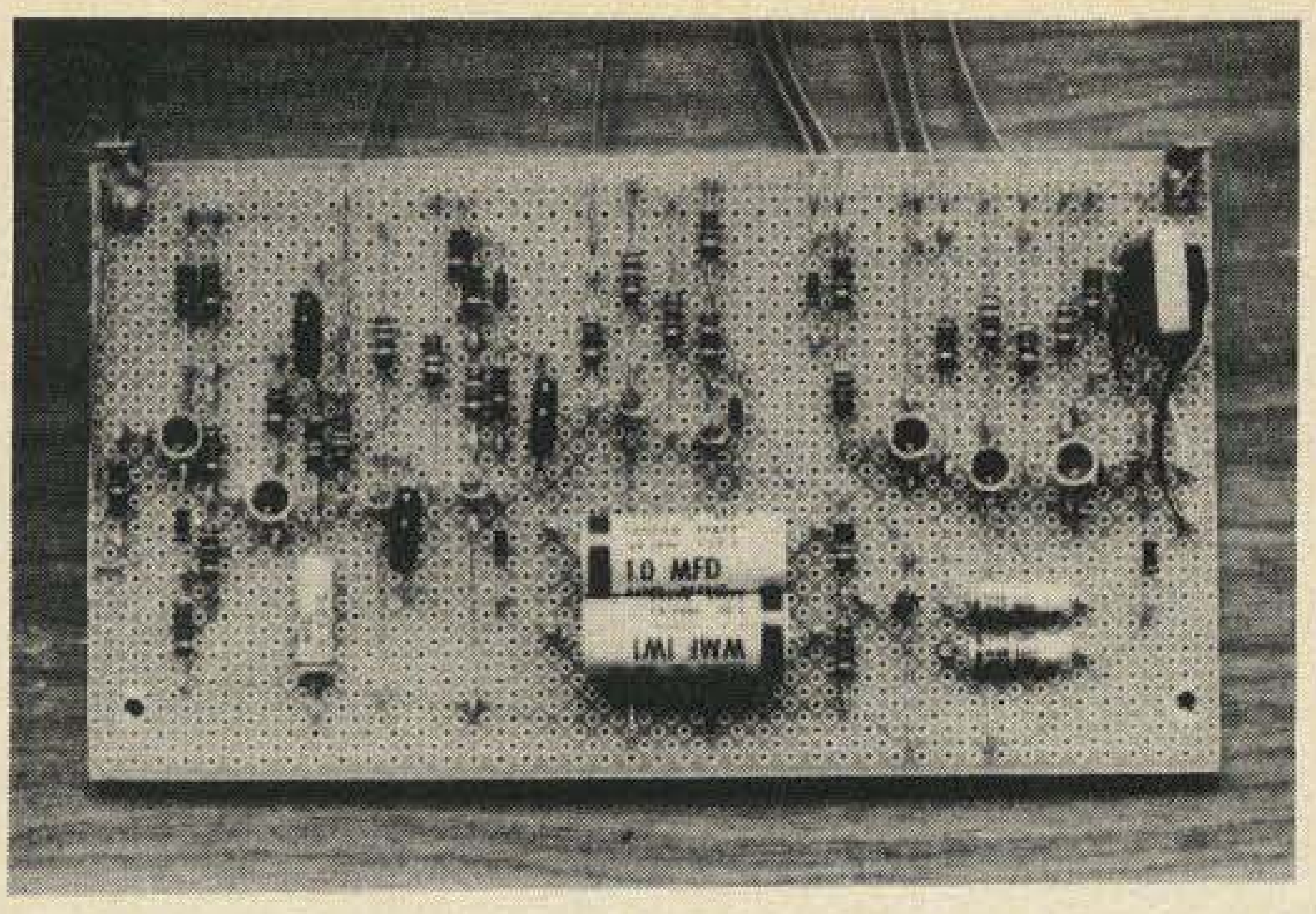

Fig. 3. Photograph of the vector circuit board layout used by the author for the SSTV test generator used in the FSS system.

able. Since the scanning unit should use a CRT that is identical with the one used in the monitor, all required voltages should be available. In my case, I used a six pin Cinch Jones socket for the vertical and horizontal deflection lines (2+2), the 400V required for the astigmatism string, and a ground line. Required high voltages, approximately −1500V and perhaps +1500V (depending on the type of CRT used) are best brought out via standard UHF coax connectors. Care should be taken that the monitor CRT display is completely linear, for the linearity of the finished picture will be governed by this factor since the two CRTs in the system are "slaved" during operation. Vertical non-linearity is the most common type and is usually caused by a faulty discharge capacitor. If necessary, a number of high-quality mylar units should be paralleled to achieve the desired capacity and discharge characteristics.

Test Generator. The heart of the entire system is a solid-state SSTV test generator developed from a circuit described by K7YZZ[1]. The changes incorporated in the circuit have been relatively minor. The transistors originally specified have been replaced by Motorola HEP and RCA SK series general replacement types. These types are usually obtained fairly easily. Some of the RC values have been changed and the "dot-bar" and "sync" test positions have been deleted, while the

FSS video position has been added. The unit was constructed in its own cabinet with an internal power supply so that it can be used independently as an SSTV signal source, if required. Figure 2 shows the schematic, while Figs. 3 and 4 show the circuit board and completed unit. The unit is certainly much larger than required and if miniaturization is your thing, it could certainly be reduced considerably in size. In addition to its function in the FSS system, the generator will also produce a black raster, white raster, a raster with a continuously variable grey level, and a stable bar pattern.

Scanning Module. This module consists of the CRT and its associated control circuits, the 931 photomultiplier, and the FET dc amplifier. A piece of cobalt glass, available in most high school chemistry labs, is positioned between the CRT and 931 to filter out the long-persistence yellow component of the P7 phosphor. Without this precaution, the amplified phototube output would continuously drive the sub-carrier oscillator to white (2300 Hz) due to the persistent yellow glow on the face of the CRT. My module is built on a 6x17x2 in. chassis. A shorter chassis could be used if mirrors were used

Fig. 4. Interior view of the completed SSTV test generator. Front panel controls (not shown) include power, function selector (S1), horizontal frequency, and the grey scale adjust (R1). The remaining pots are mounted on the chassis between the circuit board and the front panel. The rear portion of the chassis contains power supply components. The small circuit board includes bridge rectifier diodes and a zener and regulating transistor.

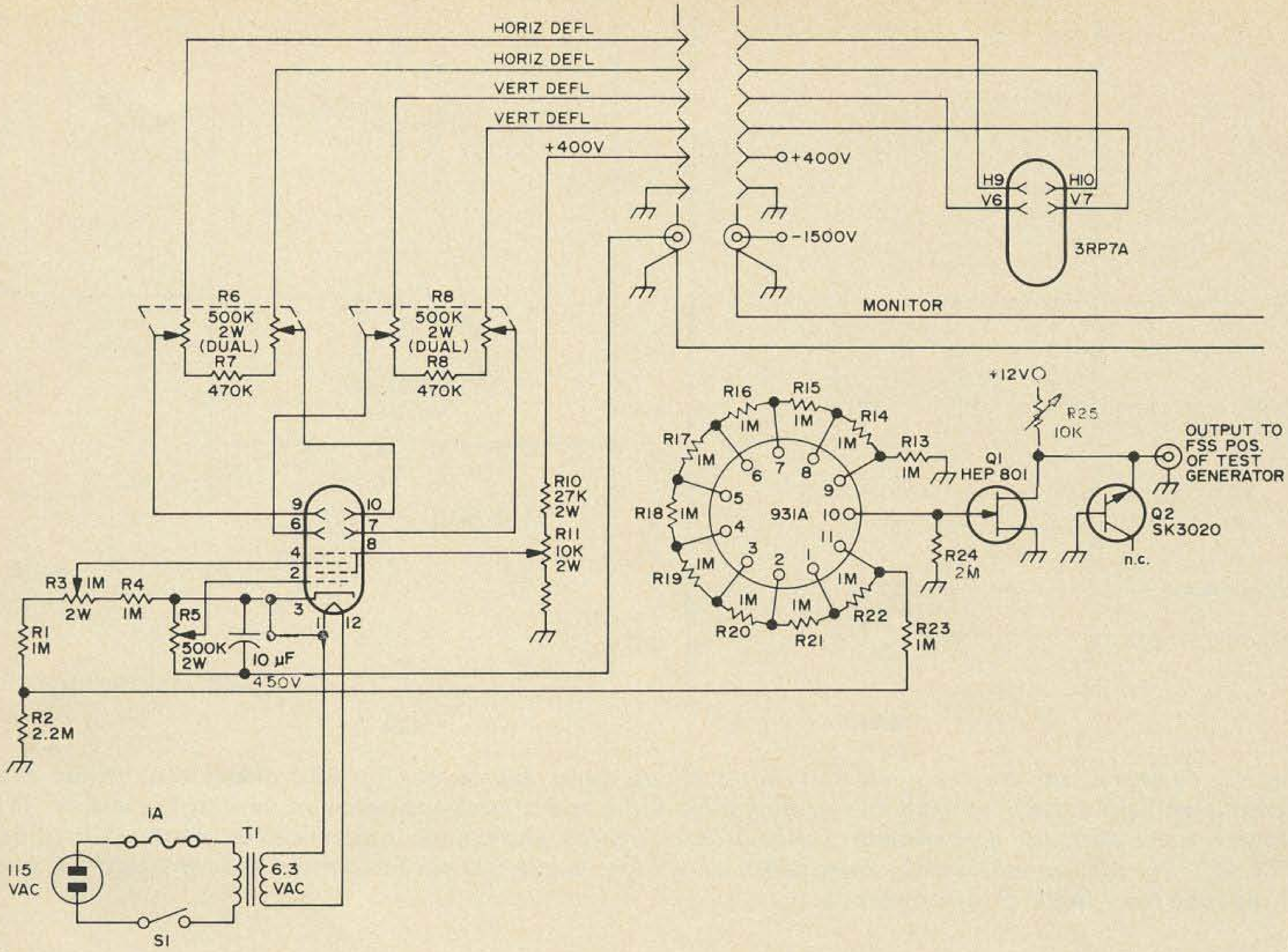

Fig. 5. Scanning module and interconnections with the monitor. The 3RP7A CRT is shown as an example only, for in actual practice the scanning CRT should be of the same type as that used in the monitor. Other CRTs will require different values in the astigmatism and brightness-focus networks and the monitor values should be duplicated. The −1500V is most easily carried via coaxial cable and suitable connectors. If a high positive accelerator voltage is required for the CRT used, it may be carried via a similar cable. Controls are: R6 – Horizontal Size; R8 – Vertical Size; R11–Astigmatism; R5 – Brightness; R3 – Focus; and R25–Dc Level Adjust. T1 is a 6.3V 1.2A filament transformer with secondary windings rated at 2 kV or better.

in the system, but the distance between the CRT face and the photomultiplier should be kept at least 4 or 5 in. if the picture definition is not to be degraded by parallax factors. The CRT should be firmly mounted and some means incorporated to keep the photographic slides pressed firmly against the tube face. Small metal clips may be used or a slide holder can be constructed and attached to the tube face. If elegance or convenience are no object, the slides can simply be taped to the CRT screen! If you plan to use the scanner in a lighted room, a black hood or box assembly can be constructed so that the CRT and the 931 form a light-tight system once the slide is in place. The top of the chassis and the inside of the hood should be painted flat black or faced with black construction paper to eliminate stray reflections.

The schematic of the scanning module and monitor interconnections, Fig. 5, show values in the brightness, focus, and astigmatism networks that are consistent with the 3RP7A used in my own monitor. If your monitor uses another tube, simply substitute equivalent networks from your own monitor circuit. In the event of such a change, be sure to modify the CRT socket connections as required. The 931 requires a negative voltage of some 600 or 700V for proper operation. Alter the relative values of the resistors following the focus pot in your own circuit so that this voltage is available.

High voltage wire should be used where appropriate and the brightness and

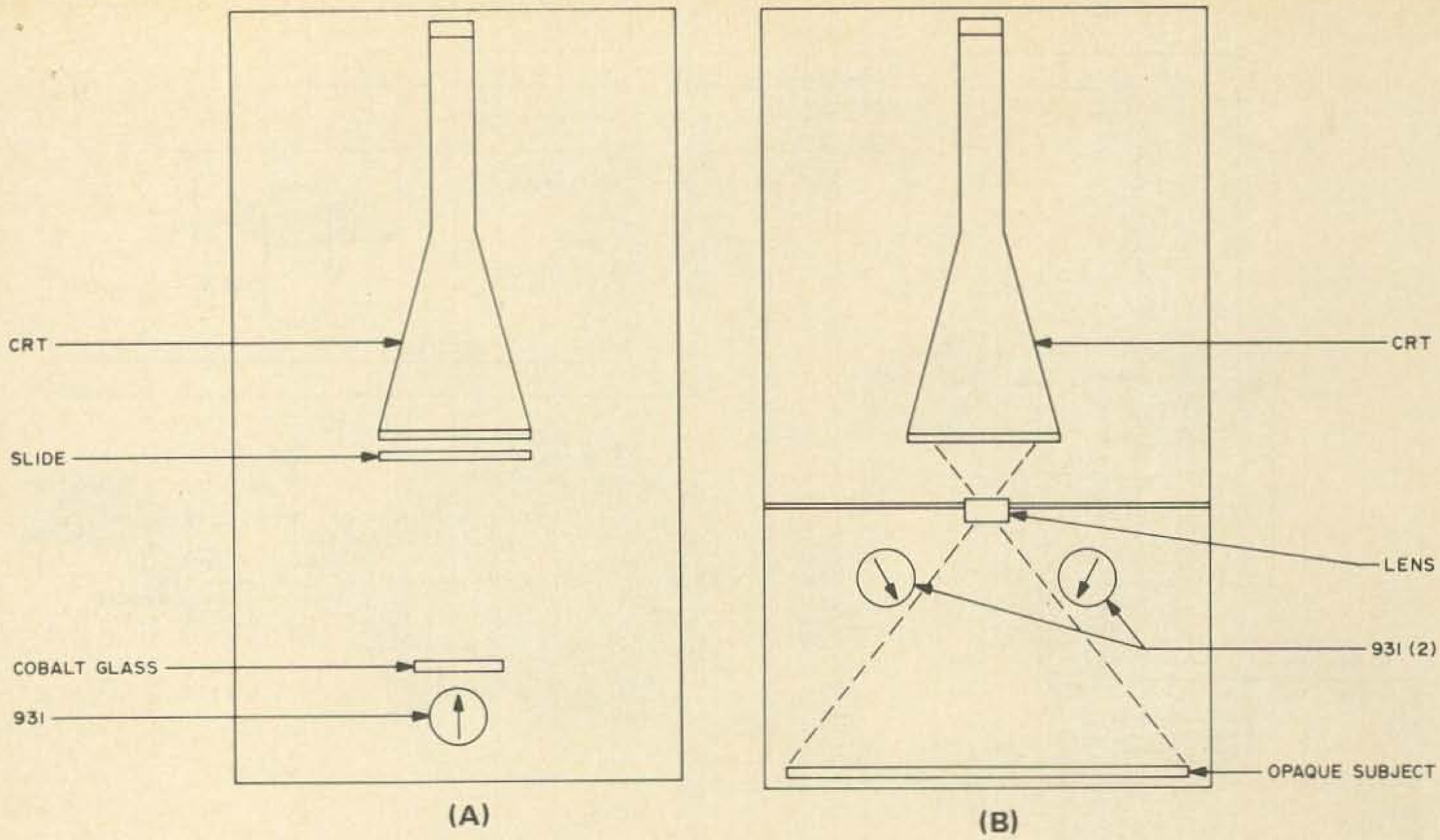

Fig. 6. Diagrams of the mechanical layout for two basic approaches to FSS design. (A) shows the transmitted light system, suitable for photographic slides and other transparencies, used by the author. (B) shows a more complex arrangement, suitable for televising photograph prints and drawings, as used by K7YZZ[2]. The arrows indicate the orientation of the key in the 931 sockets so that the light sensitive area of the tube faces in the proper direction.

focus pots should be *insulated from ground and equipped with insulated shaft extensions*. The focus, astigmatism, and dc output level can be placed anywhere that is convenient as they are rarely adjusted after initial setup. The brightness control is the system contrast control and should be placed for convenient adjustment when the scanner is in operation.

There are actually two options available in constructing the scanning unit. My own unit is built to handle photographic slides and transparencies and the general layout is diagrammed in Fig. 6a. It is also possible to set the scanner up to transmit pictures from photographic prints and drawings. The somewhat more complicated mechanical layout is diagrammed in Fig. 6b. Here a lens is used to focus an image of the scanning raster onto the photographic subject. The light *reflected* from the subject is picked up by two 931 photomultipliers. This approach was used by K7YZZ in his tube FSS circuit[2] and anyone contemplating this approach is urged to consult this article for details of mechanical layout.

Adjustment and Use

The test generator should be aligned first. The generator output should be connected to a frequency counter or some other setup for determining the frequency of the audio output. The base of Q8 should be grounded with a test lead and the sync frequency control adjusted for 1200 Hz output. Remove the

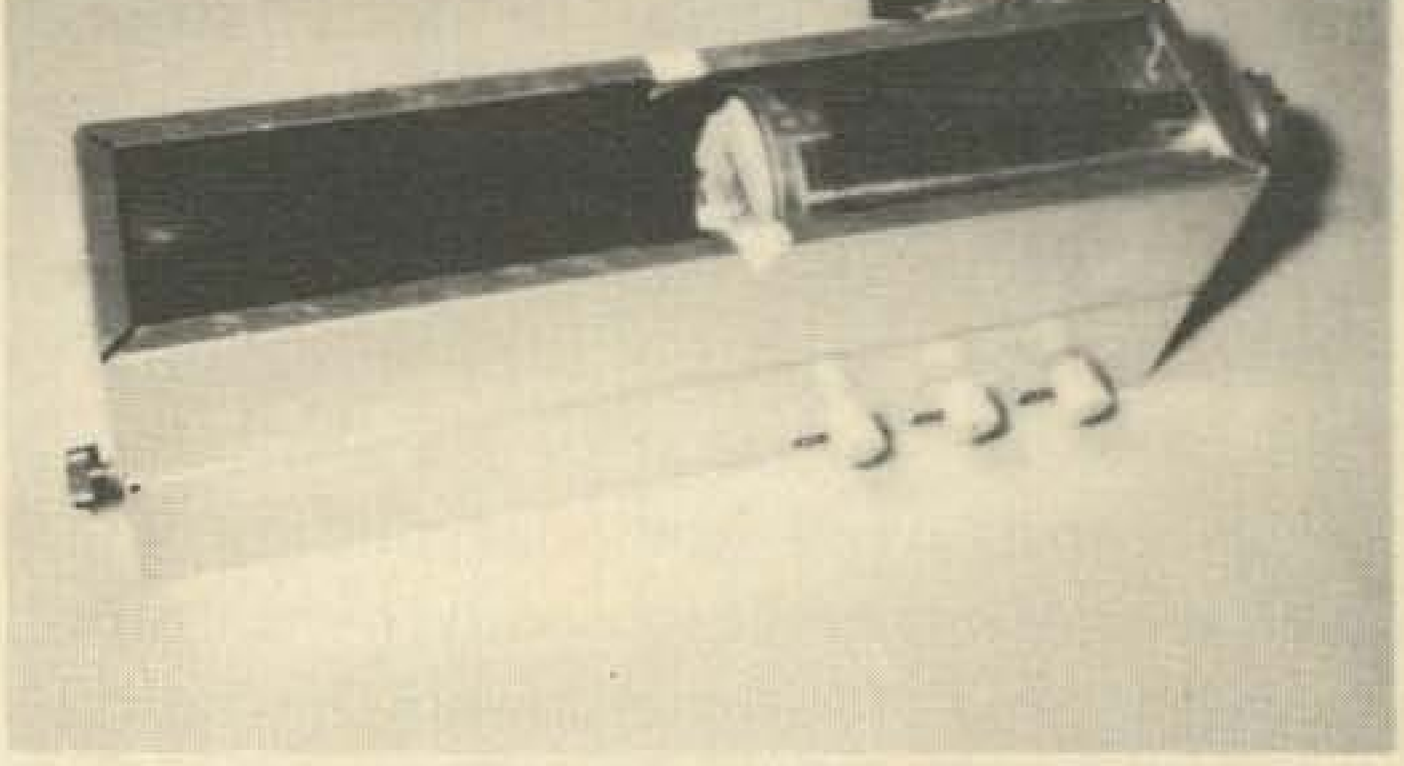

Fig. 7. A photograph of the author's scanning module. The CRT is enclosed in an alloy shield to eliminate the effect of external magnetic fields. The 931 on the far left has been painted black except for the photosensitive "window" while the chassis enclosure has been lined with dark felt. A felt lined cover is placed over the top of the unit after the slide is in place.

test lead and switch S1 to the "black" position, adjusting the black frequency control for 1500 Hz output. Switch S1 to the "white" position and adjust the white frequency control for 2300 Hz output. This series of adjustments should be repeated several times as there is some interaction between the various frequency controls. The generator should then be connected to the monitor and S1 switched to the bars position. The horizontal frequency should be adjusted for a stable display of four vertical white bars and the vertical frequency should be adjusted for an eight sec. frame time. At this point, without plugging the scanning module into the test generator, the following monitor displays should occur at each setting of S1:

BARS – four vertical white bars on a black background.

BLACK – a pure black raster.

WHITE – a pure white raster.

GREY – a raster whose intensity can be varied from black to white using R1.

FSS VIDEO – a black raster.

Turn out all of the room lights or cover the 931 photomultiplier. Plug the video line from the scanning module into the generator and apply power to the scanning unit. The dc level control should be adjusted to the point where the subcarrier output *just* begins to rise above 1500 Hz. Turning on the room lights or removing the cover on the 931 should immediately cause the raster on the monitor to go from black to white. Turn out the room lights and adjust the scanning module brightness, focus, and astigmatism controls for a moderately bright, well-focused raster. The respective size controls should be adjusted for a square raster of a size appropriate for the slides being used. Very small adjustments in centering can be made using the monitor centering controls. Put a slide in place and adjust the scanning module brightness control for the best picture contrast when viewed on the station monitor.

Photographic slides, either color or black and white, may be used directly in the system. Call signs and other printed material can be prepared on clear acetate using dry transfer lettering. "Instant" slides can be made on acetate using india ink, wax marking pencils, or many of the felt tip pens available on the market. Various portions of the slide may be cropped or enlarged, within the resolution limits of the CRT, by changing the size and position of the scanning raster. Figure 8 shows some typical output from the system. Building a system of this sort is certainly one of the easiest and least expensive ways to produce high quality SSTV pictures.

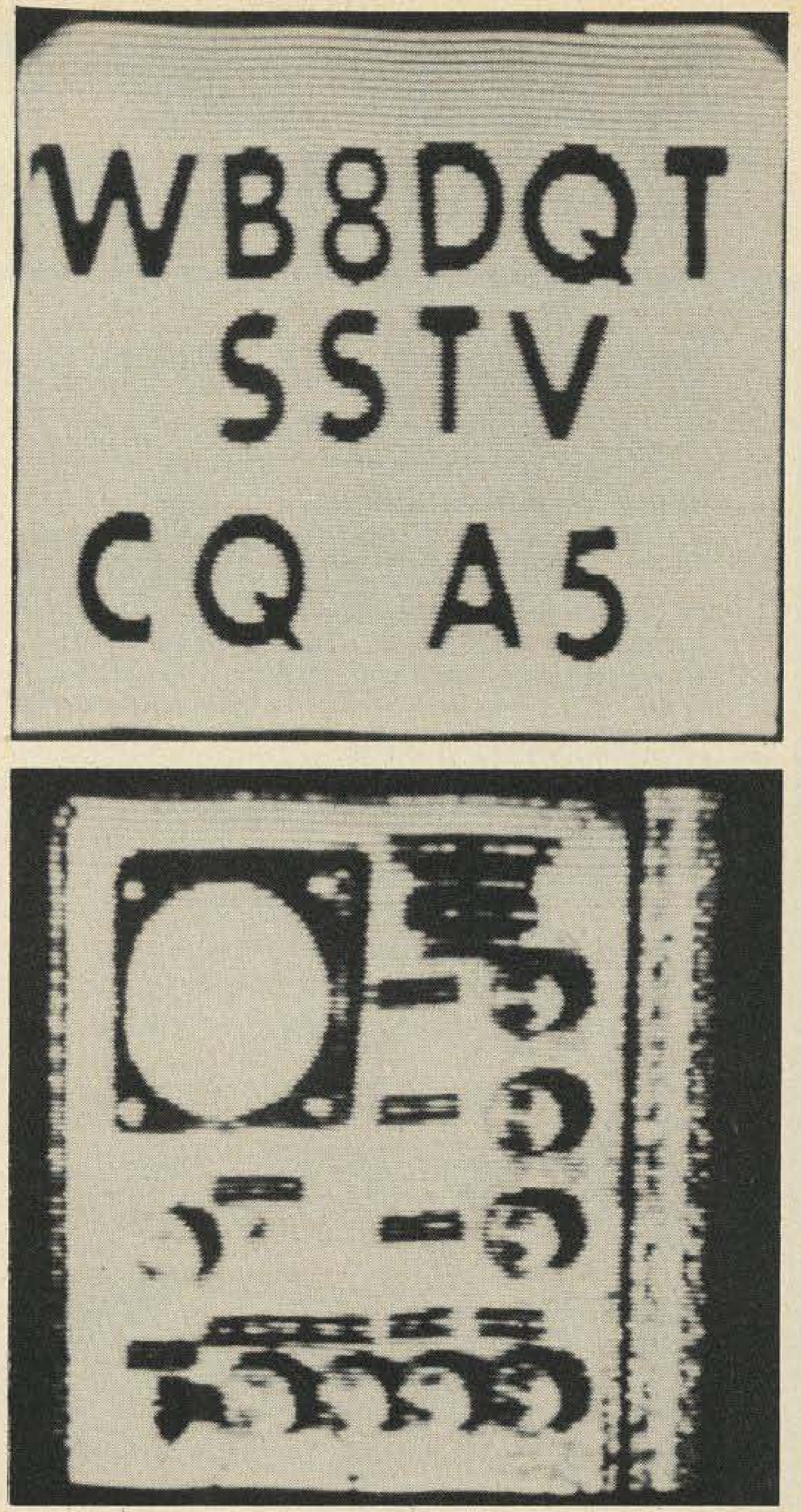

Fig. 8. Typical picture output as viewed on the author's SSTV monitor.

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[1]Hutton, L. K7YZZ. A Slow-Scan Television Signal Generator. 73 Magazine, July 1969.

[2]Hutton, L. K7YZZ. A Slow-Scan Television Picture Generator. 73 Magazine, October 1967.