Simplified HAM TV STATION

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Fig. 1. To simplify construction and testing, system is built in separate units.

Part 1. Complete description of a ham TV station that can be built from available parts at relatively low cost. Succeeding articles will present details on constructing entire station.

BOTH SOUND AND VIDEO ARE INCORPORATED IN SINGLE TRANSMITTER

STANDARD DEFINITION, 525 LINES, 60 FIELDS, 4.5 MC. BANDWIDTH IS PROVIDED

NO EXPENSIVE ICONOSCOPES OR IMAGE ORTHICONS REQUIRED

STATION COVERED OPERATES ON 420 MC. BAND. HIGHER FREQUENCY AMATEUR BANDS CAN BE USED

SYSTEM DESCRIBED IS FOR TRANSMISSION OF STILLS. ALTERNATE METHOD FOR SCANNING MOVING OBJECTS IS DISCUSSED

IMPROVED SYSTEM, ALSO DESCRIBED, EMPLOYS STANDARD TV RECEIVER TO PROVIDE SYNC AND SCANNING PULSES. SAME RECEIVER CAN ALSO BE USED TO RECEIVE PICTURE AND SOUND FROM ANOTHER AMATEUR STATION

TO REDUCE COST, ANY STABLE 420 MC. TRANSMITTER, EITHER SURPLUS OR HOME-BUILT CAN BE USED

OPERATOR OF EQUIPMENT MUST BE A LICENSED AMATEUR. TO BUILD COMPLETE STATION CONSTRUCTOR SHOULD BE FAMILIAR WITH RADIO DESIGN AND THEORY

FROM time to time there have been amateur television systems described in the various radio publications. While these have been of good design in most cases, all lacked the definition and quality that people have been led to expect since the advent of popular television. The system to be described is capable of the full resolution and detail associated with the present day television standards.

By the ingenious use of scanning pulses taken from any standard television broadcast station by means of a standard TV receiver, much of the complication of a commercial transmitter is avoided.

The expensive image orthicons and iconoscopes are replaced by standard cathode-ray tubes which may be of the surplus variety.

Reception of the signal is accomplished by any TV receiver equipped with a simple converter. If desired it is possible to use the same receiver to pick up both the scanning pulses from the transmitter, and for reception of the transmitter picture from another amateur TV station.

Operation is on the 420-450 mc. band, permitting the use of small high gain antennas and readily available tubes.

While the equipment may appear complicated, it has been broken into several component parts to simplify the construction. This enables the advanced amateur to construct and test the units individually and avoid many of the pitfalls associated with a combined unit.

It should be pointed out that the equipment is operating on an amateur band and only licensed amateurs may operate this television equipment.

This first article will outline the system used and show different ways of accomplishing the final result. Succeeding articles in this series will give details of the various component parts which go to make up the complete station.

Many of the components used are taken from surplus equipment to reduce the over-all cost. Most amateurs will have many of the parts needed and be able to hold the completed cost to a low figure. In any event the cost will be far below that of any comparable system.

This television system uses relatively common components and is capable of being built by the average experimenter experienced in the radio art. It provides a means of making a standard-definition broadcast picture of 525 lines, 60 fields, 30 frames interlaced two-to-one, having a video bandwidth up to 4.5 megacycles. In this system, for simplicity, a single transmitter sends the sound simultaneously with the video by means of frequency modulation of a 4.5 megacycle sub-carrier. The complete signal is transmitted on an amateur carrier frequency, such as 432 megacycles. Reception can, therefore, be accomplished on a standard television receiver preceded by a simple frequency converter.

The basic "picture maker" or camera used in this inexpensive system is derived from an old device used in early television experiments with ro-

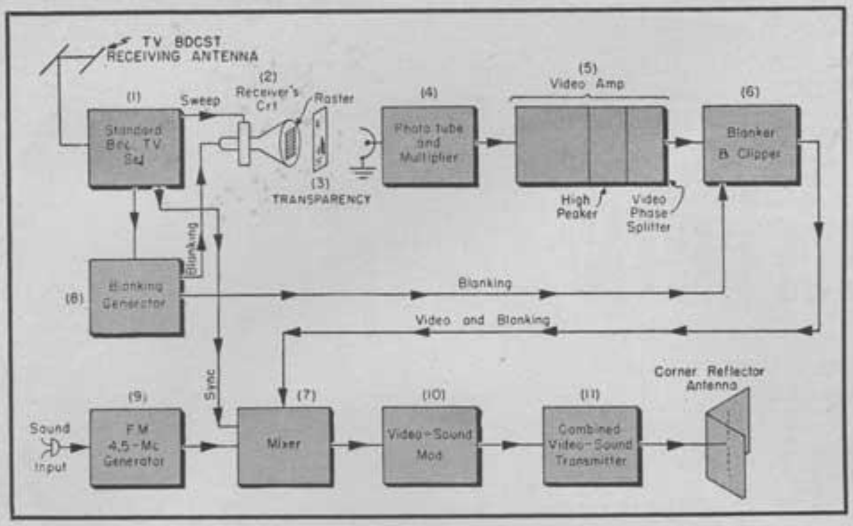


Fig. 2. Block diagram of transmission system showing functions of the units.

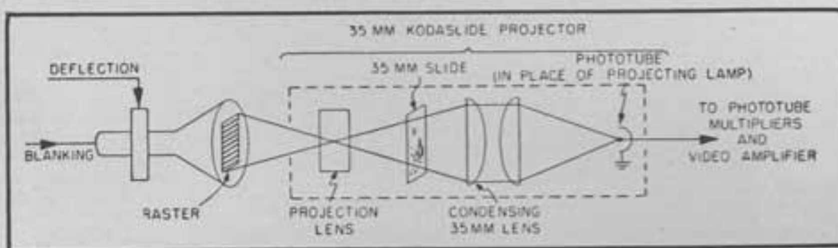


Fig. 3. Method for using cathode-ray tube as light source for 35mm transparencies.

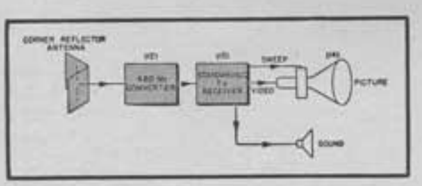
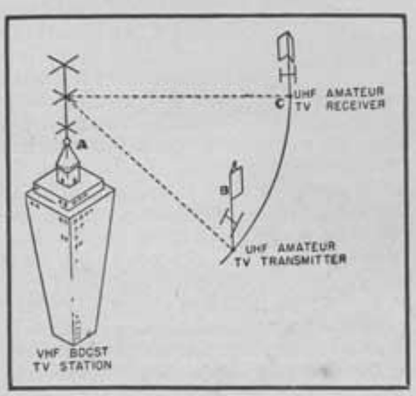


Fig. 4. A 420 mc. converter is used with a standard television set for reception.

tating discs and known as the *flying spot scanner.*

Suppose that a spot of light such as is generated by an arc lamp is fed through a rotating disc with small holes in it arranged spirally so that they progressively become nearer to the center of the disc. This means that if a scene is illuminated by this light,

Fig. 5. Diagram showing direct reception of scanning signals from a TV station.



there will be one small flying spot after another traversing the scene, each illuminating a line of the scene, and each line successively displaced, so that at the end of one revolution of the disc the entire scene has been covered. As the spot of light covers each small portion of the scene, a phototube picks up the light derived from this particular portion of the scene. The phototube current is then a video signal suitable for transmission. (At the receiver the corresponding signal is amplified and drives a source of light which can be modulated in intensity. This light is then viewed through a similar receiving disc rotating in synchronism with the transmitting disc, allowing the original scene to be observed.) This old principle is applied electronically in the modern flying-spot scanner. Instead of using the rotating disc with holes, a raster is generated on the screen of the cathode-ray tube shown as unit (2) in Fig. 2. Since the raster is produced by the motion of one dot behind the transparency, the variations of light value from point to point of the transparency are picked up by the phototube.

In the present system the transmitter uses an ordinary TV receiver altered so as to separate the sync from the received television signal from any local TV station. This sync is then used to generate the interlaced standard RMA sweeps. A block diagram of the sending end of the system is given in Fig. 2. Unit (1) is the broadcast TV set, which is standard and whose sweeps and sync-separating circuits are as normally found. It is tuned to any local TV broadcasting station. In the event that it is not possible to receive a standard TV signal, then it is merely necessary to derive the sync and blanking from the TV set's own sweep circuits. In this case the picture will often have only 262 lines non-interlaced, since the horizontal oscillator is running free. The picture retains the same horizontal resolution but the vertical resolution is reduced by a possible factor of two. For this type of operation it is desirable to sync the vertical to the 60-cycle power supply so that hum effects will be reduced.

The lead to the video amplifier from the grid of the television set's cathode-ray tube (2) is disconnected in the set and is instead connected to the blanking generator (8). (For this source (2) of the flying-spot illumination, practically any CRT can be used, including surplus P7-phosphor radar types.) In addition, the sync derived from (1) is to be used later for transmission purposes in mixer (7). The light from the raster of (2) is then passed through a transparency (3) (which is the picture being transmitted). This can be held in a slide projector holder or put directly on the face of the cathode-ray tube (2). If a slide projector is used the phototube is substituted for the slide projector light source, as shown in Fig. 3. Returning to Fig. 2, the light passing through the transparency is picked up by a phototube (4), amplified by a video amplifier (5), passed through a video clipper and blanking inserter (6), and then passed through a sync and sound sub-carrier mixer (7). The output of the mixer is fed to a combined video-sound modulator (10), which modulates a transmitter (11), and this feeds an antenna radiating the picture and sound signals simultaneously.

The receiver block diagram is given in Fig. 4. The combined picture and sound carrier is picked up by a converter (12), which includes a "cascode" (grounded-cathode triode followed by a grounded-grid triode) i.f. amplifier as its output section; it delivers an output corresponding to an unused channel of a regular standard broadcast TV set (13), where the picture and sound are separated by the normal processes.

Other possibilities lend themselves suitably to this system. In Fig. 5 the TV station *A* supplies picture and sync for the amateur television transmitting station located at *B*. If the receiving station is located along a circumference of radius *AB*, say at *C*, it becomes possible for the receiver *C* to use the sync directly derived from station *A* without having to receive sync from transmitter *B*. This means that all that is necessary to receive *B*'s transmission is to disconnect the video from the picture-tube grid of *C*'s receiver and use instead the video received from *B* over the u.h.f. link. The broadcast TV receiver at *C* is tuned to station *A* and is, therefore, scanned in synchronism.

Under these conditions reception of *B*'s picture at *C* will be accompanied by a horizontal shift or displacement of the picture proportional to the delay with which *B*'s picture arrives at *C* with reference to the sync received from *A*. For short distances this shift is small. For greater shifts recentering of the picture at *C* or adjustment of the horizontal sync phasing control becomes necessary.

This system is not limited to transparencies. It is possible to send pictures of live subjects or of fixed objects as shown in Fig. 7. The raster from the CRT is projected by a projection lens on the object, and the reflected light from the object is collected by a condensing-lens system for delivery to the phototube. The remaining operations are then just the same as with a transparency. Considerably greater light is needed than for the transparencies, and a 5TP4 or 5WP15 projection-type CRT with associated high voltage is suitable.

For sending motion pictures the setup is essentially the same as for still transparencies. A film projector has its light source removed and the phototube put in its place. A 60-cycle synchronous motor is used to drive the film sprocket and the film is run through the projector at 30 frames per second instead of 24. This speeds up the motion on the film somewhat. It is also necessary to blank the raster during the film pulldown time. More elaborate means are needed to show the film at 24 frames per second.

Since the transmitter (unit (11) in Fig. 2) sends out the picture double-sideband, a total bandwidth of nine megacycles at the transmitter is desirable. This presents no problem on 420 megacycles. However, in order to use a standard receiver advantageously it is preferable to follow the vestigial-sideband method as in broadcast practice. One TV sideband with the vestigial other sideband is obtained by the selectivity of the receiver's i.f. amplifier, resulting in reception and reproduction of standard RMA pictures. See Fig. 8. The shaded portion represents the sideband eliminated by the selectivity of the receiver. Of course in tuning up the transmitter it is also possible to adjust the tuning in such a way that one sideband is amplified more than the other—naturally the sideband to be used in the receiver should be favored.

Since the sound is transmitted as a sub-carrier, it becomes impossible to use full modulation on the transmitter for pictures as this would not allow the sub-carrier of 4.5 megacycles to be continuously transmitted. Generally fifty per-cent modulation is used for the sideband carrying the FM sub-carrier and the other fifty per-cent devoted to video signal. Changing these proportions of modulation in favor of more picture modulation will result in undesirable buzz in the sound portion of the transmission. Of course, if it is desired, a separate sound transmitter spaced 4.5 mc. can be used, or other sound not necessarily associated with a picture can be used.

Fig. 6. The original transparency (left) compared to the reproduced image (right).

The phototube used is a standard surplus 931A multiplier type. These were used in most of the radar countermeasure noise generators for radar jamming (AN/APT-5). In the noise-generator application, use is made of the extreme amplification capabilities of the tube. However, it is not desirable, in the present case, to employ enough gain to reach the noise-level capabilities of the tube, as this results in "snow" in the television picture. For convenience in handling the total of 550 volts supply potential, a positive and negative source of voltage is used. The gain control of the whole video system is obtained by adjusting the value of the negative supply voltage.

The output of the phototube is fed to a series of video amplifiers, including one stage, known as the high-frequency peaker. This peaker is necessary to equalize or compensate for the time it takes a spot of light to build up and decay, as the phosphor of the cathode-ray tube (2) does not light up or die down instantly. This corresponds to a pulse of voltage in the phototube which is exponential in rise and decay time. This is the same as saying that the pulse derived from the spot of light is deficient in high frequencies, which are then equalized by the additional high-frequency response of this stage. The desired rise and fall time of the pulse is shown in Fig. 9 by the dotted line. The actual pulse without the high-frequency peaker is shown by the heavy lines. If the peaker is used, the higher video frequencies are favored so that the dotted wave shape is obtained. This effect is produced by an *RC* network. As the condenser *C* is adjusted, the "blurs" and smears in the video picture will disappear causing the picture to sharpen up and display the detail expected.

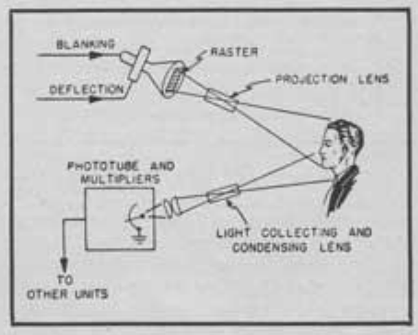


Fig. 7. Method of using cathode-ray tube as a light source for scanning live subjects.

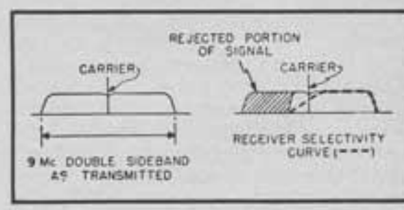
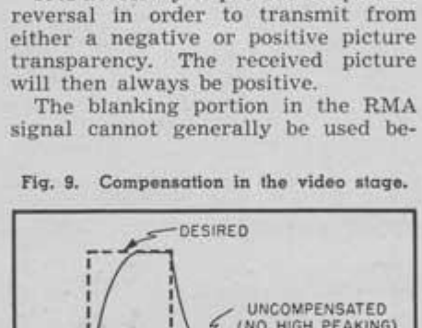


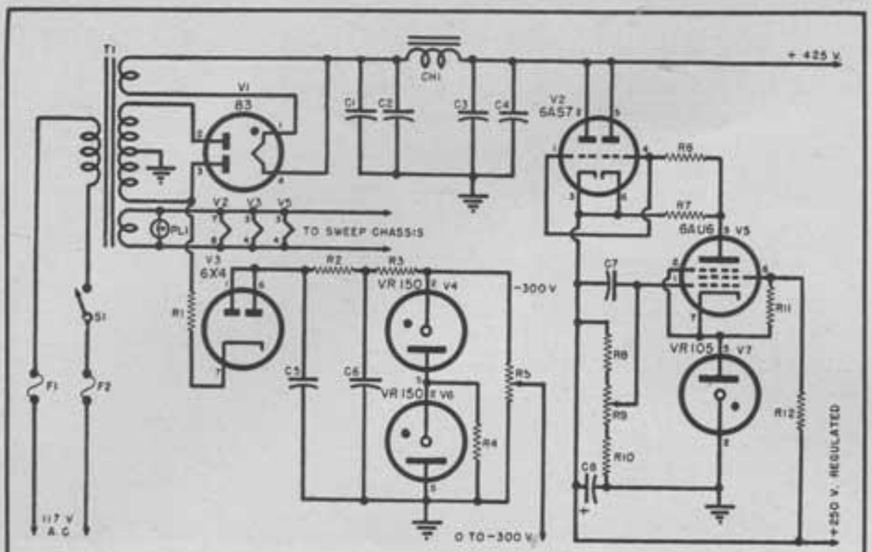
Fig. 8. The carrier as transmitted and the vestigial sideband obtained (right).

It is necessary to provide for picture reversal in order to transmit from either a negative or positive picture transparency. The received picture will then always be positive.

The blanking portion in the RMA signal cannot generally be used be-

Fig. 9. Compensation in the video stage.





R_1—4700 ohm, 2 w. res.
R_2—33,000 ohm, 2 w. res.
R_3—5600 ohm, 2 w. res.
R_4, R_7—1 megohm, ½ w. res.
R_5—500,000 ohm pot. (screwdriver adj.)
R_6—100 ohm, ½ w. res.
R_8—100,000 ohm, ½ w. res.
R_9—250,000 ohm pot (screwdriver adj.)
R_{10}—50,000 ohm, ½ w. res.
R_{11}—10,000 ohm, ½ w. res.
R_{12}—22,000 ohm, ½ w. res.
C_1—10 μfd., 600 v. oil-filled cond.
C_2, C_3, C_4—6 μfd., 600 v. oil-filled cond.
C_5, C_6—4 μfd., 600 v. oil-filled cond.
C_7—.5 μfd., 600 v. cond.
C_8—16 μfd., 450 v. elec. cond.
T_1—Power trans. 400-0-400 v. @ 250 ma.; 5 v. @ 3 amp.; 6.3 v. @ 8 amp.
CH_1—Filter choke, 6 hy. @ 250 ma., 85 ohm
S_1—S.p.s.t. toggle sw.
PL_1—6.3 v. pilot light
F_1, F_2—5 amp. fuse

Fig. 10. The regulated supply used to power all units except the r.f. section.

cause the black portions of broadcast pictures are sometimes so close to the blacker-than-black region of the composite signal that the flying-spot raster might have some unwanted black portions. However it is possible to use the horizontal sync pulses as H blanking pulses. A better way is to use the flyback period of the H and V oscillators in the receiver for deriving blanking signals. It is usually possible to find some place in the sweep circuits which already has a good pulse of the proper polarity. For example, the vertical pulse present at the output of the vertical integrating network. The horizontal blanking is easily obtained from the output of the sync separator or by taking a portion of the flyback pulse present in the horizontal deflection coils. These signals are then fed to the blanking generator where they are clipped and then fed to the flying-spot CRT grid and the video blanking inserter.

So far in our discussion, the video has been allowed to go through the video amplifier without thought of what should be done with the blanking and the sync. Actually the video is limited by superimposing on it a pulse which will shut off the picture-tube grid when the time comes for the retraces of the lines to take place. This is accomplished by adding together in unit (6) of Fig. 2 the video signal amplified by (5) and a pulse derived from the blanking generator (8). The extremity of the blanking pulse with its video superimposed is then chopped off in the same unit.

Beyond the clipped portion, the sync signals derived from the TV broadcast (or locally generated) are superimposed in mixer (7). The result is a standard RMA experimental signal capable of being received on a standard receiver without any difficulty.

The FM sub-carrier unit (9) consists of a 4.5-megacycle oscillator modulated by a reactance tube. A portion of the 4.5-megacycle output is mixed with the video and handled then in the same manner as if it were a video component.

The video modulator is a straightforward amplifier similar to the power video stage of an ordinary television set. However, it has to swing over a much wider voltage range than is required in a normal television set. The output of a 6AQ5 feeds a 6AS7G power-handling cathode follower which is used directly to modulate the transmitter. The use of the cathode-follower modulator, with its low source impedance, is especially desirable because of the high bypass and stray capacitances generally associated with the transmitter.

It is desirable to use a regulated power supply for most of the circuits associated with the video, scanning, blanking, and related circuits. For those anxious to get started, a satisfactory supply is illustrated in Fig. 11 with the schematic diagram shown in Fig. 10. Many amateurs will have a supply available which will meet these requirements.

Succeeding articles will deal with the construction of the various units and cover the tuning and adjustment. The experienced amateur will be able to make many changes in the basic design to accommodate equipment on hand.

For those who desire more power, a transmitter of the SCR-522 type will serve as a driver for a tripler furnishing an output of ten to twelve watts on the 420 mc. band.

There are several pieces of surplus equipment which operate on the 420 mc. band and if some of this equipment is on hand, many of the components may be used. Usually the receiver portion of this surplus equipment is of the superhet type with a broad i.f. system, and by substituting a front end capable of tuning to a TV station, the necessary signal for scanning may be obtained. In many cases there will be unused tubes which may be adapted to serve as the vertical and horizontal oscillators, or the video section included in the receiver may be used.

Of course operation is not limited to the 420 mc. band and the system may be used on any of the amateur bands above this frequency. The 420 mc. band was chosen as it permits the use of familiar techniques without resorting to waveguides and plumbing.

(To be continued)

Fig. 11. Photograph of the power supply of Fig. 10. Three outputs are available.