Extended-Range Television Reception

A Receiving System for Weak-Signal Areas
In Three Parts—Part I

BY MARSHALL P. WILDER,[*] W2KJL

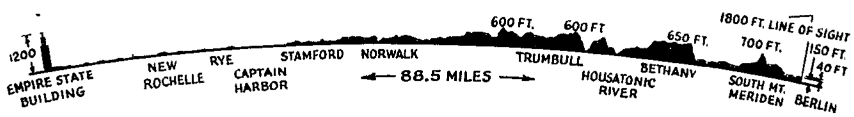
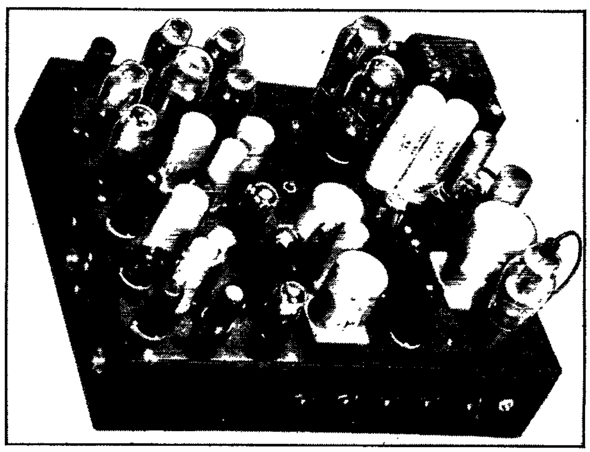


Fig. 1 — Cross section showing the signal path between the Empire State Transmitter and the author's home in Berlin, Conn. The receiving antenna is approximately 1000 feet below the line of sight.

It is usually taken for granted that reception of television broadcast programs is confined to the area in which the signal can be received over a substantially line-of-sight path. For reliable, day-after-day reception this is no doubt true. However it does not mean that those who live outside the normal service area have to go without television entirely — not, that is, if they are willing to take the extra pains necessary to make the most of the signal that does penetrate the outlying regions. While it is not to be expected that reception always will equal that obtainable within a stone's throw of the transmitter, the fact is that the entertainment quality can be high for a surprising percentage of the time. At least that has been the writer's experience at a location in Berlin, Conn., almost 90 miles from the Empire State transmitter and well below the line of sight. Consistent reception of WNBT (51.25-Mc. picture carrier, 55.75-Mc. sound carrier) has been obtained over the path [1] shown in cross-section in Fig. 1, a result which, while naturally dependent upon atmospheric conditions, has been made possible by a receiving system that includes a high-gain antenna as well as a receiver of advanced design.



This chassis contains the video amplifier, limiters, automatic frequency control synchronizing circuits, vertical and horizontal deflection circuits, and the d.c. power supply. Layout of components is described in the text.

Beginning with the December, 1937, issue the writer published a series of articles in *QST*, "Introducing Modern Electronic Television to the Radio Amateur." During the intervening eight years the art has progressed considerably, and standards of good engineering practice have developed both as a result of action taken by the Federal Communications Commission and by the industry as a whole. For instance, modern television calls for a receiver capable of quasi-single sideband reception (type RA) as indicated in Fig. 2.[2]

The picture reproducing tube and associated deflection circuits should be capable of linear deflection of the beam at a frequency of 15,750 traces per second horizontally, and 60 traces per second vertically. The rate of horizontal deflection of the return trace of the beam is approximately five times faster than the trace time. The return trace

The author of this article has been getting good television reception for a considerable proportion of the broadcasting time at a location nearly 90 miles from the nearest broadcaster and a thousand feet below the line of sight. This is a description of the equipment with which it is done.

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[1] For the method of constructing such a map, see P. S. Rand, "Choosing U.H.F. Sites," *QST*, September, 1945.

[2] Fink, *Television Standards*, McGraw Hill Book Co.

time of the vertical deflection is approximately twelve times faster than the trace time. A total of 525 lines is traced in one-thirtieth of a second. Interlacing is accomplished by dividing one complete picture or frame into two "fields," each forming a 262½-line picture scanned in $^1/_{60}$th second. The lines of the second field fit in between the scanning lines of the first so that a 525-line picture is achieved, although alternate lines are

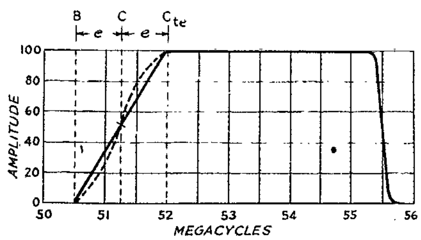


Fig. 2 — Ideal receiver response characteristic for reception of 525-line television transmissions (based on 51.25-Mc. picture carrier).

separated in time by $^1/_{60}$th second. At the end of the first field, when the scanning beam has moved only a half line across the bottom of the picture, the beam is returned to the *top* of the picture to finish the line. Because the beam is moving down the picture (as a result of the continuous vertical

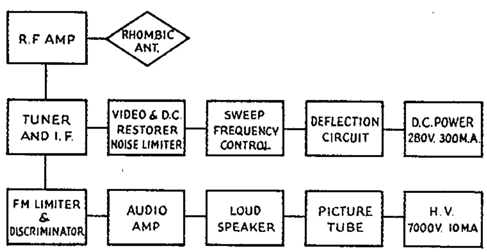


Fig. 3 — Block diagram of receiving system.

deflection) at the same time that it is moving across, this process places the last half line *above* the last half of the first line of the first field, the displacement being just the width of one line. The lines of the second field thereby are automatically placed between the lines of the first as the scanning continues. The reason for interlacing two fields is to achieve a picture interruption rate of sixty times a second rather than thirty, thereby achieving a decided reduction in picture flicker. The brighter the picture, the higher the interruption rate has to be to avoid annoying flicker. An interruption rate higher than approximately thirty-five fields per second is not noticeable at ordinary levels of picture brightness. To insure against the development of noticeable flicker as pictures are further increased in brightness, an interruption rate of sixty fields per second has been established by the Federal Communications Commission.

The principal requirements for a receiver operating under the conditions encountered when signals must be received over non-optical paths are a good inherent signal-to-noise ratio, ample gain, and a method of synchronization which is as insensitive as possible to the upsetting effects of local interference such as automobile ignition. For the most part the circuits in the receiver to be described follow designs which will be fairly familiar to those who have kept in touch with television development, hence the discussion will be concentrated on those aspects that are particularly useful for weak-signal reception.

Two unusual features of this receiver are the means for synchronization, employing the flywheel or electrical inertia type of circuit, and electronic regulation of the d.c. power. A noise limiter is an important element in the receiver. The description to follow covers the units furnishing power, synchronization, beam deflection, video signal amplification, noise limiting, and low-frequency restoration. Fig. 3 is a block diagram of the receiver.

A.F.C. Synchronization

Aside from band width, horizontal and vertica resolution depend on the accuracy of synchronization as well as the intensity of the noise impressed on the kinescope grid. This is especially true when signals are weak or the noise level is high. If methods of synchronizing other than automatic frequency control are used there are often conditions when horizontal resolution is reduced, regardless of the pass band of the receiver.

A report based on an original paper by Wendt and Fredendall,[3] prepared by the television section of RCA Laboratories, Princeton, N. J., for the Radio Technical Planning Board, Panel 6, Television Committee 2, describes an automatic frequency-synchronizing circuit. This circuit will not follow sudden changes in the synchronizing-pulse repetition rate and is recommended for all receivers operating at or near the fringe of television service areas. The repetition rate, line by line and field by field, is held rigidly at the broadcasting station. At the receiving point any spurious pulses such as those generated by auto ignition or other local interference will not cause loss of synchronization unless the rate of the

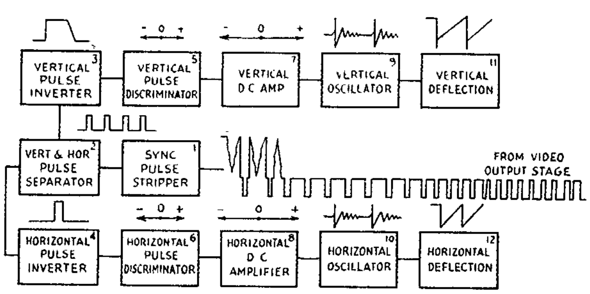


Fig. 4 — Block diagram of circuits for sync separation, a.f.c. synchronization, and deflection. Approximate waveforms at each point are indicated.

[3] Wendt and Fredendall, "Automatic Frequency and Phase Control of Synchronization in Television Receivers," *Proc. I. R. E.*, January, 1943.

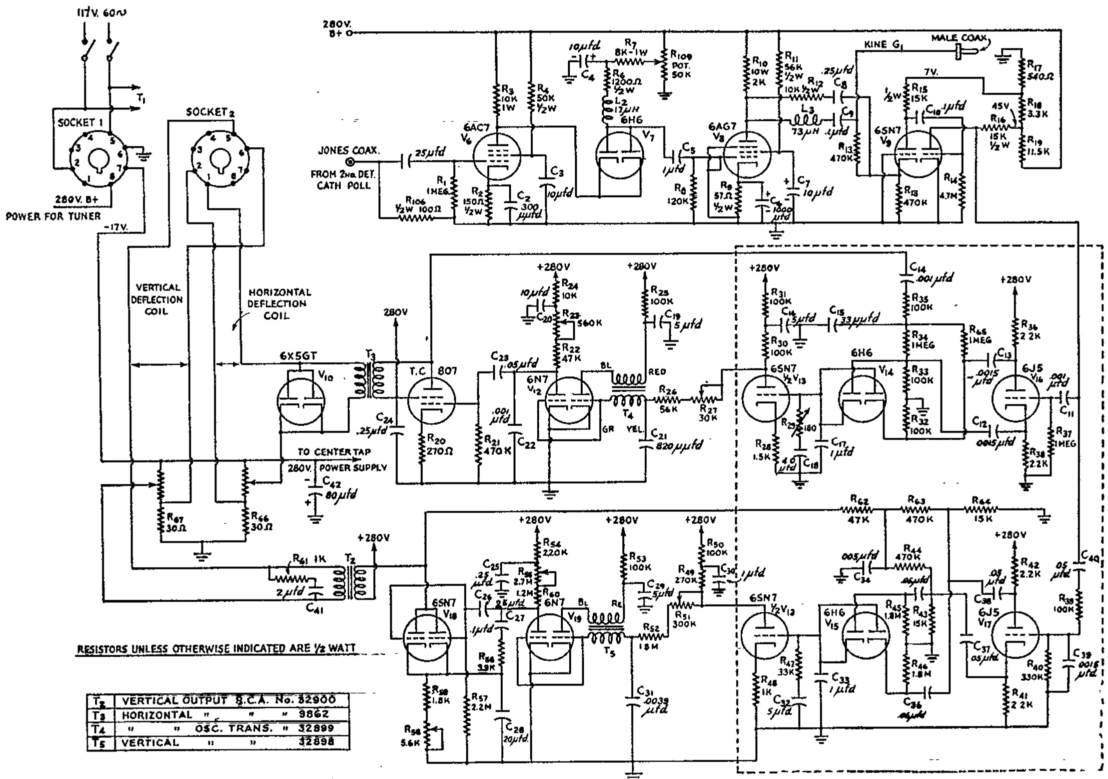


Fig. 5 — **Wiring diagram of the video, synchronizing and deflection circuits.**

interfering pulse is very near that of the picture sync pulse for an extended time, a very unlikely coincidence. The synchronizing circuit employed in this receiver, shown in block form in Fig. 4, is essentially the type described in the RTPB report.

Fig. 5 is the detailed wiring diagram of the video, synchronizing and deflection circuits. Referring to this figure and to Fig. 3, the tuner chassis transmits the composite video-sync signal from the second detector via a cathode follower to the grid of V_6, where it is amplified and passed on to the noise limiting diode, V_7. R_{109} sets the voltage on both plates of V_7 to allow the video to pass through, along with the synchronizing pulses. V_7 clips off noise pulses to the top of the synchronizing pulses. It will be noted that compensation for high-frequency losses in the plate circuits of V_6 and V_7, including the grid of V_8, is accomplished by an inductance, L_3, in series with the load resistor, R_6, for V_7. Further high-frequency compensation is effected by C_2, R_2. Two stages of video amplification are used instead of one, to permit greater freedom in design, noise limiting, and simpler high-frequency compensation. The output tube, V_8, is a video power output tube capable of supplying 75 volts peak-to-peak to the grid of the kinescope with a passband of 4.5 Mc. Series peaking is employed.

The video signal is supplied from the video output tube, V_8, through R_{12} and C_8 to the cathode of tube V_9 (Block No. 1, Fig. 4). The high value of R_{13}, in combination with the low voltage applied to the plate of V_9, results in saturation of all signals except the tips of the synchronizing pulses.

It is a feature of this type of synchronizing circuit that the wave form need not be sharply defined; that is to say, considerable high-frequency content can be lost without affecting the quality of synchronization. It will be noted that the input to V_9 is through a series resistor of not less than 10,000 ohms, a decided advantage in retaining high frequencies on the grid of the kinescope.

The second triode section of V_9 inverts, amplifies and clips off the top of the sync pulses to a common level. Both the vertical and horizontal pulses are fed to the grids of V_{16} (Block No. 4) and V_{17} (Block No. 5) via *RC* components designed to separate and apply essentially horizontal pulses to the grid of V_{16} and vertical pulses to the grid of V_{17}. The purpose of V_{16}, in the horizontal deflection case, is to apply signals of equal amplitude but opposite polarity to V_{14} (Block No. 6), a diode bridge-type phase discriminator. At the same time a portion of the sawtooth appearing in the plate circuit of the output tube, V_{11} (Block No. 12), is fed back to the bridge through C_{14}. These two voltages, one from V_{16} and derived from the received signal, and the other from the plate circuit of V_{11} and generated

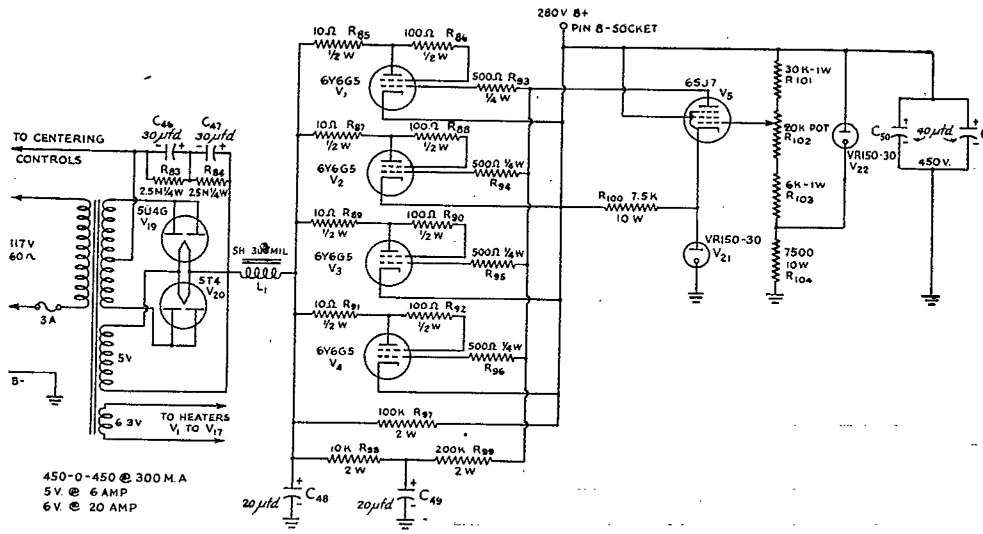


Fig. 6 — Wiring diagram of regulated power supply for the video and sync circuits.

locally, are compared in V_{14}. If there is a phase difference, a bias will be developed of a polarity which, when applied through the d.c. amplifier (Block No. 8, one-half of V_{13}) will cause the blocking oscillator V_{12} (Block No. 10) to slow down or speed up until the voltage output of the phase discriminator is essentially zero. When this is achieved exact synchronization will be maintained. Constant hunting back and forth is prevented by the *RC* filter R_{29}, C_{18}.

A similar action takes place in the vertical deflection circuits. The vertical synchronizing pulses are inverted in V_{17} (Block No. 3) so that a pulse of opposite polarity can be applied to a double-diode phase discriminator, V_{15} (Block No. 5). At this point vertical pulses derived from the vertical output tube V_{18} (Block No. 11), are mixed with them so that the resulting voltage is either positive or negative depending on whether the locally-generated pulses are leading or lagging the received pulses. In V_{13} (Block No. 7) this voltage difference is amplified, and in V_{19} (Block No. 9) the amplified voltage difference is employed to speed up or slow down the local oscillator. When the local oscillator is operating at the same frequency as the received pulses, the voltage difference is essentially zero and complete synchronization is effected. Small sketches accompanying each block indicate the approximate wave forms to be observed on a cathode-ray oscilloscope.

Power Supply Circuits

The beam in the picture tube is deflected by a magnetic deflection coil from power developed in conventional deflection circuits, but controlled as to frequency by the automatic frequency synchronizing circuit outlined above. To avoid hum bars in the picture or ripples along the edges, an electronically regulated source is required.

Fig. 6 is a circuit diagram of such a power supply. This circuit passes all current through the four 6Y6's from plates to cathodes and the internal resistance of the tubes is varied by the potential on their grids. Any fluctuations on the grid of V_5 will be applied in opposite phase to tubes V_1, V_2, V_3, V_4 to restore the potential of the power supply to a constant output voltage which can be set over a narrow range by R_{102}. In order to have a reference point of rigidly fixed voltage two VR150's are used. The arm of R_{102} is set so that the grid of V_5 is approximately 5 volts more negative than its cathode.

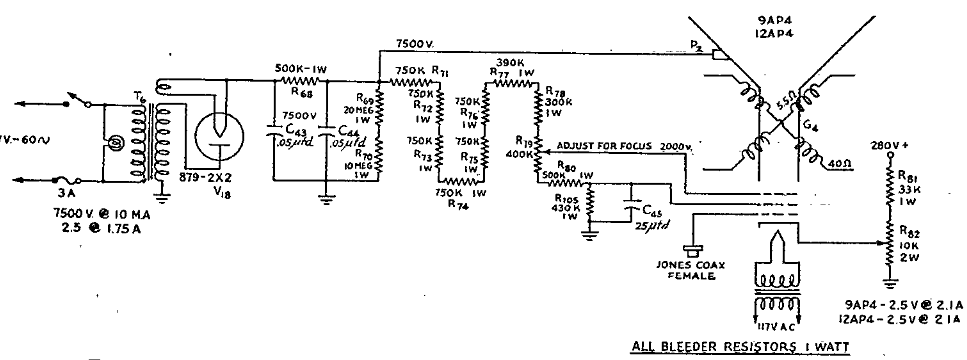
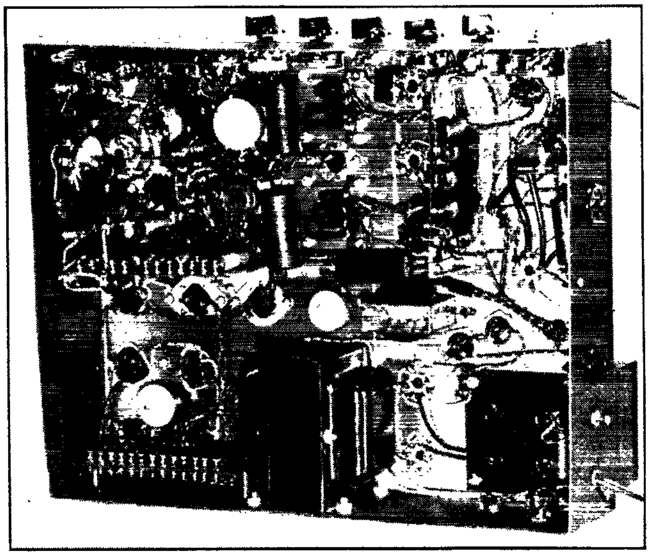


Fig. 7 — Circuit diagram of high-voltage power supply for the picture-reproducing tube.

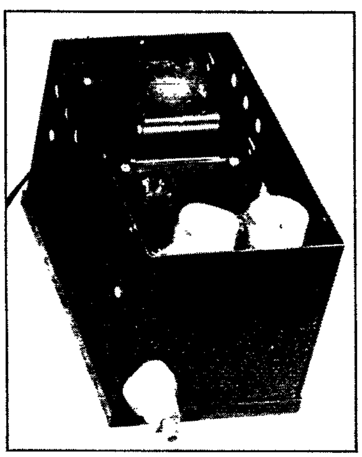
A circuit diagram for the high-voltage power supply is given in Fig. 7. Too much emphasis cannot be placed on the personal danger involved when dealing with the high voltage required in a television receiver. High-voltage sources of power resulting from rectification and filtering of either high-frequency oscillators or fly-back voltage developed in a horizontal output tube are to be preferred whenever it is possible to obtain components. Unfortunately such transformers and other components were not available and a conventional high-voltage supply of prewar design had to be used.

A 12AP4 or 9AP4 is recommended for use in this receiver. However, if a suitable deflection yoke is employed the 7CP1 and the 9JP1 can be used without essential changes in the circuit. Most of the writer's experience has been with the 7CP1.

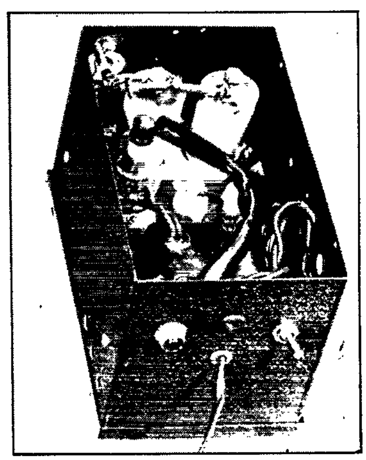
The average brightness of the picture is controlled by R_{82} in the cathode circuit of the kinescope.



Bottom view of the video-sync-deflection chassis. Insofar as possible, small parts such as resistors and paper condensers are mounted on terminal boards, with cabled leads to tube sockets and other chassis-mounted components.



Left — The 7500-volt power supply for the picture-reproducing tube is built in a metal cabinet separate from the other chassis units.



Right — The rectifier tube and filter condensers are visible in this bottom view of the high-voltage power supply.

Chassis Arrangement

A top view of the d.c. power supply, video amplifier and limiters, automatic frequency control synchronizing circuits, and vertical and horizontal deflection output circuits is given in one of the photographs. The tube in the lower left-hand corner is the first video stage, V_6. The next tube above is the noise limiter, V_7, followed along the chassis edge by V_8, the video output tube. Two VR150s, V_{21}, V_{22}, and a 6SJ7, V_5, regulating the d.c. power supply, complete the line of tubes along the edge. The second row starts with the horizontal phase-inverter tube, V_{16}, followed by the d.c. restoring sync separator, V_9. Next in line is the vertical-pulse phase inverter, V_{17}, followed by two 6Y6s, V_1 and V_2, part of the d.c. regulator. The third row begins with the horizontal discriminator, V_{14}, the vertical and horizontal d.c. amplifier, V_{13}, the vertical phase discriminator, V_{15}, and the other two d.c. regulators (6Y6s), V_3 and V_4. The fourth line of tubes starts with the horizontal blocking oscillator, V_{12}, followed by the vertical oscillator, V_{19}, and the vertical output tube, V_{18}. The two 5U4G rectifiers, V_{19} and V_{20}, are above. The last line of tubes consists of the 807 horizontal output tube, V_{11}, and the 6X5 damping tube, V_{10}.

The large cans contain transformers and are adjacent to the tubes with which they operate.

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Television Reception

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The small cans are electrolytic condensers. The controls are in a row along the front edge of the chassis. From left to right, they are as follows: horizontal speed, vertical speed, horizontal amplitude, vertical speed, horizontal centering and vertical centering. The control for the noise limiting diode, V_7, is between the input and output coaxial sockets on the left edge of the chassis.

In the bottom view of the chassis, the video amplifier occupies the upper left-hand corner. The resistors and condensers for the horizontal sync control are on the card at the upper left, while those for vertical sync control are located at left center. The card in between and at right angles to the first two is for the sync separator and d.c. amplifier circuits. The card above and to the right of center mounts the components for the sweep circuits, and the card in the lower left-hand corner mounts all components for the d.c. regulator circuit. The upper socket at the right-hand edge of the chassis is for deflection power output, and the lower socket is for power output to the tuner unit.

The two potentiometers to the left of the two large paper condensers in the upper left-hand side of the chassis adjust the delay filters in the horizontal and vertical discriminator circuits. The vertical output transformer is in the lower right section of the chassis just to the right of and slightly above the d.c. filter choke mounted on the lower wall.

In the top view of the high-voltage power supply, the bottom of the socket for V_{18}, the high voltage rectifier tube, appears between the transformer and the two high voltage condensers. The high-voltage output terminal is in the lower left foreground. In the bottom view, the high-voltage filter condensers are at the top, above the 879 tube, V_{18}. Two feed-through insulators for the 879 filament are between the condensers and the transformer. On the lower edge are the on-off switch, pilot light and line cord.

(Part II of this article, covering the intermediate-frequency amplifier and detailed methods of alignment, will appear in an early issue.)

Extended-Range Television Reception

In Three Parts—Part II

BY MARSHALL P. WILDER,* W2JLK

• The first part of this article covered the construction of the video, synchronizing, and sweep-generating circuits of a modern high-performance television receiver especially designed for weak-signal reception. In this second part the author discusses a simple method of video circuit design and describes the r.f. and i.f. sections of the receiver.

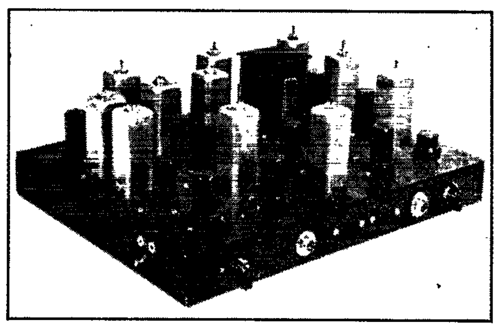
THE video circuits of the receiver already have been described in the preceding section,[1] but before going on to the r.f. and i.f. circuits it may be of interest to discuss the methods used in designing and aligning the video amplifiers in this set.

In general, video amplifiers employ constant-current devices, of which the pentode is an example. A generalized formula for the gain of a pentode when the load resistance is low compared to the plate resistance is the tube transconductance expressed in mhos multiplied by the load resistance in ohms. The transconductance of the 6AC7 is 0.009 mhos. Load resistor values of the order of 1000 to 4000 ohms cover those generally used when the pass band of modern television is amplified. The value of the load resistor should be as high as the total shunt capacitance, C_t — output capacitance plus input capacitance of the following stage plus stray capacitances — will allow. This capacitance, of the order of 30 $\mu\mu$fd. when a 6AC7 couples into a following 6AC7, must be measured since it determines the values of load resistance and peaking coil inductance when a certain pass band is required.

The method for measuring C_t from the plate of a video stage to ground employing an inductance of known value substituted for the load resistor of the stage in question will be the easiest for most amateurs to use. An inductance of approximately 40 μh. can be made by winding 90 turns of No. 30 enamel wire close-spaced on a one-half inch form. Substitute for the load resistor in the plate of the following stage a non-inductive 100-ohm resistor. A vacuum-tube voltmeter, magic eye, or similar device is connected from the plate of this stage to ground. A signal of such amplitude as not to overload the grid of the second tube or the indicating device is applied to the grid of the first tube. The frequency of the signal is then adjusted until resonance between the known inductance and C_t is shown by maximum reading on the indicating device. With frequency and inductance known a Type A Lightning Calculator or other *LC* slide rule will give the capacity, C_t.

Charts A and B, Fig. 8, may be used to design video amplifiers around the values most commonly encountered. For example, should C_t prove to be 26 $\mu\mu$fd. and a pass band of 4.5 Mc. be desired, chart A will indicate the proper value of load resistor as 1360 ohms. From chart B, with C_t equal to 26 $\mu\mu$fd. and a pass band of 4.5 Mc., the peaking coil size will be found to be 21.5 μh. The value of C_1 is equal to 0.353 C_t, or 9.1 $\mu\mu$fd. A practical value for C_1 would be 7 $\mu\mu$fd., since the distributed capacitance across a single-layer coil of this inductance value is of the order of 2 $\mu\mu$fd. The gain of this stage is the tube transconductance in mhos $\times R_L$. For a 6AC7 the gain is $0.009 \times 1360 = 12.2$.

The method outlined above is the simplest and most practical form of high-frequency compensation. Other more complicated methods will allow use of a higher value of load resistance and in turn result in more gain per stage. A review of the literature will quickly familiarize one with the other methods and the reasons for employing them.[2]



The r.f.-i.f. chassis, containing both picture and sound i.f. amplifiers. Locations of components is described in the text.

* Electronic Division, Remington Rand Inc., Middletown, Conn.

[1] Wilder, "Extended-Range Television Reception," Part 1, *QST*, November, 1945.

[2] For example, Terman's "Radio Engineers' Handbook," McGraw-Hill Book Co.

Low-Frequency Compensation

When a video amplifier stage has been corrected for high-frequency response to allow a desired pass band the amplifier must also be corrected to give proper low-frequency operation. In the case of television amplifiers the amplitude response curve must be flat down to 20 cycles per second and should have useful response to as low as 2 cycles per second. This is readily accomplished by using a filter circuit in the plate of each video stage in such a way that as the frequency becomes lower the capacity C_f of the filter network (see diagram on chart C, Fig. 8) becomes less and less capable of by-passing R_f, so that effectively R_f becomes a part of R_L. This boosts the output of the amplifier stage at low frequencies. If the values are correctly chosen the loss at low frequencies in the network C_gR_g will be compensated for in the low-boost network $C_fR_fR_L$. The time constant of C_fR_f should be chosen to be approximately four times that of R_LC_f. A good value for C_f is 8 μfd., and for R_f, 8000 ohms. A useful value for C_g is 0.1 μfd. The value for R_g will be found by the formula $R_gC_g = C_fR_L$. The values must be right if perfect correction is to be effected — and it must not be assumed that the values stamped on the condensers or resistors are precisely as represented.

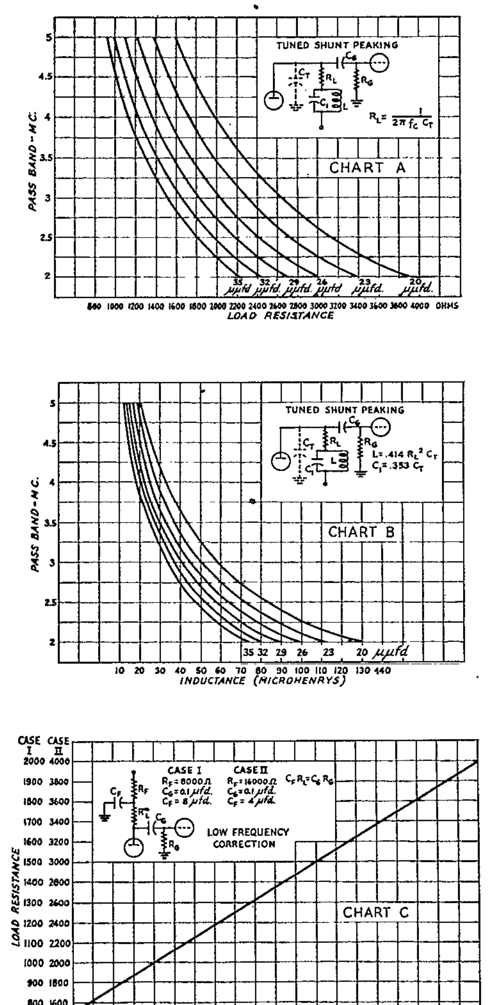
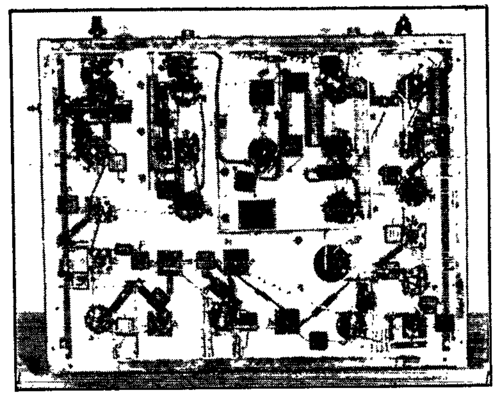


Fig. 8 **— Video amplifier design charts. The method of using them is described in the text.**



Below-chassis view of the r.f.-i.f. unit. Despite the number of stages, the wiring is clean and simple in layout.

Design values for R_g will be found in chart C. For example, if the load resistor, R_L, is 1400 ohms, the coupling condenser, C_g, is 0.1 μfd., the plate decoupling filter, R_f, is 8000 ohms, and C_f is 8 μfd., then the correct grid leak is 112,000 ohms as read from the chart. If R_L lies between 2000 and 4000 ohms the plate decoupling filter, C_fR_f, should be 4 μfd. and 16,000 ohms.

It should be pointed out that if the cathode is not connected directly to ground it must be by-passed for all frequencies down to 20 c.p.s. This usually requires a condenser of 1000 μfd. Final adjustment for low-frequency response is best made by observing on a cathode-ray oscilloscope the tilt of the top of vertical blanking. Substitute a variable resistor of the order of ½ megohm for the grid resistance and adjust until the top of vertical blanking is flat. Remove the variable resistor and substitute a fixed resistor of equal value. During this adjustment the 'scope probe should be on the grid being corrected.

It is not always possible to use this type of low-frequency correction. Triodes (with the exception of very high-mu triodes), diodes, or cathode followers are constant voltage devices and must be coupled to the following grid through a large capacitance, such as 1 μfd., and as large a value of grid leak as the tube will allow.

R.F.-I.F. Circuits

To be conventional, the description of a receiver should confine itself to the circuits and construction. But in this case the antenna is such an important part of the complete system that a few words about its dimensions are in order before going on with the receiver proper.

The rhombic antenna used is 60 feet on a side and has a major angle of 130°, a minor angle of 50°, and is 40 feet above the ground. One corner is supported by the house and the other three by wooden poles 50 feet high. The direction to the Empire State Building was quite accurately determined and the antenna designed and erected accordingly. The end of the rhombic pointing towards the signal source is terminated in a 600-ohm carbon resistor; as a precaution against the weather, a glass tube is slipped over the terminating resistor and the ends filled with sealing wax. A 600-ohm line approximately 90 feet long brings the signal to the side of the house where the r.f. amplifier is located. The spacers for the 600-ohm transmission line may be pieces of glass rod or other suitable insulators. An open transmission line was used because the losses with such a line proved to be much lower than with any of the coaxial or twisted-pair lines available.

The r.f. and i.f. circuits are shown in Fig. 9. The r.f. stage uses a 6AK5, one of the new miniature-type pentodes, with inductive coupling between the transmission line and the grid coil. The latter is adjusted to resonate with the tube and stray capacitances. Cathode-resistor bias is required with this type of tube, and a series dropping resistor of the proper value insures correct voltage on the screen. The plate voltage must not exceed 180 volts. Link coupling between the plate coil and the mixer grid coil via a 600-ohm open line 30 feet long affords a decided advantage in signal to noise ratio because a television receiver itself is a considerable source of interference. This interference results from the steep wave fronts of the sweep oscillators and from unavoidable corona discharge noise in the high-voltage power supply. Although all precautions were taken to minimize these sources of noise, such as ground bonding, corona shields at high-voltage points, and by-passing at various points in power supplies and in sweep circuits, a small amount of electrical disturbance remains, and all efforts to build up the signal should be at a point remote from the receiver proper. If the r.f. stage were located at the terminals of the rhombic further improvement might

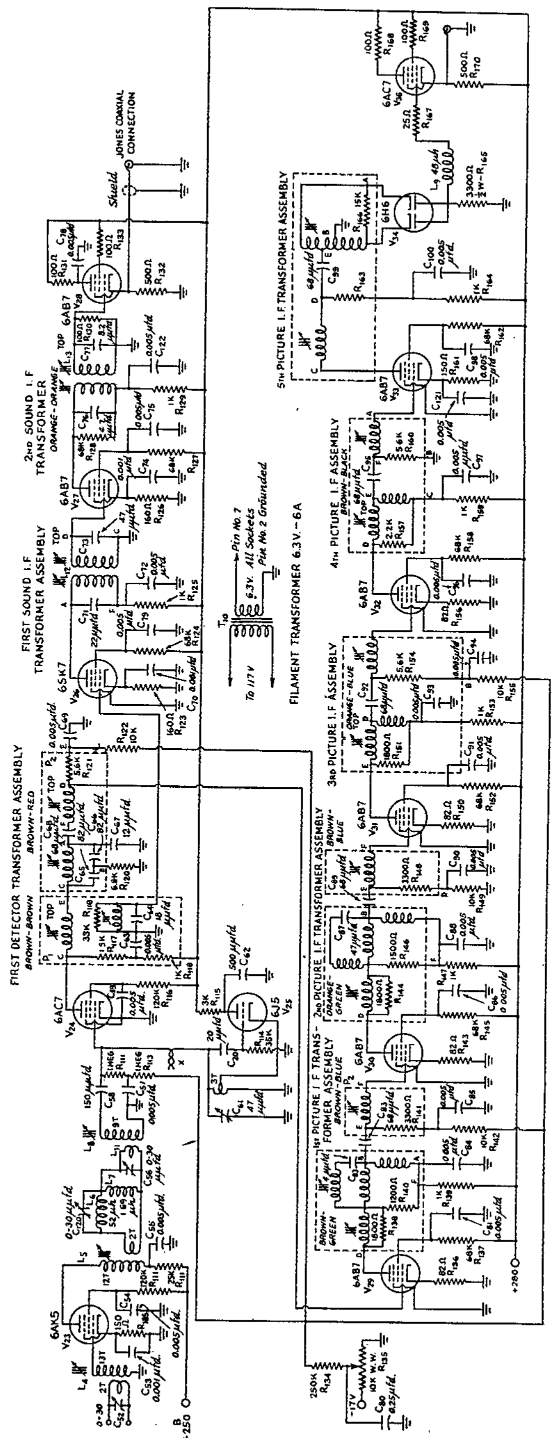


Fig. 9 — **Circuit diagram of the r.f. and i.f. section of the receiver.**

result, but this was not practical at the writer's location.

A high-pass filter was inserted as close as possible to the grid of the mixer in the link line. This filter was designed for infinite rejection below 10 Mc. and a rising characteristic leveling off at 40 Mc.[2] The filter (or wave trap) proved desirable in eliminating many signals from powerful transmitters in the 7- to 13-Mc. band, a form of interference which appears as a series of bars in the picture.

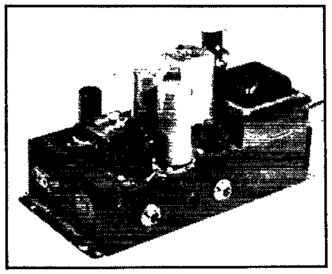
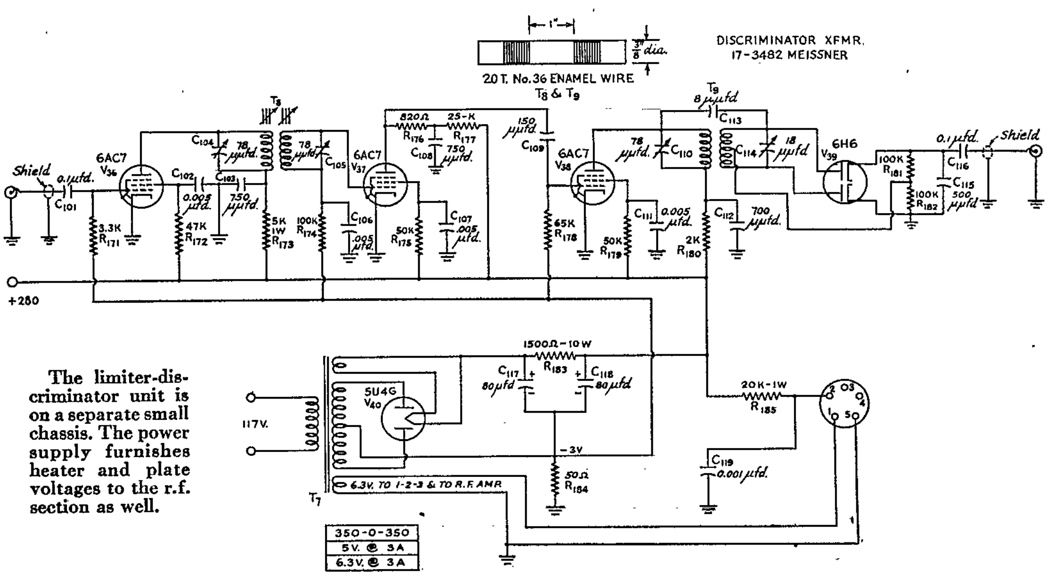


Fig. 10 — Final sound i.f. amplifier, limiters and discriminators.

Oscillator injection into the grid of the 6AC7 mixer results in excellent conversion. A grounded-plate Hartley oscillator operates at 64 Mc. to beat with the a.m. picture signal at 51.25 Mc. to develop picture i.f. from 8.25 to 12.75 Mc. The same oscillator beats with the f.m. sound carrier at 55.75 Mc. to generate 8.25-Mc. sound i.f. with 75-kc. deviation. Proper oscillator injection will be indicated by − 7 volts d.c. at the grid of the mixer. This voltage must be obtained by rectification at the mixer grid. The energy so rectified is stored by the mixer grid condenser and can be measured by an electronic voltmeter such as the Volt-Ohmist Jr. It is not necessary that this bias be exactly 7 volts but it should be between 5 and 10 volts, negative with respect to ground. Less injection voltage than the above minimum will result in the mixer's acting more as an r.f. amplifier (in the 8.25- to 12.75-Mc. band) than as an efficient converter.

The picture i.f. transformers were purchased as a kit from the RCA Manufacturing Co., Camden, N. J., and wired to operate with the tubes required by their design. The circuit of the i.f. amplifiers is essentially that of the TRK-120 RCA television receiver. Alignment of these amplifiers is straightforward and is greatly simplified if a frequency-modulated signal generator is used. Such a generator either can be purchased or built of simple components as will be described in the next article of this series. The second detector is phased so that peak blacks are negative as taken out of the plates of the diode and fed into the grid of the cathode-follower output tube. A filter, L_9, between the second detector and cathode follower removes any undesired carrier present, passing only the 0- to 4.5-Mc. picture signal. The video signal is then transmitted through a coaxial cable to the video amplifier in the chassis described in Part I.

The sound i.f. is amplified through two stages as shown in Fig. 9, and then fed into a cathode-output stage. From there, the signal goes by a coaxial cable to the auxiliary chassis shown in one of the photographs, where it is built up in a pentode, V_{36}, Fig. 10, to a level for effective limiting in V_{37} and V_{38}. The latter tube drives the diode discriminator which translates the frequency-modulated signals into audio frequency. The cascade limiter practically eliminates auto ignition noise, which otherwise would be extremely an-



The limiter-discriminator unit is on a separate small chassis. The power supply furnishes heater and plate voltages to the r.f. section as well.

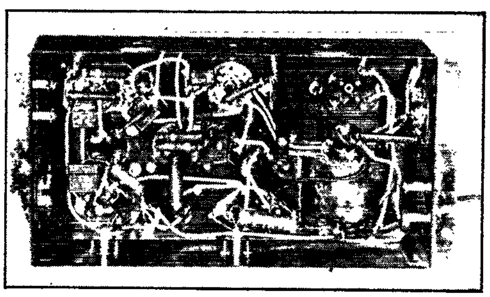
noying since a six-lane highway passes a short distance from the front door of the house. A separate power supply for this auxiliary unit is included on the same chassis and also feeds power to the r.f. amplifier through a three-wire twisted cable.

Alignment of the sound i.f. amplifier is best achieved by using a test oscillator and output meter as in a.m. alignment procedure. Adjustment of the shape of the discriminator curve can best be made by observation on a cathode-ray oscilloscope when a frequency-modulated signal generator of the proper deviation is applied to the mixer grid.

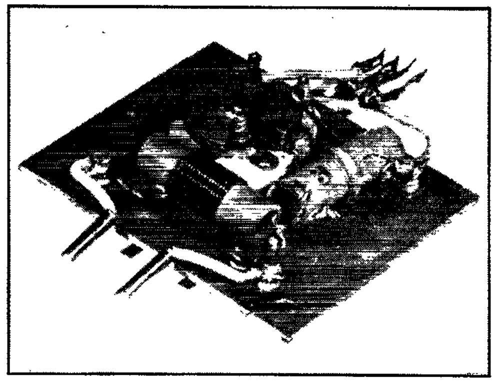
R.F. Alignment

Experience with this receiver has shown the value of normalizing all currents and voltages of all tubes as specified in the tube handbooks. Do not *assume* that the heaters are operating at 6.3 volts, because there may be considerable drop in the heater wiring. If all voltages and currents are correct the receiver will be considerably easier to adjust.

Final alignment of the front end of the receiver in the r.f. and mixer stages is best done on the air. However, it will help considerably to make some preliminary adjustments on the bench. A 6J5 separate oscillator adjustable in frequency from 50 to 90 Mc. is a very useful tool to help in this alignment. The mixer grid coil and the plate and grid coils of the r.f. amplifier are tuned with brass slugs. A brass slug just outside the hot end of the coil will lower the inductance of the coil as it is drawn in by the adjusting screw, and the eddy currents flowing in the brass will effectively flatten and widen out the frequency response of the amplifier. The output is coupled in with approximately two turns at the ground end of the coil. Using an indicating device as in the video amplifier alignment procedure, put a 100-ohm noninductive resistor between B+ and the plate of the mixer. Adjust the test oscillator to 53.5 Mc., and then add or subtract turns from the mixer grid coil until resonance is indicated at 53.5 Mc. with the brass slug just coming in. The 64-Mc. oscillator coil should be close enough to the grid coil to develop the −5 to −10 volts re-



A bottom view of the limiter-discriminator unit.



The high-pass filter for eliminating intermediate-frequency signals picked up by the r.f. transmission line.

quired on the mixer grid as outlined earlier in this article. Sometimes this is easier to achieve by soldering a small wire on a hot point on the oscillator coil and bringing it near another small wire soldered to the mixer grid. These two wires, if insulated, may be twisted together to form a small condenser, as shown at X in Fig. 9. It is wise to adjust the oscillator injection before adjusting for mixer grid resonance. During the adjustment of the mixer grid coil, the plate voltage must be disconnected from the oscillator so that excessive bias will not lower the mixer tube sensitivity below that of the indicating device. During the above adjustments the gain control must be set so that −2 volts bias is present on the mixer grid.

The alignment of the grid coil of the r.f. stage is accomplished in a similar manner. This adjustment is somewhat easier because the complication of the oscillator injection voltage is not present. After the grid circuit is aligned remove the 100-ohm test resistor and disconnect the grid coil at the grid and substitute a 10,000-ohm grid resistor. Inject through a capacitor of a few $\mu\mu$fd. approximately 1 to 2 volts from the test oscillator at 53.5 Mc. Trim the plate coil for resonance, as shown by maximum deflection of the indicating device when connected across the two-turn output coil. Remove the 10,000-ohm grid resistor and reconnect the grid coil. A strong indication at the resonant frequency of 53.5 Mc. will be observed with the test oscillator very loosely coupled. And once again resonance should occur with the brass slugs just entering the coils. When the oscillator is shut off the indicating device should show zero output. If it doesn't, the stage is probably unstable and better shielding and a recheck of voltages and currents is in order.

Constructional Details

The construction of the various units is shown in the photographs. The large chassis contains all the r.f. and i.f. stages except the r.f. amplifier, which is separately mounted in a metal box affixed to the side of the house as previously mentioned. Looking at the top view of the main chassis, the r.f. input terminals and mixer tuning slug are on the left-hand edge near the front. On the front edge of the chassis, from left to right, are the oscillator trimmer condenser, C_{61}, the coaxial Jones connector for the f.m. cathode follower output, two power sockets, the coaxial connector for the video cathode follower output, and the gain control, R_{135}. Starting with the oscillator tube, V_{25}, at the lower left corner of the chassis and going toward the upper left, next in line is the mixer tube, V_{24}, then the mixer output transformer assembly, consisting of two units, P_1 and P_2, and last V_{29}, the first picture i.f. amplifier.

In the second column the first tube is V_{27}, the second i.f. sound amplifier. Next is the first sound i.f. transformer assembly, then V_{26}, the first i.f. sound amplifier, followed by the second picture i.f. transformer assembly, P_1 and P_2, and last, the second picture i.f. amplifier tube, V_{30}. In the third line, commencing with the second sound i.f. transformer, L_{13}, in the lower center of the chassis, is the sound i.f. cathode follower, V_{28}. The fourth line starts with the picture cathode follower, V_{35}. The next two sockets are not used, but were originally intended for the sound limiter and discriminator diode. The filament transformer, T_8, follows, and last is the third picture i.f. amplifier, V_{31}. Along the right edge of the chassis in order are the picture second detector, V_{34}, the fifth picture i.f. transformer assembly, the fifth picture i.f. amplifier V_{33}, the fourth picture i.f. transformer assembly, the fourth picture i.f. amplifier tube, V_{32}, and the third picture transformer assembly.

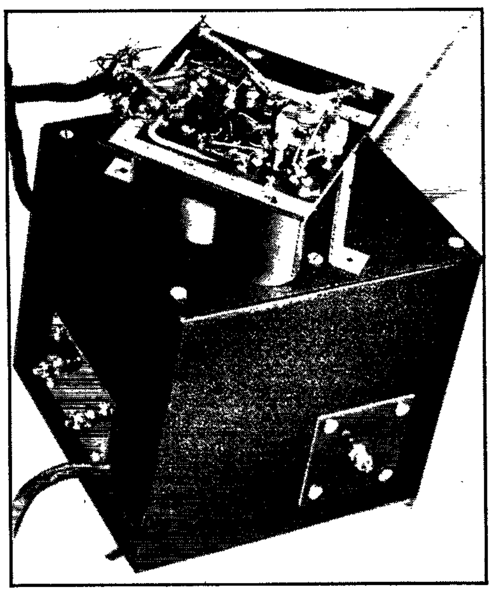
In the bottom view of this unit the socket for the oscillator tube, V_{25}, is directly underneath the oscillator trimmer condenser, C_{61}. Between the oscillator and the mixer tube, V_{24}, are the input tuning coils, L_{11} and L_7, and the oscillator tank coil, L_{10}. In the first detector transformer assembly, P_1 and P_2, the lead from P_1 terminal A goes to the right, feeding the grid of V_{26}, the f.m. sound i.f. Directly below P_1 and P_2 is V_{29}, the first picture i.f. amplifier. The rest of the picture i.f.'s follow around the lower edge and up the right-hand edge of the chassis. The low-pass filter, L_9, can be seen leading over to the picture cathode follower, V_{35}. The transformer over V_{26} is the first sound i.f. transformer assembly; it feeds V_{27}, the second i.f. sound amplifier. The output of V_{27} goes to the right, feeding the second sound i.f. transformer. Its output goes down to the sound cathode follower, V_{28}, the output of which goes to the sound output terminal through a short length of coaxial cable.

The remainder of the sound channel is on a separate small chassis shown in another photograph. In this unit, the input terminal is on the front edge of the chassis at the left. V_{36}, the third sound i.f. amplifier, feeds T_8, the third sound i.f. transformer directly behind it. V_{37}, the first limiter, feeds V_{38}, the second limiter, through an RC network, C_{109}, R_{178}. The output of V_{38} is fed to V_{39}, the discriminator diode, via T_9. The output of V_{39} at audio frequencies is fed through C_{116} to the sound output terminal. Pre-emphasis is corrected by C_{115}. The d.c. power supply is conventional. In the bottom view, the socket at the upper left is for the input tube, V_{36}. Transformer T_8 is between V_{36} and V_{37}, with V_{38} to the right. Above V_{38} are the terminal of T_9. The audio output terminals are directly above V_{39}.

In the photograph of the r.f. amplifier the bakelite "chassis" has been removed from the housing for the purpose of showing its construction. The tuning condenser, C_{30}, for the input circuit is plainly visible. All resistors and by-pass condensers are returned to ground as close to the socket as possible. The input and output coils are shielded from each other by shield cans above the chassis card. The input terminals from the feeders are on the left and right sides of the housing, the two output terminals being side by side. This unit is mounted on the house so that the output terminals are beneath.

The low-pass filter for eliminating i.f. interference is shown in another photograph. The input from the r.f. amplifier goes to the two terminals on the upper edge of the Formica board. L_6 (52 μh) is on the right edge of the board and C_{120} is to the left of L_6. L_7 (1.69 μh) is on the lower

(Concluded on page 102)



The r.f. amplifier removed from its housing. The box mounts on the side of the house so the amplifier can be placed as close as possible to the antenna terminals.

Television Reception

(*Continued from page 40*)

edge. The output terminals extend from the lower edge of the board. These terminals have tube-base pins soldered to them to push into the input terminals of the tuner chassis.

This completes the description of the receiver. The third part of this article will discuss the results that have been obtained over the transmission path described in Part I. In order to present a comprehensive picture, the observations begun last summer will be continued through the winter and early spring so that the part played by atmospheric bending can be evaluated before the data are published. At that time, also, it is expected that information will be available on changing the r.f. circuits to the new channel allocation to become effective during the early part of 1946.