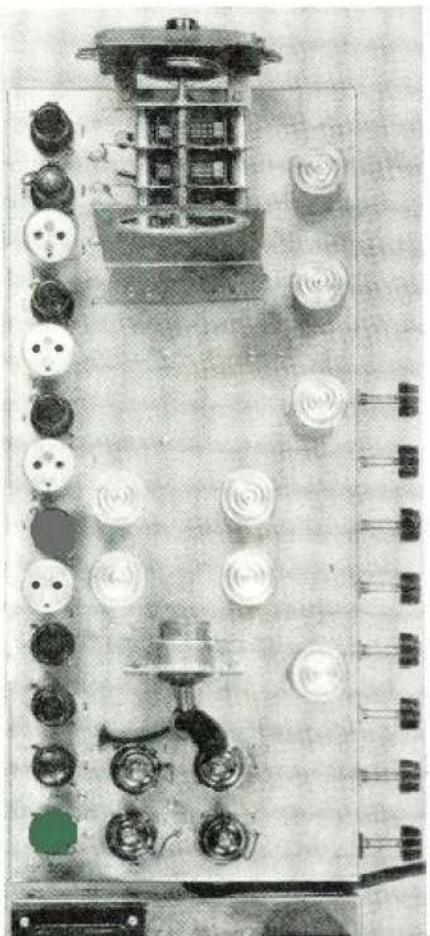
Build Your Own

TELEVISION RECEIVER



■ Top view of the television receiver as it will appear when it's completed. It will receive fine telecasts in a radius of about 30 to 40 miles from the transmitter site.

WITH television looming on the horizon an attitude of watchful waiting is being assumed by the radio public in general. But neither the ham nor general radio experimenter is the type to sit and wait for someone else to do things for him. Not so many years ago when there began to be some thought given to the possible practical value of short waves for communication and broadcasting these men didn't wait for someone else to point the way. They dug in and pioneered development. There is every chance that they are likewise going to play a big part in the evolution of television. Even the Radio Corporation of America recognized this possibility when over a year ago it made both information and special television tubes available to experimenters, and particularly to hams.

The public in general can watch and wait, and can plunge when satisfied that television is not only here, but here to stay. But how about the experimenter? Is he going to do this too, and then become a stereotyped looker in? Or is he going to dig in before that time, find out what makes the wheels go round by building his own receiving equipment, and be one of those "in on the ground floor" when the game becomes fully and finally established in the spring of 1939?

There are many experimenters whose minds are made up in favor of the latter course of procedure, just waiting for a ripe time to get going. To these a few words of suggestion may be in order to get these more hardy persons started in this field.

In this video set, which is based on the Garod Model 100, certain refinements have been avoided—refinements whose complications do not justify their advantages. It is believed by the designers, for instance, that to build the sound and video receivers in one unit would add complications not warranted by the saving in space and a few tubes that might result. Moreover, a separate receiver can be more readily used for other ranges such as the 5- and 10-meter ham bands, the u.h.f., high-fidelity broadcast stations, etc. than can one whose circuits are intertwined with those of the video receiver.

The complete circuit diagram for the video receiver and power supply is shown in the figure. These are two separate units as shown and are interconnected by means of cable and plug.

The first six tubes constitute the superheterodyne receiver and include one r.f. stage, combined oscillator-mixer, 3 i.f. stages and diode detector. This differs in a number of respects from conventional broadcast superhets. First of all, every r.f. and i.f. circuit must be capable of passing a tremendously wide band of frequencies which constitutes the video signal. Even where only a single side-band is transmitted the receiver circuits are called upon to pass a band approximately 2500 kilocycles wide or more. This is accomplished by heavily loading the tuned circuits of both r.f. and i.f. with resistors as shown at R1, R6, R10, etc. The r.f. and i.f. tubes are all of the new ultra-high frequency type developed especially for television use. These tubes provide high gain at these frequencies — gain comparable with that obtained at lower frequencies from the 6K7, etc.

The tuning range is approximately 39 to 63 megacycles, and the intermediate frequency 12 megacycles. The receiver is designed to receive pictures from stations using the R. M. A. standards of 441 lines, 30 pictures per second with interlaced scanning. It can be adapted to other standards by alteration of the sweep constants.

The first and second video amplifiers (1852 and 6V6G) function like the audio amplifier in a sound superhet except that they must be capable of passing a wider frequency range. There is also the difference that the signal as amplified by these tubes contains not only the picture modulation, but also the synchronizing impulses by means of which the viewing process at the receiving end is kept in exact step with the scanning operation at the transmitter. There are two groups of impulses, one controlling the horizontal sweep and operating at 13,230 cycles per second, the other the vertical sweep, at 60 cycles per second.

These three components must be separated at the output of the 6V6G so that each can perform its individual function. The image signal is fed to the control grid of the 2005 cathode-ray tube where it varies the brilliance of the spot of light on the end of this tube, thus providing just the right degree of light or shadow for each small element of the image as it is built up. [See Introductory Television Course in this issue.—Ed.]

The scanning impulses are of greater voltage amplitude than the picture signal and are separated from the latter by means of the 6H6 diode just to

For those living within a short radius of the transmission of television pictures, this fine receiver will give entire satisfaction with a large, clear and distinct image reproduction.

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the right of the 6V6G video amplifier. This diode is biased by means of the potentiometer R36 so that it passes current only voltages above a predetermined level appear in the output of the 6V6G. Thus by adjusting this level (by means of R36) to a point somewhat higher than the picture signal output the synchronizing impulses are separated from the picture signal and cause current to flow through the 6H6 corresponding to the synchronizing impulses. Then by means of properly proportioned circuits, the high-frequency and low-frequency synchronizing impulses are separated, the former being fed to the control grid of the high-frequency sweep oscillator and the other component to the low-frequency oscillator.

These two oscillators each utilize two tubes in a multi-vibrator arrangement, the circuit constants of which are adjusted to approximately the desired frequency. Then when the synchronizing frequencies are impressed on their grids, they lock in at the impressed frequency exactly. Their outputs, taken off at the cathode circuits of the 6F8G's are fed to the deflection plates of the cathode ray tube and thus control the horizontal and vertical movement of the electron beam which traces the picture on the sensitized end of this tube.

Separation of the synchronizing signals after rectification in the 6H6 is accomplished through selection of the proper resistance-capacity filter values. C32, having a value of only .00001 mfd. will not pass the low-frequency signal but will pass the high-frequency impulses to the grid of the high-frequency oscillator. The low-frequency impulses are readily passed by C31 to the grid of the low-frequency oscillator but the high-frequency impulses are blocked out of this circuit by the high resistance of R34. Thus complete separation is effectively obtained.

The cathode-ray tube employed is one of the 5-inch type in which the image has a greenish tint. Tubes which provide a black and white image can be used but have the objection that for given anode voltages the images are less brilliant, which is another way of saying that for equally brilliant pictures the "green" tube is less expensive.

All voltages for the cathode-ray tubes are provided by the 879, high-voltage supply. The 5Z3 supply takes care of all other tubes.

Referring to the top view, the tube line-up beginning with the 1852 r.f. stage corresponds exactly with the left-to-right arrangement of the tubes in the figure. The four sweep oscillator tubes are those grouped at the end of the chassis. The cathode-ray tube mounts horizontally above this chassis, being supported by its socket and a large bracket just behind the variable condenser gang.

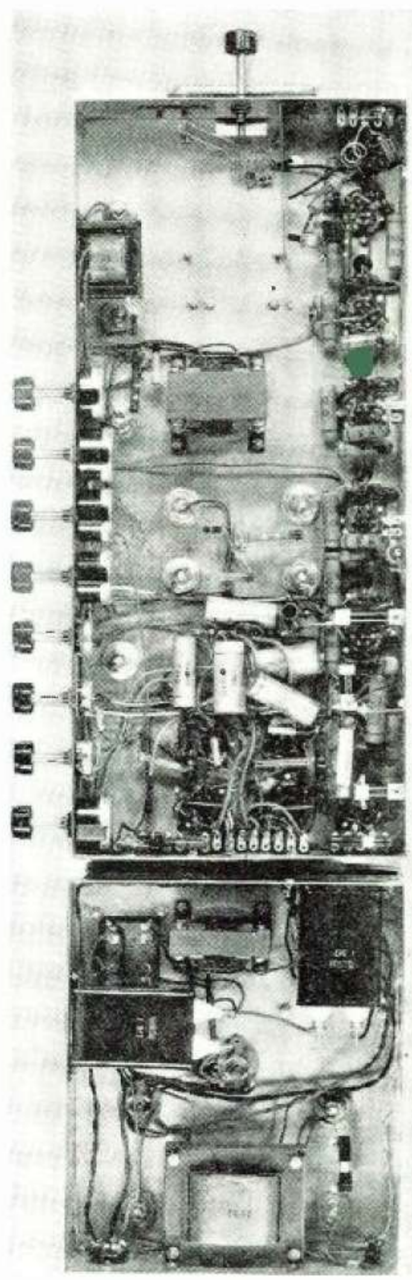
Considering the front of the chassis as the end on which the tuning condenser is mounted, the controls along the left-hand side, from front to rear are: i.f. gain (contrast), vertical (low-freq.) sweep, horizontal (high freq.) sweep, synch. separator bias, vertical centering, horizontal centering, focus, cathode-ray tube bias (brilliance).

As will be seen from the foregoing, the construction is straight-forward and is well within the ability of the experimenter who has had an appreciable amount of experience with radio construction. The building of this equipment is *not* recommended for the novice, or for one whose technical background is not sufficient to provide an understanding of the principles utilized in television circuits. A television receiver necessarily involves a considerable amount of technical complication but is well within the ability of anyone who has a fair understanding of the principles of operation of other modern radio equipment, and who is willing to devote a little study to the fundamentals of television. A more complete discussion of television theory and practice will be found in (1) two comprehensive volumes entitled *Television*, published by the R C A Institutes Technical Press, 75 Varick Street, New York City, and (2) in the extremely simple comprehensive television course appearing in this publication.

So, for the experimenter who is "rarin' to go" it is believed that this set provides the means, and will be productive of real results in actual on-the-air operation. In addition the job of constructing and adjusting the finished receiver will provide first-hand experience which will prove invaluable for the man who looks on television as an opportunity to get into an unquestionable coming field of business activity.

Construction Hints and Data

The antenna primary L16 is connected to the Dipole (or other type) antenna through a twisted pair. The secondary is tuned to the carrier fre-



■ While the connections may seem complicated, they are not; and the set is easily assembled by following the excellent instructions and routine suggested by the author. Careful construction makes good pictures.

quency by the first section of the three gang condenser, and is fed into the grid of the 1852 R.F. amplifier. The plate circuit feeds through inductor L2 as a plate load into the control grid of the 6K8 converter (through the .0001 mfd. coupling condenser). The oscillator is of the Hartley type, although the elements have been used in a somewhat unconventional manner. Note that the oscillator plate (No. 6 pin) is not used. It was found that better stability was obtained with the circuit as shown, than with the conventional arrangement. The converter is followed by three I.F. stages operating at 12 M.C. The 6H6 is used as a diode detector in the usual way. The two chokes L8-L9 together with the .00003 mfd. condenser serve as a filter to remove the I.F. component from the *video* channel. The 1852 and 6V6 act as 1st and 2nd *video amplifiers* respectively for the picture signal. A single 1½ volt cell such as is used for Pen-Lite flashlights supplies the "C" bias for the 1852 first video stage. This cell will last for a considerable period, since no current is drawn. The output of the 6H6 is connected to the control grid of the cathode ray tube as well as the *synch. separator*.

The sweep circuit oscillators are of the multi-vibrator type, are very stable in operation, and can be readily controlled by the *synch.* pulses, which are introduced into the respective grids of the 6L7 tubes. Both sweeps utilize the same circuit arrangement, except of course, that different constants are used for the horizontal *(high)* and vertical *(low)* sweep frequencies. The saw-tooth waves generated in such a multi-vibrator, are, if no compensating means is used, logarithmic in form. Chokes L12 and L13 are therefore inserted to correct this deficiency and produce a saw-tooth, substantially linear, so that the electron beam is carried across the tube at a uniform rate.

The synchronized saw-tooth pulses are then fed to the two sets of deflecting plates to scan the face of the picture tube by means of the electron beam emitted by the electron gun in the neck of the tube. This beam is in turn modulated (through the control grid) by the picture impulses obtained from the output of the 6V6.

Means are provided for centering the picture by varying the fixed positive potential on the two sets of deflecting plates. Other controls focus the beam by changing the potential on the focusing electrode (R59) and adjust the bias on the cathode ray tube (R56) to set the average brightness, (*contrast*).

Assembly and Wiring

The assembly of the component parts may be seen from the photographs and diagrams. All parts should be assembled as shown and checked against the circuit diagram to prevent any possibility of error.

Note that the end of the shield on the underside of the chassis is soldered to a lug fastened under one of the screws on the gang condenser.

Coils L1, L2, L3, and L16 are wound with No. 16 bare wire. A ½" diameter form is used and removed after winding. Turns are spaced approximately ⅛". The number of turns is indicated in the diagram.

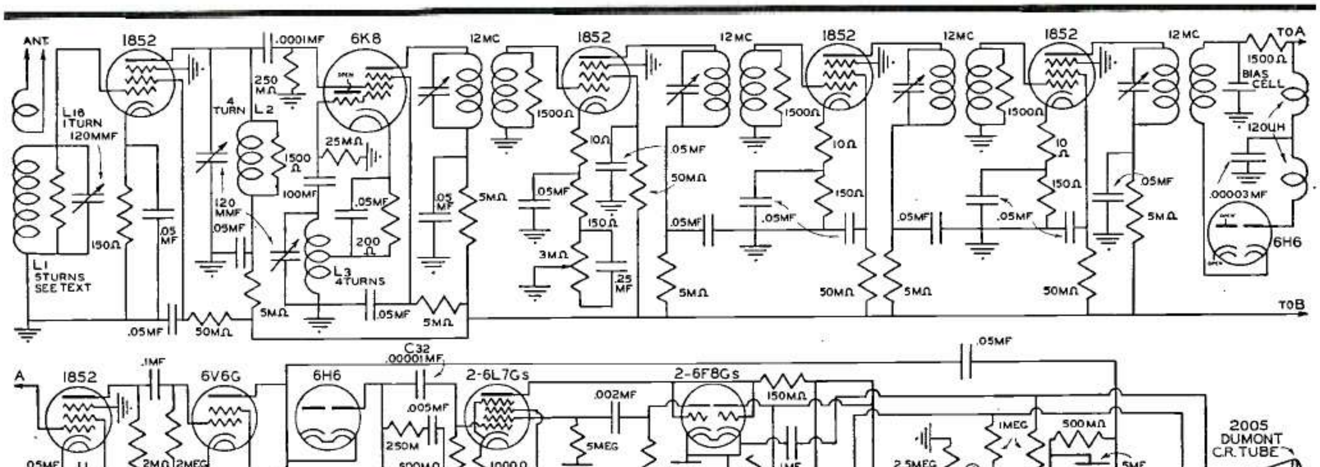
It is important that the wiring shown in diagram be followed carefully. As each wire or component is put in, it should be checked off. The grounds and heaters should be wired first, then the various B voltages, i.f. transformers; then resistors, mica and tubular condensers. All wiring should be as short and direct as possible. Particular care should be taken in wiring the *video amplifier* to avoid high grid or anode capacities to ground, since this will result in a loss of high frequencies with consequent poor detail. This applies especially to leads from the Diode detector to the 1852 and coupling condenser from 1852 to 6V6 as well as wiring from L11. These should be lifted away from the chassis ¼ to ½ inch. Do not fasten the *grid lead* from the picture tube to the chassis or wrap it around the other leads in the cable.

CAUTION

Approximately 1400 volts is supplied to the high voltage Anode. This voltage should be treated with great respect, since under certain conditions it may be DANGEROUS. Be sure that the power switch is OFF or better still, remove the line cord from the outlet, when making any changes, or touching any parts, other than the control knobs.

With a high resistance (1000 ohms per volt) voltmeter, measure all voltages, with respect to the chassis. Results should be approximately as tab-

(*Synchronize further on page* 64)



Circuit diagram of the home-built television receiver.

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Television Receiver

(Continued from page 24)

ulated. Variations will occur due to line voltage conditions and tubes. If there is any substantial deviation in voltage from that given in this table, ascertain the reason, and correct it before proceeding further, or damage to tubes or other parts may result.

WARNING

Be sure that the Voltmeter prongs are well insulated and use great care in making these measurements to avoid shock from the High Voltage supply.

Alignment and Operation

Set the picture tube bias control (No. 1) all the way to the right. Set the horizontal and vertical sweep (Nos. 6 and 7) controls half way.

Now turn the spot locating control (No. 3) all the way to the left and rotate the other spot control (No. 4) through its entire range. If neither a spot nor a *raster* (the scanning pattern) appears, move the first spot locating control (No. 3) slightly to the right and rotate the other locating control through its entire range again. Continue this procedure step by step until something appears upon the viewing screen of the C-R tube.

Now adjust the vertical and horizontal sweep controls until a complete *raster* appears. This should be approximately 4" square (the actual picture will be somewhat smaller due to the presence of the blanking and sync pulses in the station carrier).

By means of the spot location controls (Nos. 3 and 4) this pattern may now be centered on the tube face.

The size of the picture is determined by two factors, namely: the sweep circuit voltage and the voltage applied to the second anode. The picture increases with increase in sweep voltage and decreases *inversely* as the square of the second or high voltage anode potential. The saw-tooth voltage developed by the multi-vibrators is a function of the "B" voltage applied to the plates. Since we are operating near the voltage limit of the 5Z3 rectifier tube, it is impractical to obtain any improvement in this direction. Amplifiers could be used to increase the sweep voltages, but this would complicate matters greatly. The other alternative is to reduce the 2nd anode voltage. Referring to the circuit diagram, a 100,000 ohm (R66) dropping resistor is indicated in series with the low voltage filter system. This results in a larger picture, at only a slight sacrifice in brilliance. The use of this resistor is optional, depending upon which characteristic is the more desirable.

The image ratio should be 4:3. If the picture does not conform to this ratio, a rearrangement of resistors in the sweep plate and screen circuits will correct this. Potentiometers could be inserted to control the voltages applied to the deflection plates, but these additional controls are hardly necessary, since once this adjustment is made, it need not be changed, for a given set of tubes.

After this has been satisfactorily checked, we may proceed to the i.f. amplifier adjustments. An output meter or preferably an oscilloscope is connected across the output of the video amplifier (6V6 plate). A signal from a signal generator or equivalent source is now introduced at the converter grid (6K8). The intermediate frequency is 12 mc. The i.f. transformers are now adjusted for maximum output in the conventional way.

Now introduce a signal, whose frequency is approximately that of the principal station to be received, into the antenna circuit. Tune this signal by rotating the dial, then align the antenna and r.f. circuits for maximum output by means of the trimmers on the variable condenser.

After this has been done, the receiver is ready for a test on the air. It is best to make adjustments on the fixed pattern transmitted by television stations during test periods preceding the regular scheduled programs. The i.f. system should now be readjusted by staggering the peaks to accept a wide band of frequencies (2 megacycles). This will result in considerable improvement in picture detail, with relatively slight loss in gain.

The i.f. transformers are heavily loaded (with 1500 ohms across each secondary). It is possible to omit these, with an increase in gain if they are carefully realigned so as to stagger the peaks, with a resultant "square top" resonance curve over the band.

The r.f. circuits should now be realigned for best tracking. It may be necessary to adjust the r.f. coil inductances slightly to obtain the proper range and tracking. If necessary the end plates of the variable condenser may be bent to accomplish this.

About 20 volts at the control grid of the cathode ray tube is necessary in order to obtain a good picture. If everything is functioning properly this should be easily obtained from stations within range. This can be checked with a vacuum tube voltmeter or calibrated oscilloscope.

A little experience will enable the user to tune in a station quickly and clearly. Proper manipulation of the controls is important, and the function of each should be studied carefully and thoroughly understood.

T_1—*1500V. Power transformer 8C12*
T_2—*Rcvr. power trans. 8K93*
L_{15}—*Rcvr. Filter choke 20H No. 1 L 11 R*
L_{14}—*Hi-Voltage filter choke 1000H No. 1 F45R*
L_{13}—*Low frequency sweep choke 2000H No. 1 F47A*
L_{12}—*High frequency sweep choke 300H No. 1 C42J*
L_{11}—*R.F. Choke—50 MH*
L_{10}—*R.F. Choke—55 MH*
$L_{8,9}$—*R.F. Choke—120 MH*
$L_{1,5,6,7}$—*I.F. Transformers—12 M.C., U100*
SIZES:
C—21, 23, 25, 28, 30, 33, 34, 39, 46, 47, 48—*525V. Peak net electro.*
C—44, 45—*2000V. (J347)*
C—41—*1000V. (J345)*
C—37—*1000V. (J344)*
C—42, 50—*2000V. (J346)*
C—40, 43, 26, 5, 7, 9, 10, 12, 14, 15, 17, 18, 20, 22, 24, 27, 29, 49—*400 volts.*
C—51, 4, 13, 16—*200V.*
C—35, 36, 8, 52, 19, 31, 32, 38—*Mica*
C—1, 2, 3—*3 gang variable*
R—64, 36, 52, 56, 44, 61, 62—*Wire wound pots.*

—30—