(PART 1)

How To Build A 441 - Line T. R. F. TELEVISION RECEIVER

I HAVE just completed field tests on something new in television receivers. The new feature is that it actually works! The set was assembled from parts which are obtainable at any radio store, and the whole work of constructing the receiver took only about 72 hours. The set functioned on its first trial, but a few minor adjustments were necessary in order to get a degree of perfection comparable to that of the commercial receivers now produced.

The receiving circuits of the set are merely modifications of standard practice and should present no unusual problems for the experimenter. The cathode-ray tube unit, low and high frequency sweep circuits and synchronizing impulse separator are here illustrated. This first article will describe the construction of the cathode-ray unit and will include the easily constructed power-packs, which may as well be constructed immediately and placed to one side to be ready for use as the set progresseses. One power-pack must deliver an output of 3000 volts for various anode voltages of the cathode-ray tube. The first anode voltage of 500 volts comes from a voltage divider in the bleeder circuit of this power-pack. This control should be insulated from the chassis for the full 3000 volts. A bakelite coupling unit should be inserted between the shaft coming to the front of the panel and the shaft on the potentiometer. (Refer to photograph Fig. B.) The power-pack is simply a well filtered 300 volt unit for supplying the operating voltages of the receiver and sweep circuits. Two standard 17"x12"x3" pans are hinged together and form a completely shielded compartment for both power supplies. It might be well to mention that great care should be taken in assembling the high voltage power-pack; no leads should be exposed, as these voltages are dangerous should one accidentally get in contact with them. Photographs show the approximate placement of parts and no difficulty should be encountered in wiring these power-packs. Standard automobile spark plug cable should be used for the output of the high voltage leads in the 3000 volt unit.

The standard 300 volt pack is the usual type of power supply one would build for a standard broadcast receiver

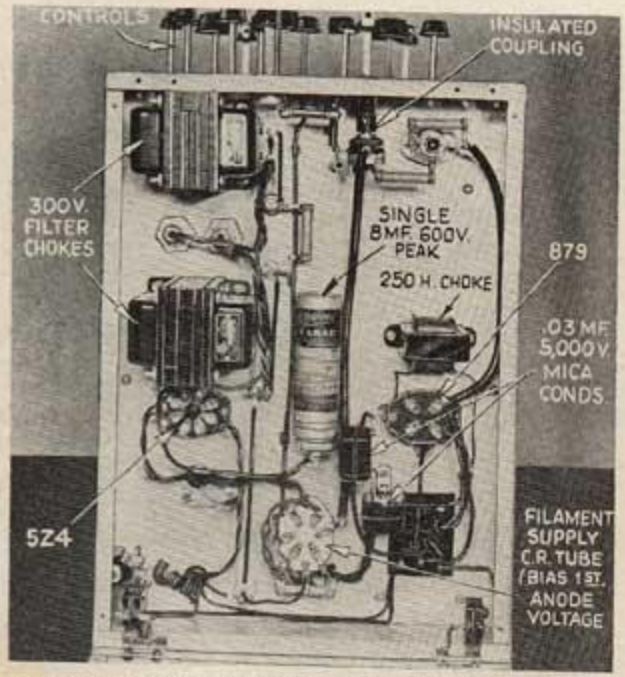


Fig. B. Under view of top power-pack pan. The under pan, hinged to it, is used only as a support and shield.

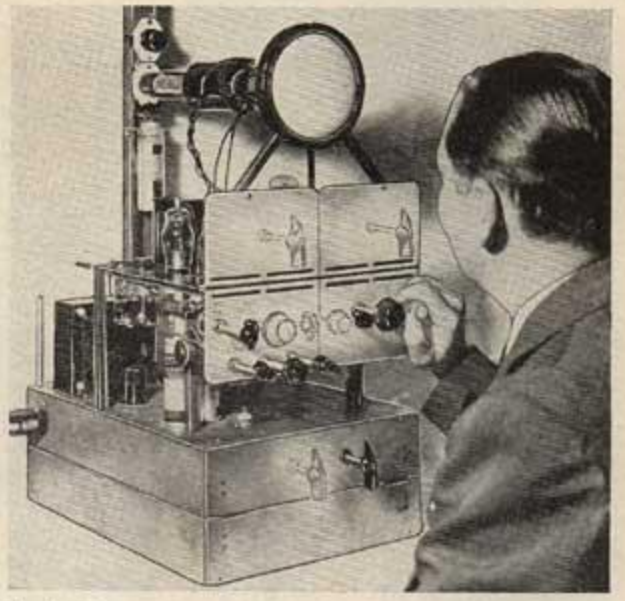


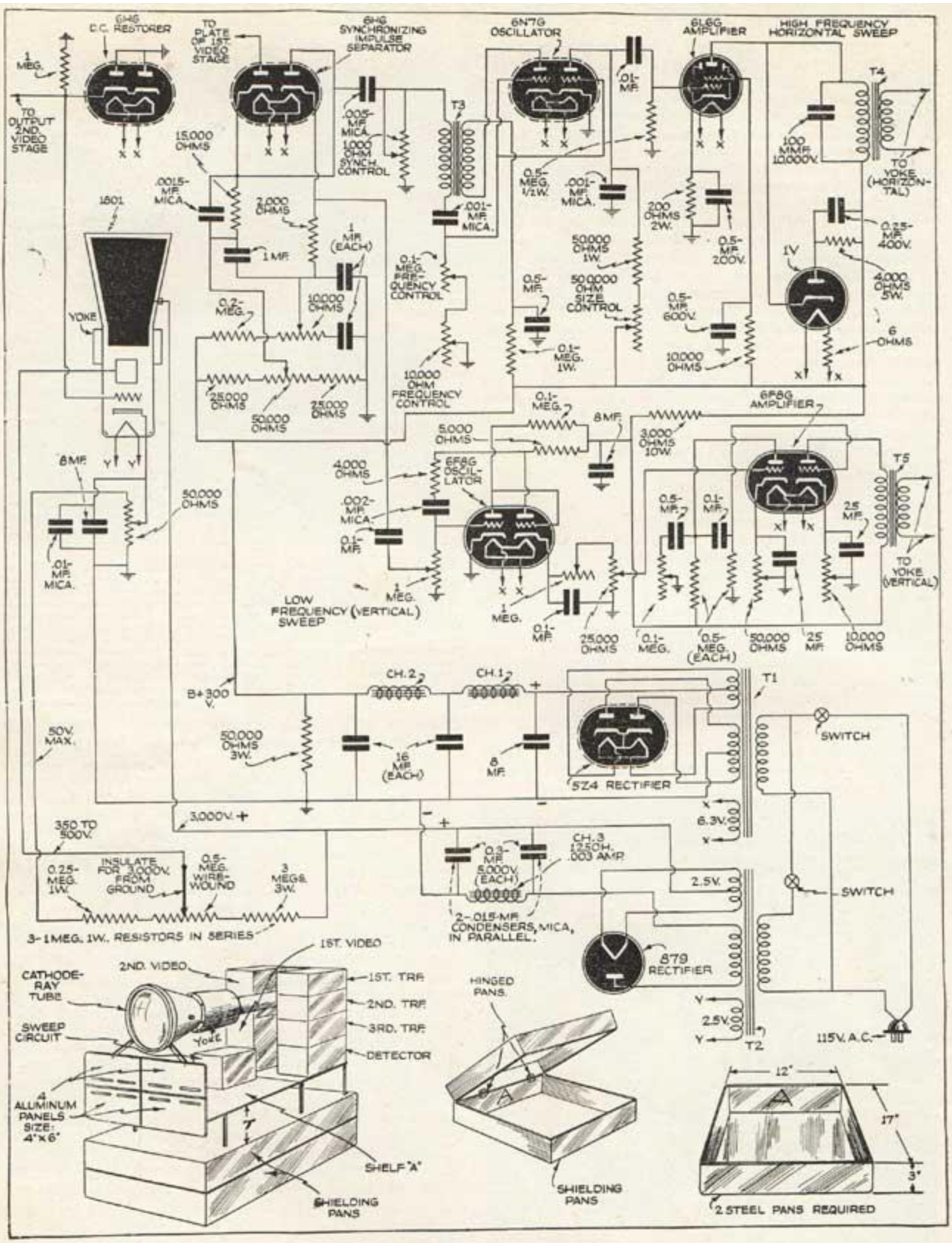
Fig. A. The controls, left to right, are:—Top pair, Low frequency (vertical) synchronizer input*, and High frequency (horizontal) synchronizer input*. Next row, Low frequency sweep control, L.F. size control*, L.F. synchronizing separator*, High frequency synchronizing separator*, H.F. speed control, Vernier for same, and H.F. size control*. Third row, Bias on right hand section of 6F8G*, Peaking (60-cycle) control, and Bias on left hand section of 6F8G*. Bottom pair, brilliancy control for C-R tube, and 1st Anode voltage control for C-R tube. Controls marked *(shown in phantom), may be slotted shafts, and need not be brought out through panel; once set, they may be left without further adjustment until receiver is moved to new location.

delivering 125 milliamperes, with the possible exception that 16 mf. are used instead of the usual 8 for filtering.

A number of experiments have been made to determine the simplest form for the sweep circuits, synchronizing separators and power units, and it was found that each item described in this constructional article was fool-proof, easily adjusted and highly satisfactory in performance.

Of the several types of sweep circuits that are used in sweeping the spot of the cathode-ray tube across the fluorescent screen, it has been decided that for the low frequency sweep, the multivibrator type (as suggested by Bedford & Puckles) is the most stable and easily constructed. Two 6F8G tubes (of the dual type) are used, as will be noted from the schematic diagram. One tube is so connected that it forms a resistance-capacity coupled type of amplifier with feed-back to make this circuit oscillate. The second tube is used to amplify these sawtooth impulses. The output of this amplifier is connected to the yoke through the output transformer. The high frequency oscillator circuit uses three tubes—the first tube, a 6N7, is so connected as to form a blocking type oscillator; the second tube is 6L6G and is the output tube. A type 1V, operated at 5 volts, absorbs the circuit shock excitation oscillation produced by coupling the yoke with the output transformer and reflecting back the spurious oscillations in the plate of the 6L6. This tube smooths out the sawtooth impulses so that they are of the proper wave form when applied to the deflecting yoke.

Both of these sweep circuits are designed to give sufficient sweep for either a 5 in. or 9 in. tube. The synchronizing impulse separator is used to separate the synchronizing impulses transmitted, from the picture impulses. These occur once for every line of the sweep in the horizontal direction and once for every frame of the picture in the vertical direction. A 6H6 type tube is used for this purpose. Another 6H6



Schematic diagram of the 441-line T.R.F. Television Receiver and complete dimensions for building the 2 required steel pans. The layout of all the main components is also shown.

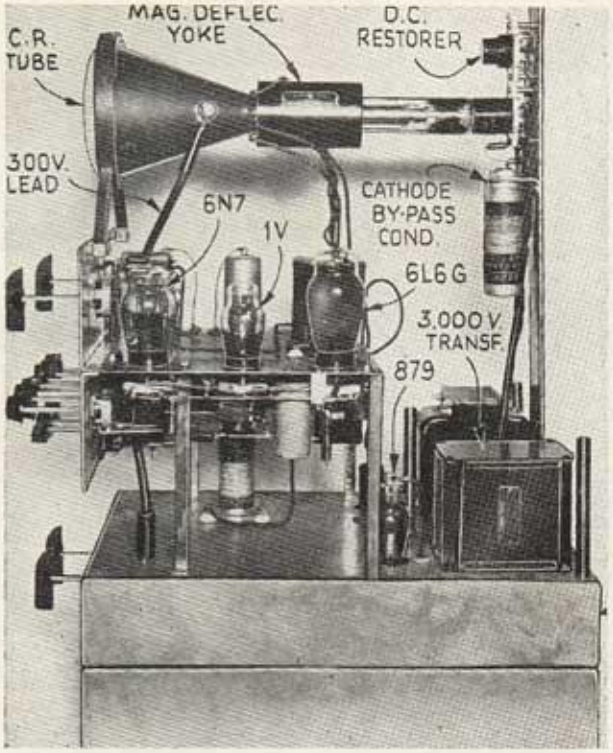


Fig. C. Right-hand view of assembly. The R-F stages are mounted beside the rear panel which supports C-R tube. The heavy lead from the pan to the C-R tube is the 3,000-V. lead.

type is used for the D.C. restoring circuit. This tube establishes the background level of the picture and is mounted directly above the cathode-ray tube socket, as shown in photograph Fig. C. In photograph Fig. D on the left side, are assembled the low frequency sweep circuit and the synchronizing impulse separator. The right-hand side of the photograph shows the high frequency circuit. This unit is mounted on the upper pan of the power-pack chassis, as shown in the photographs. Great care should be used in wiring these circuits, due to the dual type tubes used in them.

A list of standard parts is given at the end of this article, and the values given should not be deviated from.

Assuming that the constructor has completed the television receiver thus far described, the unit can be tested, and no difficulty should be experienced in forming a pattern on the face of the cathode-ray tube, which has an aspect ratio of 3 to 4. The picture can be used either as a square or stretched out beyond the end of the tube, filling the complete face of the 5 in. cathode-ray tube.

If this unit has been correctly constructed, you will see a pattern on the face of the cathode-ray tube, consisting of a great number of horizontal lines. This pattern can be stretched **vertically** and **horizontally** by adjusting the size control. Should this pattern fail to appear, some mistake has been made in the wiring of the sweep circuit and careful check will disclose where the trouble lies.

If the 1V tube is taken out of the socket, a bright vertical line should appear in the rectangle scanned on the face of the cathode-ray tube, showing that the saw-tooth current in the yoke is not linear, due to the spurious oscillation present.

LIST OF PARTS REQUIRED THUS FAR

RCA (Tubes)

1—1801 5" cathode-ray tube
1—879 rectifier

Electrolytic Condensers

AEROVOX

1—8 mf. 600 V. Peak
1—8 mf. 200 V. Peak
3—8-8 mf. 525 V. Peak
2—25 mf. 50 V. Peak

Fixed Condensers

AEROVOX

Paper	(Mica)
1—.25 mf. 200 V.	1—.0015-1000 V.
3—1.0 mf. 400 V.	1—.0001-10,000 V.
3—.05 mf. 600 V.	2—.001-1000 V.
2—.1 mf. 400 V.	4—.015-5000 V.
3—.5 mf. 400 V.	2—.005-500 V.
	1—.01-500 V.

Variable Resistors

I.R.C.

2—1.0 meg
1—1000 ohm
1—500,000 ohm
3—10,000 ohm
2—50,000 ohm
2—100,000 ohm
1—25,000 ohm

CLAROSTAT

1—50,000 ohm (wire)
1—500,000 ohm

Sockets

HAMMARLUND

7—8-Prong Isolantite
2—4-Prong Isolantite
1—5-Prong Isolantite

PAR-METAL

2—Chassis 12" x 17" x 3"

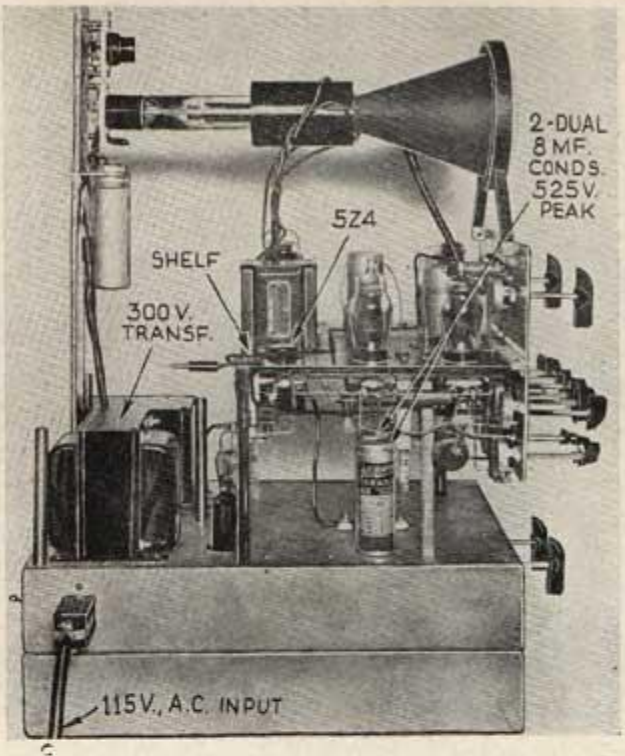


Fig. D. Left-hand view. The video amplifier attaches to the rear panel on this side.

Fixed Resistors

I.R.C.

½ Watt	1 Watt	3 Watts	5 Watts
1—1 meg.	2—100,000	1—200	1—3500
2—.5 meg.	1—200,000	1—10,000	1—4000
	1—500,000	2—2000	
	2— 25,000	1—50,000	
	1— 15,000		
	1— 50,000		
	1— 4,000	1—6.0 ohm wire	

Transformers and Chokes

RCA
1—Trans. 9835

STANCOR
1—P5059 trans.
2—C1412 chokes

THORDARSON
1—T29C27 choke

KENYON
1—T203 trans.
1—T11 trans.
1—T112 trans.
1—T700 deflecting yoke

RAYTHEON (Tubes)
1—6L6G
1—1V
1—6N7G
2—6F8G
2—6H6
1—5Z4

Hardware & Miscellaneous

2—½" x 1" hinges
1—115 volt outlet plug and cord
1—Bakelite ring 5¾" diam. ½"wide
2—½" x ½" x 3¾" brass
1—¼" x 2" x 20" aluminum
1—Bakelite ¼" coupling and shaft
Angle brackets
Assorted 6-32 and 8-32 screws and nuts
2—115 V. toggle switches
4—½" x ½" x 7" brass posts (tapped both ends) (8-32)
4—½" x ½" x 4¾" brass posts (tapped both ends) (8-32)

ALCOA
4—Brackets 4" x 6" ½" bend
1—10" x 12" 16 gauge (iron) sheet (or aluminum)

● THUS far our description was of the cathode-ray tube mounting together with the D.C. restorer circuit, the synchronizing separator, two power-supplies, and the vertical and horizontal sweep circuits for a T.R.F. (tuned radio frequency television receiver.

There follows a description of the tuned radio frequency circuits, the detector, the video amplifier and a suitable antenna system for this receiver.

The reasons for choosing a T.R.F. receiver for television are obvious.

1. Simplicity of construction.

2. Broad frequency response (2,500,000 cycles side-bands must be passed for maximum detail of the transmitted image, according to present day standards).

3. Minimum number of tubes and associated apparatus.

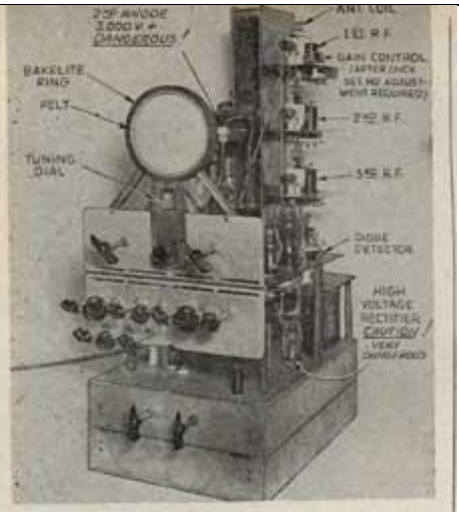
4. Freedom from complicated alignment procedures.

5. Last, but not least, lower cost to the constructor.

Three R.F. Stages

The radio frequency section of this receiver consists of three stages of amplification, using the special television amplifier tubes designated as type 1851, which have a very high mutual conductance, namely 9000 micromhos, as against 1200 to 1800 for a similar tube used in short-wave and broadcast receivers; yet the inter-electrode capacities are reasonably small.

Here is a word of caution on using

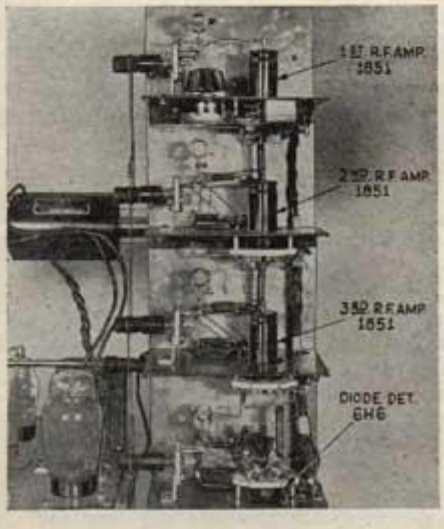


The finished chassis—ready for a cabinet and a visual broadcast.

the 1851 tubes. Under no circumstances must these tubes be used in a horizontal position, as the close spacing between the elements would surely cause trouble due to these elements sagging and touching one another.

Each R.F. stage is thoroughly shielded, preferably in copper or brass. Aluminum may be used, but because of the difficulty in soldering it, the shielding is not as effective.

The circuits used differ from the usual T.R.F. receiver only that each stage is broadened out by "swamping" a fairly low resistor across the tuned circuit in order to pass the unusually broad frequency band previously mentioned. Great care must be taken in the physical "layout" of the components so that every lead is as short as possible. By way of mention, no wire need be purchased for wiring the R.F. and V.F. circuits other than the filament, ground and B+ leads for the various tubes. The leads of each resistor and condenser serve satisfactorily for connectors, and in many instances these leads should be cut much shorter. Too much



Side view of the R.F. stages. Note the careful interstage shielding.

emphasis cannot be stressed in using the very **shortest** leads posible.

Another very important factor to remember is to run all ground leads to one point in each shield, and then solder this point to a wire which runs down through all the shields on each side and connects only at **one** point on the chassis. In other words, there will be one wire from each stage (R.F., detector, and V.F.) running to one point of the chassis somewhere in the lowest compartment of the assembly, and there grounded to an actual ground.

"Ground loops" are the greatest "bugaboo" in the construction of T.R.F. ultra short-wave receivers. Great care should be exercised to avoid them. In some cases, where oscillation of one or more of the R.F. stages is encountered "by-passing" the filament leads or inserting a small R.F. choke in series with each filament lead will remedy the trouble. (See Fig. 1.)

Mica condensers are used throughout the R.F. detector and V.F. circuits for bypassing. Where paper condensers are imperative due to the large capacity required, these should be shunted with a mica condenser no smaller than .005 mf. The reason for this procedure is that at these very high frequencies, mica condensers have the least inductance. Therefore, the high frequencies will be by-passed while the paper condensers will take care of the lower frequencies. The total gain of the receiver is governed by the biasing resistor of 1500 ohms in addition to the regular bias of 175 ohms in the cathode of the first R.F. stage.

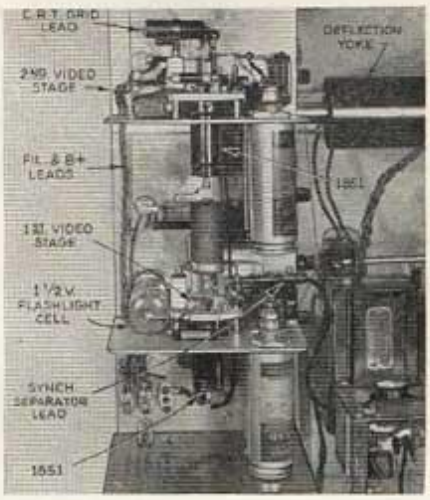
Detector

The detector is a diode of the 6H6 type, similar to the detectors used in broadcast receivers, with the exception that only one section is used in order not to load up the circuit with too much "shunting" capacity, and thus lose some of the very high video frequencies. The plate resistor of this tube is in series with a small choke which, with the reflected capacity of the succeeding tube, "boosts" the response at the highest frequency to be amplified and still keeps the phase change down to negligible proportions. This procedure is followed in the two succeeding video stages. (See Fig. 2 and the schematic diagram.)

Video Amplifier

The video amplifier also uses two of the special television steep slope pentodes designed expressly for this purpose. This amplifier must pass frequencies from 30 cycles to 2.5 megacycles and amplify these frequencies equally, with negligible phase displacements.

The data furnished with these tubes recommends that a cathode resistor of at least 150 ohms be used as bias. At radio frequencies, this resistor can be by-passed without the least bit of degeneration or phase change, but when we encounter this problem at a frequency of 30 cycles, it would require a



Side view of video stages. A flashlight cell provides hum-free biasing.

by-pass condenser of at least 1000 microfarads. Even at the low voltage used, it would be quite a large condenser physically, and therefore, instead of the usual cathode biasing, a small 1½-volt dry cell was chosen for the bias of these tubes, shunted by a .01 mf. mica condenser. This eliminated all problems of phase change and degeneration at this frequency; and in the end, it is more economical.

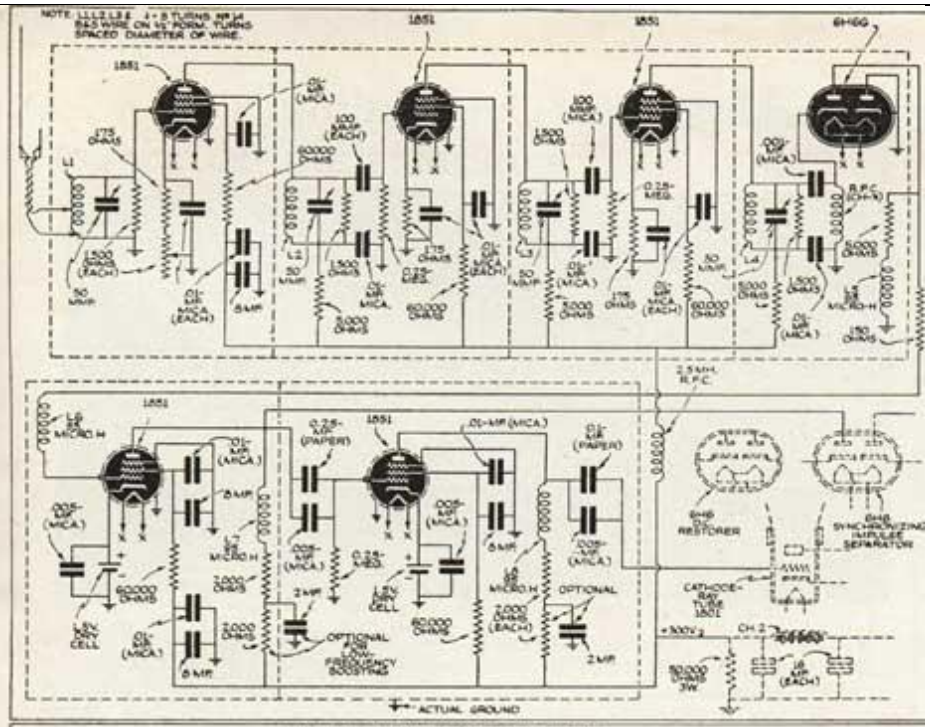
By studying the photographs accompanying this article, the reader will notice that the physical "layout" of the R.F., detector and the video amplifier makes for extremely short leads between stages and, at the same time, looks well and functions better than would a less compact layout.

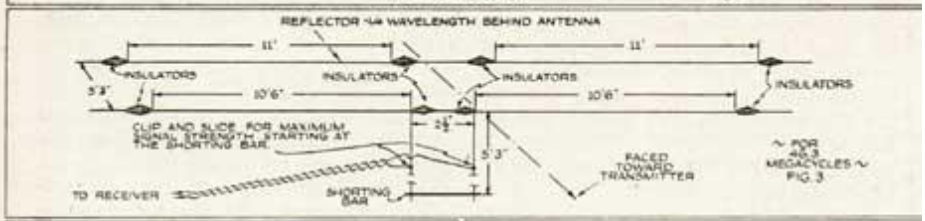
The condensers, tuning the three R.F. stages and detector, are so arranged that extensions (preferably of bakelite) protrude from the shield and these, in turn, can be "ganged" together with a "fish line" for single dial control.

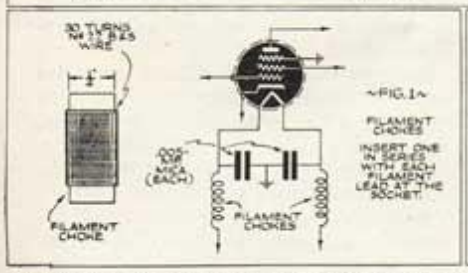
The writer does not deem this the ultimate in mechanical perfection and perhaps the constructor will find a better way to do the same thing more efficiently and economically. However, this television receiver **works**, and works well.

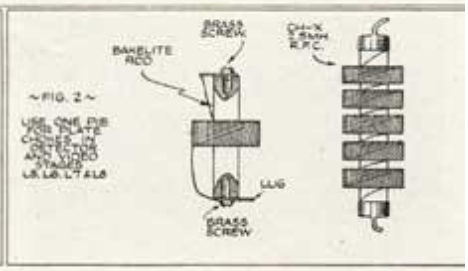
If this article will instill a better thought or design in the mind of the constructor, either mechanically or electrically, he is at liberty to follow his reasoning to a conclusion.

It is to be remembered that the receiver incorporates only three R.F. stages and should be able to receive the transmission of television stations throughout the country for reasonable distances, but under no consideration should this be taken that a receiver located, say in Chicago, will pick up programs from New York or Los Angeles. The capability of this receiver will depend not only upon location, but the power of the transmitter and oher conditions peculiar to ultra-short wave transmission and reception.







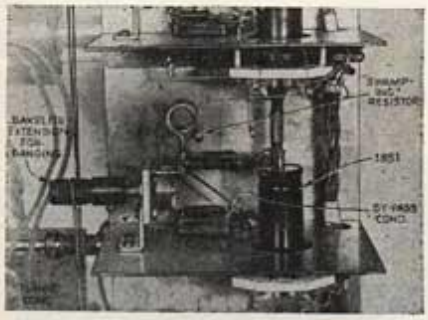


Schematic diagram at top shows R.F. and video circuits. Fig. 1 illustrates method of avoiding ground loops"; Fig. 2, detail of special choke; Fig. 3, all antenna specifications.

To make a check-up easier for yourself, locate the receiver for the first trial within a two or three mile radius of the transmitter. After results are obtained, greater distance between receiver and transmitter may be attempted. The set's performance will be most surprising even to the ultra critical observer.

The antenna system for this receiver consists of a half-wave doublet with a matching stub or transformer. (See Fig. 3.) Where space is available, a reflector consisting of two half-wave sections will materially increase the signal strength if properly placed and constructed.

Note: This set will operate on the new 507 line standards with no changes.



A close-up of an R.F. stage, showing an easy method of ganging condensers.

Parts List—R.F. Det. and Video Sect.

RAYTHEON (Tubes)

5—1851 tubes
1—6H6G tube

HAMMARLUND

4—HF-50 mmf. variable condensers
3—2.5 mh. R.F. chokes
6—8-prong sockets

(Continued on Page 63)

T. R. F. TELEVISION

(Continued from page 61)

AEROVOX (Condensers)

13—.01 mf. 500 V. fixed, mica
1—0.1 mf. 500V. fixed, mica
4—.005 mf. 500 V. fixed, mica
2—.0001 mf. 500 V. fixed, mica
1—.1 mf. 600 V. fixed, paper
1—.25 mf. 600V. fixed, paper

I.R.C. (Fixed Resistors)

1—150 ohms BT (all ½ watt)
3—175 ohms BW
4—1500 ohms BT
4—2000 ohms BT
4—5000 ohms BT
5—60,000 ohms BT
3—250,000 ohms BT

CLAROSTAT

1—1500 ohm potentiometer

MISCELLANEOUS

Shielding material (copper, brass or aluminum)
12—½ in stand-off insulators
Assorted screws