Building Television Receivers With Standard Cathode-Ray Tubes

Part I—Scanning, Synchronizing and Power Supply Circuits for One-Inch, Two-Inch and Three-Inch Tubes

By J. B. Sherman*

The articles by Marshall P. Wilder in QST, November, 1937, to May, 1938 constitute the first comprehensive treatment of modern television published in this country. Since their publication we have been able to gain an estimate of the widespread interest in the subject of television by amateurs everywhere and now are pleased to present this article as the first of a second series. An appropriate title for this treatment (and Part II to follow) would have been "Television for Thin Pocketbooks." It is aimed to fill the demand expressed by amateurs for simple equipment with which they can begin experimental work with an absolute minimum of expense.—EDITOR

BEFORE discussing the construction of apparatus for television reception, it may be well to review briefly the essential elements of a television receiver. Fig. 1 shows a block diagram of these elements. The total frequency band, including both sound and picture carriers, is handled in the r.f. first detector, and oscillator circuits. The intermediate-frequency output of the first detector is then fed both to an i.f. amplifier which selects the sound i.f. and rejects the picture i.f., and to an i.f. amplifier which selects the picture i.f. and rejects the sound i.f. The conventional second detector, a.f. amplifier, and loud speaker complete the sound receiver. The picture i.f. is designed to pass the wide frequency band required for good-quality pictures. The second detector and video amplifier circuits which follow the picture i.f. and supply the video signal to the cathode-ray grid must likewise satisfy this requirement. The synchronizing impulses are removed from the video signal by an amplitude-separator circuit, and the horizontal and vertical synchronizing impulses are then separated from each other and supplied respectively to the horizontal and vertical scanning circuits, which in turn furnish the cathode-ray deflections.

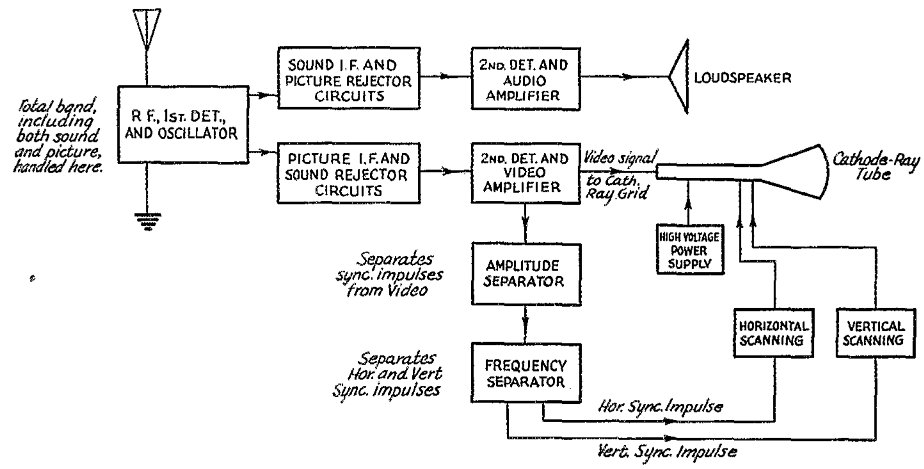

FIG. 1—THE ELEMENTS OF A MODERN TELEVISION RECEIVER

Thus there is produced on the screen of the cathode-ray tube a moving spot, the brightness of which varies from point to point in accordance with the brightness of the original scanned subject, and so reproduces on the screen an image of the original subject.

The foregoing brief outline of a television re-

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ceiving system will serve to refresh the general scheme in the mind of the reader.

Several standard electrostatic-deflection cathode-ray tubes available for oscillograph use afford the amateur the opportunity of constructing television receivers. This article will describe synchronizing, scanning, and power-supply circuits for one-inch, two-inch and three-inch tubes. Later articles will discuss the r.f., i.f., and video amplifiers.

The three oscillograph tubes mentioned are respectively the 913, 902, and 906. It will be appreciated that the picture quality of these tubes cannot equal that of regular kinescopes operating at much higher anode voltages; however, very presentable pictures can be obtained. Some definite figures on resolution obtainable are given below. "Resolution" as used here means the number of parallel lines which, if transmitted, can be distinguished as separate lines in the received picture.

The synchronizing and scanning circuits are the same for the 913, 902, and 906 and are shown in Fig. 2. The power supplies for the outfits are shown in Figs. 3 and 4.

Referring now to Fig. 2, we find a pentode-triode (6F7) which supplies synchronizing impulses from the received signal to gas triodes (884's). These 884's are used as relaxation oscillators to generate the horizontal and vertical sweep voltages. The oscillators feed 6F6 output tubes which furnish the cathode-ray deflecting voltages. It will be noted that the cathode-ray tube has a common connection for the second anode and one deflecting plate of each pair, permitting the use of single output tubes. Ordinarily, when a cathode-ray tube is connected thus, there is severe distortion of the pattern as well as bad defocusing of the spot. A special deflecting structure in the 906 and 902 greatly reduces both of these difficulties and thus allows considerable simplification of the deflecting circuits.

Tube Type	*Screen Size*	*2nd Anode Voltage*	*Resolution*
913	1"	500	Below 100 lines
902	2"	600	About 150 lines
906	3"	1500	About 250 lines

Let us now consider Fig. 2 in detail. The synchronizing signal, separated from the video signal, consists of high-frequency and low-frequency impulses, both supplied with negative polarity. These impulses are separated from each other and amplified in the 6F7 tube, the pentode section of which is connected for passage of the high-frequency impulse only and the triode section for passage of the low-frequency impulse only. The impulses leave the 6N7 with positive polarity and are applied to the respective 884 grids. The high- and low-frequency sweep outputs of the 884's are respectively 13,230 and 60 cycles. Coarse as well as fine frequency adjustments are provided to allow for variations among tubes. In use, the fine adjustment should be set to the center of its range, and the frequency set by means of the coarse control, after which the fine adjustment alone will be used. In use, each frequency control is manipulated together with the corresponding synchronizing voltage control, until best stability of the image is obtained.

The 884 oscillator outputs are not perfectly linear sawtooth waves. Adjustment of 6F6 bias gives an excellent means of

PHOTOGRAPHS OF THE IMAGE FROM A MONOSCOPE RECEIVED ON THE 906, 902 AND 913 CATHODE-RAY TUBES AND REPRODUCED AT APPROXIMATELY THE ORIGINAL SIZE

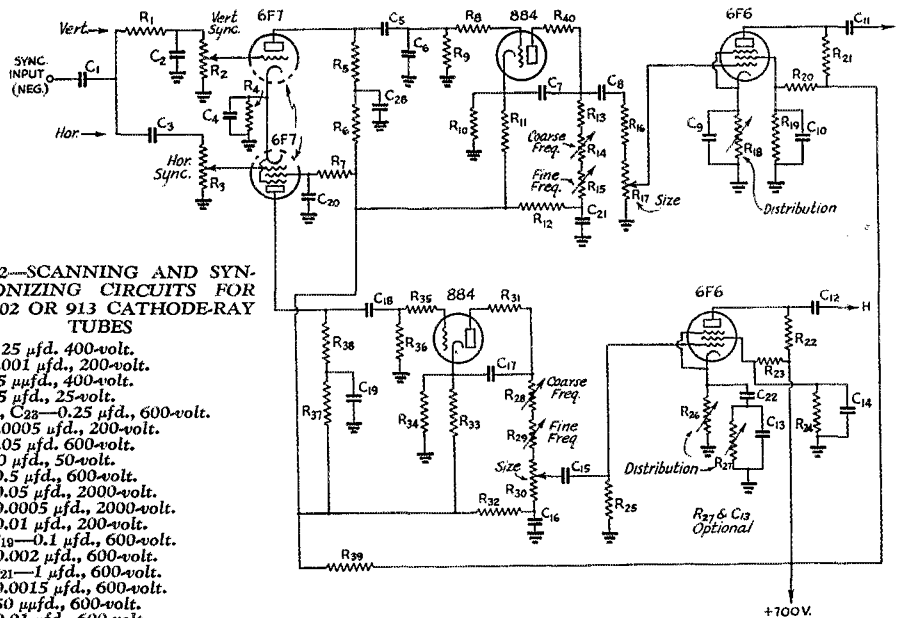


FIG. 2—SCANNING AND SYNCHRONIZING CIRCUITS FOR 906, 902 OR 913 CATHODE-RAY TUBES

C_1—0.25 $\mu fd.$ 400-volt.
C_2—0.001 $\mu fd.$, 200-volt.
C_3—25 $\mu\mu fd.$, 400-volt.
C_4—25 $\mu fd.$, 25-volt.
C_5, C_7, C_{23}—0.25 $\mu fd.$, 600-volt.
C_6—0.0005 $\mu fd.$, 200-volt.
C_8—0.05 $\mu fd.$ 600-volt.
C_9—50 $\mu fd.$, 50-volt.
C_{10}—0.5 $\mu fd.$, 600-volt.
C_{11}—0.05 $\mu fd.$, 2000-volt.
C_{12}—0.0005 $\mu fd.$, 2000-volt.
C_{13}—0.01 $\mu fd.$, 200-volt.
C_{14}, C_{19}—0.1 $\mu fd.$, 600-volt.
C_{15}—0.002 $\mu fd.$, 600-volt.
C_{16}, C_{21}—1 $\mu fd.$, 600-volt.
C_{17}—0.0015 $\mu fd.$, 600-volt.
C_{18}—50 $\mu\mu fd.$, 600-volt.
C_{20}—0.01 $\mu fd.$, 600-volt.
C_{22}—5 $\mu fd.$, 50-volt.
R_1, R_6, R_{38}—0.1 megohm, ½-watt.
R_2, R_3, R_{30}—0.2-megohm potentiometer.
R_4—7000 ohms, ½-watt.
R_5—0.2 megohm, ½-watt.
R_7, R_{20}—1 megohm, ½-watt.
R_8, R_{35}—50,000 ohms, ½-watt.
R_9, R_{36}—0.25 megohm, ½-watt.
R_{10}—2000 ohms, ½-watt.
R_{11}, R_{33}—0.15 megohm, 1-watt.
R_{12}, R_{32}—20,000 ohms, ½-watt.
R_{13}—0.4 megohm, ½-watt.
R_{14}, R_{17}—1-megohm potentiometer.
R_{15}—0.1-megohm potentiometer.
R_{16}—2 megohms, ½-watt.
R_{18}, R_{29}—25,000-ohm potentiometer.
R_{19}, R_{24}, R_{25}—0.5 megohm, ½-watt.
R_{21}—0.12 megohm, 2-watt.
R_{22}—25,000 ohms, 10-watt.
R_{23}—0.1 megohm, 4-watt.
R_{26}, R_{27}—10,000-ohm potentiometer.
R_{28}—0.5 megohm potentiometer.
R_{31}, R_{40}—500 ohms, ½-watt.
R_{34}—2500 ohms, ½-watt.
R_{37}—0.15 megohm, ½-watt.
R_{39}—50,000 ohms, 3-watt.

straightening these. Hence, variable cathode resistors R_{18} and R_{26} are provided for "distribution controls." Linear scanning is had by adjusting the amplitude controls R_{17} and R_{30} together with the corresponding distribution controls. It will probably be found easier to obtain linear vertical than horizontal scanning. The principal difficulty in the horizontal arises from the various circuit capacities which tend to reduce the transmission of the high-frequency components of the sawtooth wave. It must be remembered that a sawtooth wave is made up of a large number of harmonics, of which it is desirable to preserve about 10 if the sawtooth form is to be retained. This means that the 13-kc. sawtooth requires uniform transmission of frequencies up to about 130 kc. For this reason, care should be used in wiring and layout so that the circuit capacities, commencing with the high-frequency 884 plate circuit and going up to the cathode-ray deflecting plates, are as small as possible. Crowding of the picture due to loss of high frequencies in the horizontal sawtooth occurs at the left side of the picture. Should this occur, the insertion of R_{27} and R_{13} will be found helpful in increasing the high-frequency transmission. In practice, it will be found that the blanking signal which, during picture reception, cuts off the cathode-ray tube for the return of the horizontal sweep, removes a portion of the left side of the scanning field. Hence, some non-linearity at the extreme left can be tolerated and will not appear in the received picture.

At this point the reader will want to know how to check the linearity of the scanning. This can be done quite simply in the following manner. If a signal is applied to the control grid of the cathode-ray tube and one or both scanning oscillators synchronized with this signal, various stationary patterns can be produced on the screen. If in particular a signal of, say, 600-cycle frequency is applied to the cathode-ray grid and the vertical oscillator (60 cycles) is synchronized with this signal, the grid will be driven alternately positive and negative (with respect to its initial bias) ten times during one vertical sweep, and a series of ten bright, stationary, horizontal bars with intervening dark spaces will appear on the screen. If the vertical sweep is linear, the bars will be equally spaced and an actual picture received under this scanning condition would be uniformly spread from top to bottom. Similarly, vertical bars to determine the horizontal distribution can be produced by applying a high frequency between, say, 75 and 150 kc. to the cathode-ray grid and synchronizing the horizontal oscillator

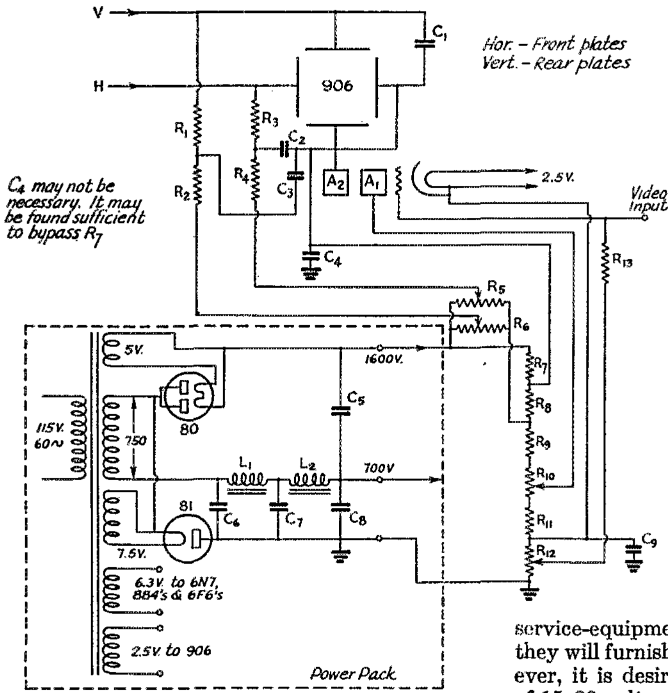


FIG. 3—POWER SUPPLY AND CATHODE-RAY TUBE CONNECTIONS FOR THE 906

Everything except the unit marked "power pack" is built into the same unit as the equipment in Fig. 2.

C_1—0.001-µfd. mica.
C_2, C_3—1 µfd., 200-volt.
C_4—0.5 µfd., 2000-volt.
C_5—0.5 µfd., 1000-volt.
C_6—16 µfd., 800-volt.
C_7, C_8—4 µfd., 800-volt.
C_9—0.05 µfd., 200-volt.
R_1—1.0 megohm, 1-watt.
R_2, R_4—50,000 ohms, ½-watt.
R_3—0.5 megohm, 1-watt.
R_5, R_6—0.2-megohm potentiometer.
R_7, R_8—0.1 megohm, ½-watt.
R_9—0.5 megohm, 1-watt.
R_{10}—0.5-megohm potentiometer.
R_{11}—0.25 megohm, ½-watt.
R_{12}—50,000-ohm potentiometer.
R_{13}—0.5 megohm, ½-watt.
L_1, L_2—5 henrys.

with this signal. If both high and low frequencies are applied together and the scanning oscillators synchronized, a checkered pattern will appear which will show both vertical and horizontal distribution at once. (It is not necessary to do this; each may be taken separately.) Fig. 5 shows a distribution pattern produced on a 906 tube in this manner.

The test signals are applied to the video input terminal shown on Fig. 2 through a blocking condenser of 0.1 µfd., and also connected to the synchronizing input terminal. Fig. 6 shows the circuit of a simple double-oscillator which is convenient for obtaining the test signals. A beat-frequency audio oscillator and r.f. signal generator of the service-equipment type may be available; if so, they will furnish convenient signal sources. However, it is desirable to have signals of the order of 15–20 volts, which the r.f. service outfit may not supply without amplification.

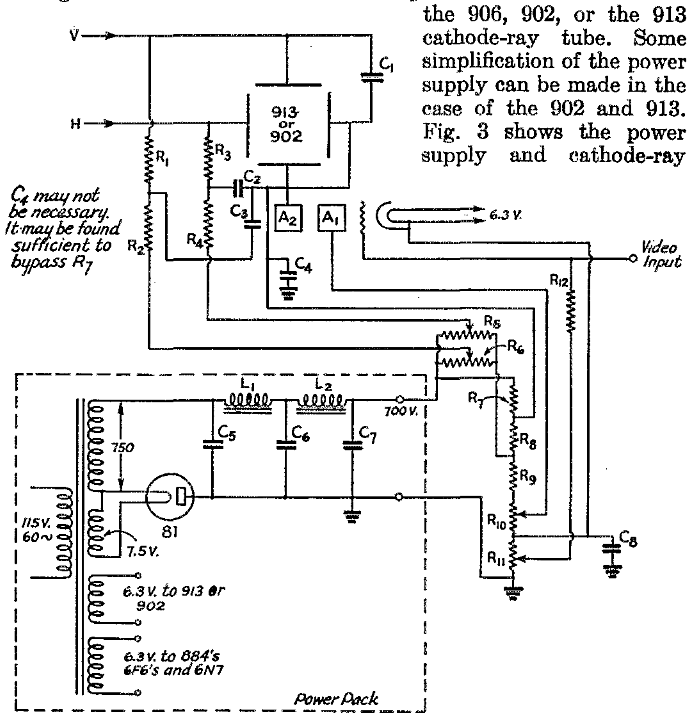


FIG. 4—POWER SUPPLY AND CATHODE-RAY TUBE CONNECTIONS FOR THE 913 AND 902

Everything except the power pack is built into the same unit as the equipment in Fig. 2.

C_1—0.001-µfd. mica.
C_2, C_3—1 µfd., 200-volt.
C_4—0.5 µfd., 800-volt.
C_5—16 µfd., 800-volt.
C_6, C_7—4 µfd., 800-volt.
C_8—0.05 µfd., 200-volt.
R_1—1.0 megohm, 1-watt.
R_2, R_4—50,000 ohms, ½-watt.
R_3—0.5 megohm, 1-watt.
R_5, R_6—0.2-megohm potentiometer.
R_7, R_8—0.1 megohm, ½-watt.
R_9—0.5 megohm, 1-watt.
R_{10}, R_{11}—0.2-megohm potentiometer.
R_{12}—0.5 megohm, ½-watt.
L_1, L_2—5 henrys.

The same scanning circuits are used for either the 906, 902, or the 913 cathode-ray tube. Some simplification of the power supply can be made in the case of the 902 and 913. Fig. 3 shows the power supply and cathode-ray tube connections for the 906, and Fig. 4 shows these for the 902 and 913. A special doubler arrangement is used for the 906 which supplies both high and low voltages from a single transformer winding. An ordinary receiver power transformer

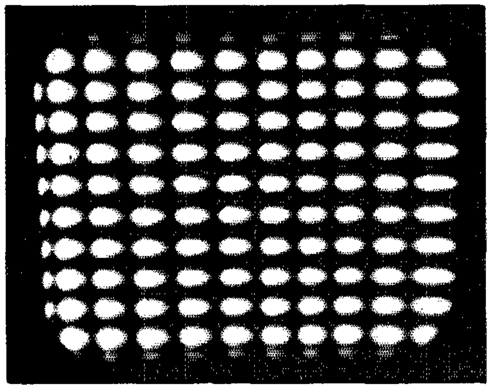


FIG. 5—THE PATTERN PRODUCED ON THE SCREEN OF THE 906 BY THE OUTPUT OF THE BAR PATTERN GENERATOR OF FIG. 6

will take care of all the requirements with the possible exception of the 81 filament, which may call for a separate transformer. The filter condenser requirements can be met economically by using combinations of standard 450-volt electrolytics; for example, four 16-μfd. condensers in series-parallel to give 16-μfd. and two 8-μfd. condensers in series to give 4 μfd.

It will be noted that, contrary to usual oscillograph practice, the cathode-ray tube is operated with cathode near ground potential and second anode at high positive potential with respect to ground. This arrangement permits a d.c. connection to the grid of the cathode-ray tube. The direct connection allows the use of the receiver, with the transmission scheme of d.c. carrier modulation for control of the background intensity of the picture, without the use of a d.c. restoring tube. This of course requires d.c. amplification between the second detector and cathode-ray grid, or a d.c. connection from second detector to cathode-ray grid if sufficient output is available without amplification.

Potentiometers R_5 and R_6 are adjustments which permit the picture to be centered on the screen.

In the absence of scanning, the intensity control should be turned far down to avoid a bright, stationary spot which may permanently damage the screen. The usual precautions in the handling of high-voltage apparatus should, of course, be observed.

The power supply should preferably be built as a separate unit and connected by cable to the cathode-ray and scanning unit. If the second-anode lead is run separately and isolated, the high-voltage by-pass condenser C_4 may not be necessary, in which case, however, R_7 should be by-passed by a 1-μfd., 200-volt condenser.

It is recommended that panel controls be made of the two amplitude, the two fine-frequency, and the brilliance and focus controls. The remainder of the controls can be screw-driver adjustments; that is, the potentiometer shafts are cut short and slotted with a hacksaw to receive a screw-driver blade.

On page 22 are shown photographs of images transmitted from a Monoscope and received on the 913, 902, and 906, respectively. Despite the inferior resolution of the smaller tubes, the smaller size of the picture tends to mask the loss of detail. The photographs were 30-second exposures, which gives some idea of the stability of the outfit. These pictures were received by direct wire connection of the video signal, no r.f. system being interposed. While the performance of regular Kinescopes must not be expected, it is nevertheless felt that some very acceptable results are obtained.

Strays

General Electric Bulletins GES-1996 and GEA-1999 are asimuthal world projection maps centered on Schenectady, New York, and Oakland, California, respectively. These bulletins, printed on letter-size paper, should be convenient for use on the operating tables of DX men.

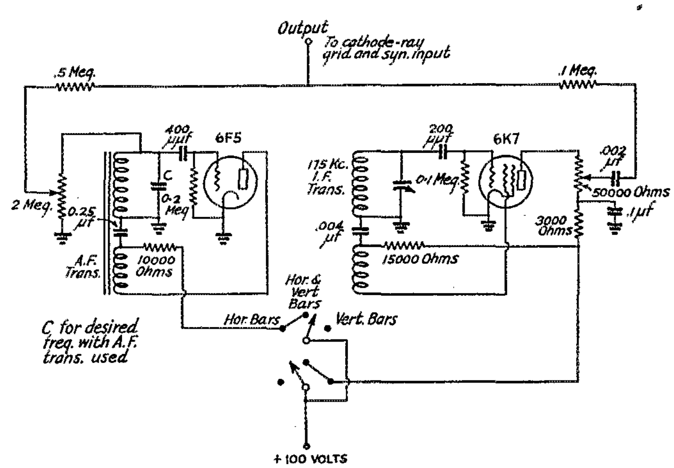


FIG. 6—CIRCUIT OF A SIMPLE BAR PATTERN GENERATOR FOR CHECKING THE LINEARITY OF SWEEP VOLTAGES

A Practical Television Receiver for the Amateur

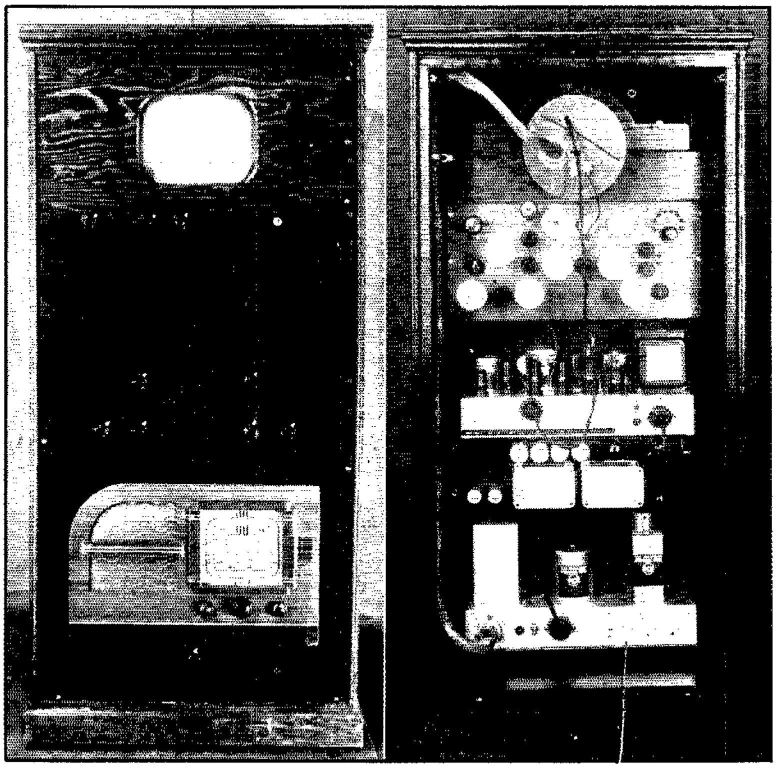
General Design Considerations, the Superheterodyne Circuit and Part of the Constructional Details

By C. C. Shumard*

With regular television programs scheduled to start with the opening of the World's Fair at New York, this description of a modern television receiver should have special interest to amateurs, especially those living in metropolitan areas. If the circuit diagram looks formidable, take heart from considering that the average amateur transmitter circuit, if drawn complete with power supplies and control wiring, would be a fearfully complicated affair. Simplicity comes with dissecting and grouping—which the author does in this article, the second of the series inaugurated in October QST.

IN a previous issue of *QST*,[1] Mr. J. B. Sherman has described a scanning unit employing electrostatic deflection. The television receiver to be described here has been designed to operate with a scanning unit of the electromagnetic or electrostatic type, the choice depending on the type of cathode-ray tube or Kinescope to be employed. Provision is also made for simultaneously supplying sound transmissions from the converter plate circuit of this receiver to the antenna-input circuit of an all-wave or suitable short-wave receiver. This auxiliary receiver for sound reproduction must be capable of tuning to about 30 meters, or 9.75 Mc.

Several views of the television receiver chassis and the low-voltage power-supply unit are shown in the accompanying photographs. The schematic diagram of the receiver is shown in Fig.

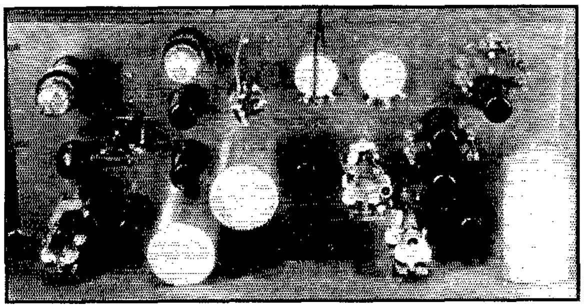


FRONT AND REAR VIEWS OF THE EXPERIMENTAL TELEVISION RECEIVER

The midget receiver set in the panel at the bottom is a standard all-wave broadcast set used as an i.f. amplifier for the sound channel. The units described in this article are the power supply (second from bottom) and the video receiver (fourth from bottom). A magnetic-deflection type Kinescope, with associated circuits, is shown in this set-up, but the receiver may also be used with the electrostatic-deflection circuits given in Part I of this series, with changes to be described in a subsequent article.

* RCA Manufacturing Co., Inc., Harrison, N. J.

[1] Sherman, "Building Television Receivers with Standard Cathode-Ray Tubes," *QST*, October, 1938.



REAR VIEW OF THE RECEIVER WITH SHIELDS REMOVED TO SHOW CONSTRUCTION OF COUPLING UNITS

The receiver is assembled on a relay-rack panel which mounts vertically in the cabinet shown in another photograph.

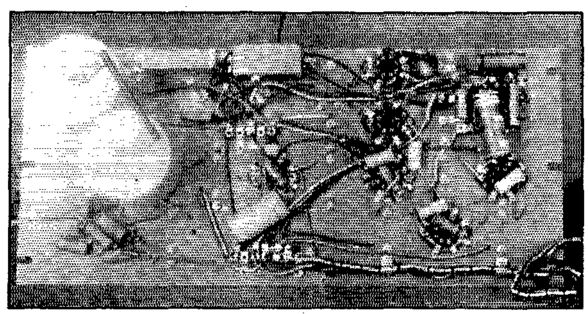
2. It should be stated at once that although the circuit itself seems to be somewhat complicated, it actually should present no insurmountable problems to the amateur set-builder who has had practical experience in building short-wave or ultra-high-frequency superheterodyne communication-type receivers. As the photographs show, the receiver itself is not as formidable appearing as the schematic circuit.

Limitation of space precludes much theoretical discussion; in addition, information of this type has been well covered in many previous papers.[2] However, a brief, general discussion of the various parts of the receiver is desirable in order to explain their functions.

In general, the television receiver is quite similar to an ordinary superheterodyne, with variations and additions. In this particular set are included one r.f. stage, a mixer, three i.f. stages, a combination detector and background-control stage, and one video stage. The video stage corresponds to the first audio stage in a communications receiver, except that it feeds the picture or video signal, after it has been demodulated by the diode detector, to the control grid of the Kinescope. Also included are the high-frequency oscillator, the "sound buffer" the "sync separator" and the a.g.c. amplifier. The tube and circuit arrangement is chosen to provide good selectivity, sensitivity, and fidelity, using parts which are readily available to or makeable by the amateur constructor. Because of the band-switching, or rather, "channel-switching" design of the r.f. circuits, the receiver can be tuned to any one of three separate television channels between 40 and 60 megacycles. Thus, when several television stations come on the air in that frequency range, the receiver will not be limited just to one station. Automatic gain control is provided to take care of different receiving locations at various distances from the transmitter, and of various signal strengths from different transmitters. There is, of course, little need for a.g.c. on the ultra-high frequencies, so far as fading is concerned.[3]

A reference to the block frequency chart of Fig. 1 will be of assistance in understanding the operation of various portions of the receiver, as well as of individual circuit components. A typical television signal, with the accompanying sound channel, is shown at A, B, and C. This type of television signal is like that which is being transmitted by the NBC's experimental station from the Empire State Building in New York City. It is in accord with the television transmission standards as recommended by the Radio Manufacturer's Association. The video carrier frequency is 46.5 megacycles, with upper and lower sidebands (picture modulation) extending to 49 Mc. and 44 Mc. The sound carrier frequency is 49.75 Mc., which is 750 kilocycles away from the upper sideband of the video carrier.

The high-frequency oscillator (Type 6J5) operates at 59.5 megacycles. Because the i.f. stages are tuned to respond only to the upper sideband of the video carrier (section B of Fig. 1) and to the sound carrier (C), the output of the i.f. stages corresponds to E and F of Fig. 1. The i.f. band width shown is 10.5 to 13 megacycles. Because the difference between the video carrier and sound carrier frequencies is 3.25 Mc. and because some separation between the two must be provided, a video band about 2.7 Mc. wide has been maintained throughout the receiver. This is sufficient to provide good picture detail. After the i.f. signal (E) is demodulated by the 6H6 diode detector (V_8), the video signal (G) is applied to the video amplifier (V_9). The i.f. sound



FRONT VIEW OF THE RECEIVER

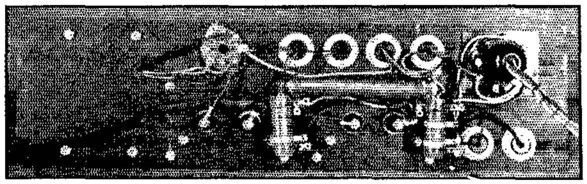
This side faces the front of the cabinet. The two cans at the left contain the r.f. circuits, with frequency-changing switches ganged together.

[2] See Bibliography. (Also M. P. Wilder, *QST* December, 1937, January and February, 1938—EDITOR.)

[3] When fading is present, as in the case of long-distance transmission through refraction in the lower atmosphere or, less frequently, in the ionosphere, frequency discrimination usually causes the picture quality to be considerably impaired.—EDITOR.

carrier (F) is demodulated and reproduced as (H) in the auxiliary short-wave receiver previously mentioned.

Included in the modulation of the video carrier (B) are two high-amplitude synchronizing signals, which must be properly separated from the video modulation and applied to the sync amplifiers (in the scanning unit) so that the scanning of the Kinescope screen will be correctly synchronized with the scanning circuits of the transmitter. The synchronizing signals are obtained from the output of the video amplifier by means of the 6F8G sync separator (V_{10}).



FRONT SIDE OF THE POWER SUPPLY

This unit also mounts vertically; a rear view is shown in the photo graph of the complete receiver.

The video amplifier (V_9) supplies the video signal voltage to the control grid of the Kinescope, for the purpose of modulating the brilliance of the spot on the Kinescope screen as it scans the picture. The polarity of the potential changes on the Kinescope grid *must correspond* to the character of the video modulation at the transmitter. This modulation is such that an increase in carrier amplitude corresponds to black on the subject picture. Therefore, the Kinescope grid must be made to swing more negative as the video carrier increases in amplitude, and less negative as the carrier amplitude decreases. Otherwise, the received picture will correspond to a photographic negative rather than to a positive. The second-detector circuit and the number of video stages employed must be properly chosen, due to the fact that each video stage acts as a polarity reverser.

In this receiver, the detector arrangement is such that a positive potential (with respect to ground) is applied to the grid of the first video stage. Therefore, an odd number of video stages is required (one or three). The gain obtained from the i.f. stages and from the 1852 video amplifier is sufficiently high so that only one video stage is needed (V_9). Because slowly shifting or "low-frequency" scenes must be transmitted, direct coupling is used between the detector and V_9 and between V_9 and the Kinescope grid.

The high-amplitude synchronizing voltages included with the video modulation at the output of V_9 are also applied to the Kinescope grid. In time sequence, they occur at the ends of the vertical and horizontal scanning lines. Thus, for the duration of each synchronizing impulse, the Kinescope grid is caused to go sufficiently negative to make its potential below the grid bias value corresponding to black. Therefore, the synchronizing signals do not show on the received picture because they are, in effect, "blacker than black."

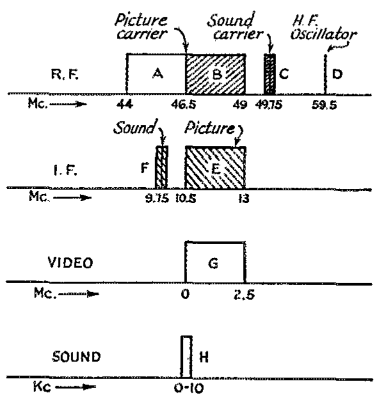


FIG. 1—BLOCK FREQUENCY DIAGRAM FOR THE VIDEO RECEIVER

VIDEO AMPLIFIER

A peak voltage of approximately 20 volts applied to the grid of Kinescope Type 1800 is required to swing the Kinescope from full brilliance to below cutoff, or to "blacker than black." A plate load of 2500 ohms, properly compensated with inductance to take care of the 2.7-Mc. band width, is employed in the video stage. A peak signal input voltage of about 1.0 volt is necessary to develop the required 20 volts over the desired video band.

DETECTOR

The detector load must be kept low and its capacitance effect must be compensated for, in order to pass the video frequencies. This compensation is accomplished by means of inductances L_{21} and L_{22} (Fig. 2). Only one diode unit of the 6H6 (V_8) is employed for the detector. With the detector-diode load (4300 ohms) employed and at the required output level of about 1.0 peak volt, the voltage drop in the diode is about 0.5 volt. Therefore, an i.f. input of approximately 1.5 peak volts is needed.

The use of only one diode unit as a detector helps to limit the capacitance and resistance load on the output of the last i.f. stage, and permits the other diode unit to be used to bias the Kinescope beyond cut-off while the Kinescope and the other tubes are heating, thus keeping the screen dark.

With single sideband i.f. operation, some undesirable overlapping of the low video-frequency modulation results. This necessitates a reduction in the i.f. gain on the high-frequency side of the i.f. band. The reduction in gain should be of the order of 40 percent.

I.F. AMPLIFIER

The choice of intermediate frequency is necessarily a compromise between conflicting requirements. A high ratio of i.f. "carrier" to video

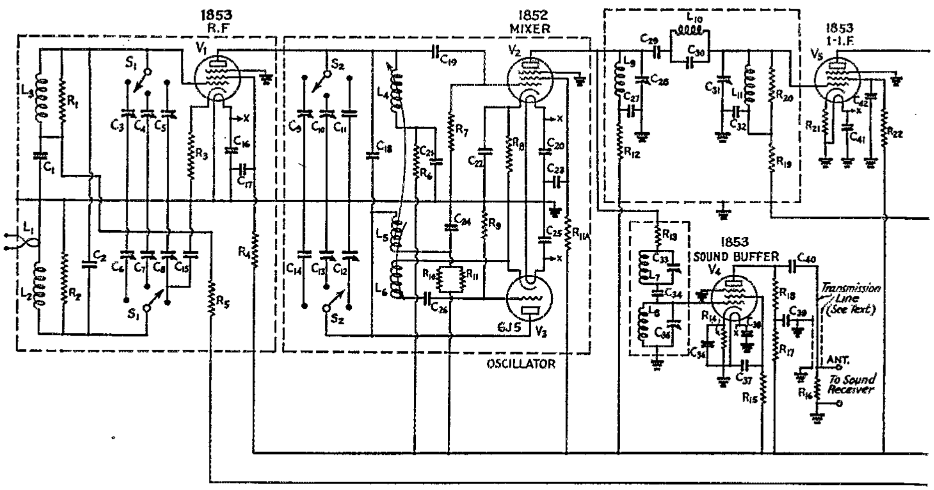


FIG. 2—CIRCUIT DIAGRAM OF THE RECEIVER AND POWER SUPPLY

C_1, C_{17}, C_{19}, C_{21}, C_{22}, C_{23}, C_{24}—500-μμfd. mica (Micamold OM900).
C_2—5-μμfd. mica (Micamold GM800).
C_3, C_4, C_7, C_8, C_9, C_{12}—20-μμfd. air trimmer (RCA-Victor 12884).
C_5, C_6, C_{10}, C_{13}—12-μμfd. air trimmer (RCA-Victor 12714).
C_{11}, C_{14}—Value depends on frequency desired.
C_{15}—10-μμfd. mica (Micamold GM 800).
C_{16}, C_{20}, C_{25}, C_{32}, C_{36}, C_{38}, C_{41}, C_{48}, C_{49}, C_{56}, C_{57}, C_{64}, C_{66}—0.01-μfd. paper, 400-volt (Solar S-0219).
C_{18}—1μμfd. (Micamold GM800).
C_{26}—40-μμfd. mica (Micamold GM-800).
C_{27}, C_{37}, C_{39}, C_{40}, C_{42}, C_{43}, C_{50}, C_{51}, C_{58}, C_{59}—0.01-μfd., 400-v. paper (Aerovox).
C_{28}, C_{31}, C_{33}, C_{35}, C_{44}, C_{47}, C_{52}, C_{55}, C_{60}, C_{63}—25-μμfd. variable (Hammarlund APC-25).
C_{29}, C_{34}, C_{45}, C_{53}, C_{61}—560 μμfd. (RCA-Victor M39, No. 12537).
C_{30}, C_{46}, C_{54}, C_{62}—18 μμfd. (See note) (RCA Victor M12, No. 12722).*
C_{65}, C_{69}—4-μfd. electrolytic, 450 v. (Aerovox ST-855).
C_{67}—0.25-μfd. (min.), 400-v. paper.
C_{67A}—1-μfd., 400-v. paper.
C_{68}, C_{70}—0.05-μfd., 400-v. paper.
C_{71}—10-μfd. electrolytic, 25-v. (Sprague TA-10).
C_{72}—0.05-μfd., 200-v. paper.
C_{72A}—50-μfd. electrolytic, 25-v.
C_{73}—2-μfd. (min.), 200-v. paper.
C_{74}—8-μfd. electrolytic, 450-v. (Sprague PTM-8).
C_{75}, C_{76}—50-μfd. electrolytic, 25-volt (Mallory RS-200).
C_{77}, C_{78}—8-μfd. electrolytic, 450-v.
C_{79}, C_{80}—16-μfd. electrolytic, 450-v.
R_1, R_{34}—3000 ohms, 0.5-watt.
R_2, R_7, R_{17}—2000 ohms, 0.5-watt.
R_3, R_{21}, R_{26}, R_{31}—68 ohms, 0.5-watt.
R_4, R_{10}, R_{11}, R_{15}, R_{22}, R_{27}, R_{32}, R_{54}—30,000 ohms, 0.5-watt.
R_5, R_{19}, R_{24}, R_{29}, R_{49}—20,000 ohms, 0.5-watt.
R_6, R_8, R_{12}, R_{18}, R_{23}, R_{28}, R_{33}, R_{41A}, R_{43}, R_{44}, R_{53}, R_{54A}—1000 ohms, 0.5-watt.
R_9, R_{47}—10,000 ohms, 0.5-watt.
R_{11A}—150,000 ohms, 0.5-watt.
R_{13}, R_{56}—15,000 ohms., 0.5-watt.
R_{14}—200 ohms, 0.5-watt.
R_{16}—50 ohms, 0.5-watt.
R_{20}, R_{25}, R_{30}—2500 ohms, 0.5-watt.
R_{35}, R_{51}—200,000 ohms, 0.5-watt.
R_{36}—4300 ohms, 0.5-watt.
R_{37}—50,000 ohms, 1-watt.
R_{38}—50,000 ohms, 0.5-watt.
R_{39}, R_{40}, R_{41}—5000 ohms, 0.5-watt.
R_{42}—5000 ohm potentiometer.
R_{45}, R_{52}—20,000 ohms, 1-watt.
R_{46}—3 megohms, 0.5-watt.
R_{48}—0.5 megohm, ½-watt.
R_{50}—50,000 ohms, 0.5-watt.
R_{55}—25,000-ohm potentiometer.
R_{57}—20 ohms, 1-watt.
R_{58}—100-ohms, 1-watt.
R_{59}—5000 ohms, 25-watt.
R_{60}—340 ohms, 10-watt.
L_1 to L_{23}—To be described in Part III.
L_{24}, L_{25}—20-henry, 200-ma., 100-ohm filter choke.
T_1—Power transformer (Thordarson Type T-13R16).
S_1, S_2—Mallory-Yaxley selector switch No. 3243-J.

** Value of these condensers is critical.*

All fixed ½- and 1-watt resistors are I.R.C. Type BT.

band-width assists in obtaining a flat i.f. response over the desired range of video frequencies. A low intermediate-frequency permits greater gain per stage and better stability. The i.f. "carrier" value chosen is 13 Mc., which seems to represent a reasonable compromise for both band-width and gain considerations.

Ordinary i.f. transformers are not employed, because the type of i.f. response curve desired can better be obtained with coupling networks consisting of inductance, capacitance, and resistance. These coupling units, as well as those used in the r.f., mixer, h.f. oscillator, and sound buffer stages, are "hand tailored". Complete design data on the various units will be given later, in Part III of this paper.

The i.f. gain per stage is about 5 to 8 for a pass-band of 13.0 to 10.3 Mc. Three i.f. stages give sufficient overall gain.

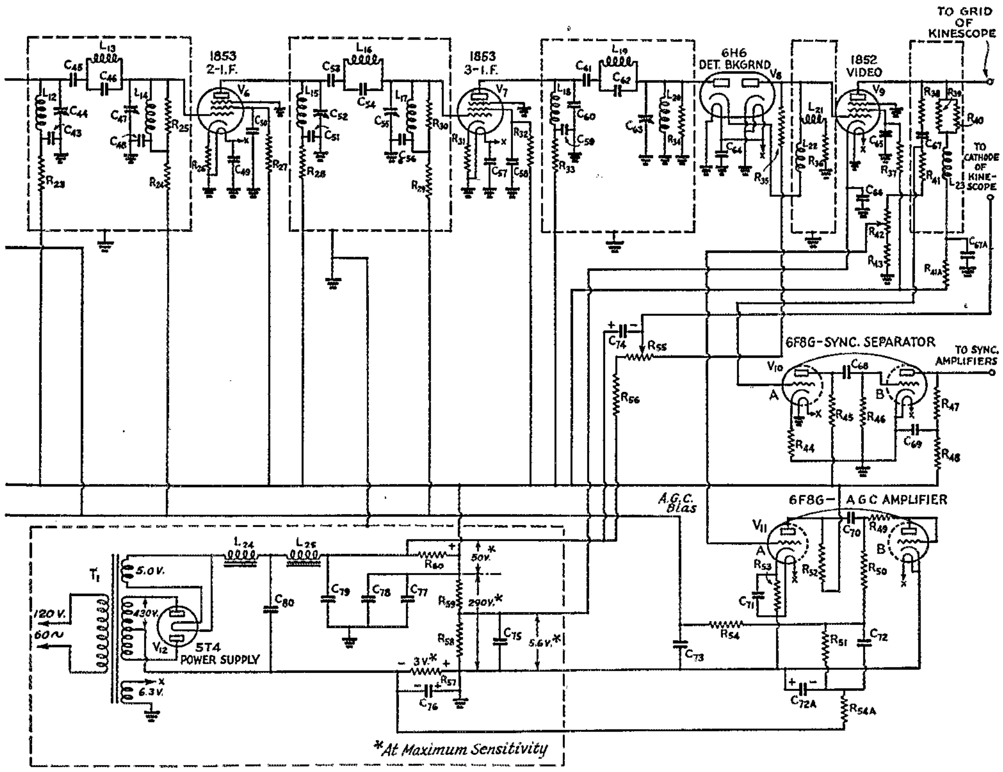
MIXER AND OSCILLATOR

An 1852 is used as the mixer (V_2) in conjunction with a 6J5 h.f. oscillator (V_3). Inductive and capacitive coupling is employed between the oscillator plate coil (L_5) and the r.f. amplifier plate coil (L_4), which is capacitance coupled to the No. 1 grid of the mixer in conventional manner.

The oscillator is operated at a higher frequency than the video carrier in order to maintain less coupling discrimination throughout the wide video sideband range. For reception of the transmitter chosen as an example for this discussion, which is assumed to have a video carrier of 46.5 Mc. (see Fig. 1), the oscillator frequency is 59.5 Mc.

R.F. AMPLIFIER

The grid circuit of the r.f. amplifier stage consists of a band-pass network (L_2, L_3 and associated



circuits) tunable from about 40 to 60 megacycles, with a pass band of nearly 3 Mc. The various tuned circuits, including the oscillator circuit, are fixed-tuned by means of adjustable, plunger-type, air condensers. Because there is not enough room in the oscillator-mixer shield can for more than four of the plunger-type condensers, C_{11} and C_{14} (not included in the present receiver) can be of the midget compression type, if the third channel is to be covered. A single-turn coil (L_1) couples the antenna to the grid circuit. This coil has a grounded center-tap, so that it is suitable for use with a doublet antenna employing a twisted-pair transmission line. The double-tuned input circuit, correctly adjusted, provides the familiar double-humped response curve of two over-coupled circuits and thus improves the over-all band-pass characteristics of the entire receiver.

The r.f. amplifier plate circuit consists of a single, broadly-resonant tuned circuit supplementing the grid network. The output of the r.f. stage is capacitance-coupled to the No. 1 grid of the mixer tube.

The adjustable plunger-type tuning condensers are ganged for channel switching by means of switches S_1 and S_2. Only one set of condensers need to be adjusted if reception of only one television station is contemplated. It is highly desirable and economical, however, to make provision for the two additional channels, in order to save the trouble and work involved in rebuilding the "front end" of the set at a later date.

SOUND BUFFER

The "sound buffer," employing a Type 1853 (V_4), receives the i.f. signal with the sound modulation directly from the plate of the mixer tube. A tuned network (L_7, L_8, and associated circuit) helps to filter out the low-frequency end of the video i.f. carrier (approximately 10.5 Mc.) while it passes the sound i.f. carrier (9.75 Mc.). An important function of the sound buffer tube is to prevent interaction between the high-frequency oscillator (tuned to about 10.2 Mc.) of the sound receiver and the i.f. circuits of the video receiver.

The output of the sound buffer tube is resistance-capacitance coupled to a 50-ohm coaxial transmission line (see Fig. 2). The transmission line consists of a length of No. 18-16/30 "Shielded Nu-Cor," made by the Cornish Wire Co., New York City. Any other type of shielded wire of similar characteristics can be employed. The transmission line is terminated at the auxiliary short-wave "sound" receiver with a 50-ohm resistor, the leads from which go to the antenna and ground terminals of the sound receiver. The sound i.f. carrier in this example is 9.75 Mc., to which frequency the sound receiver must be tuned. This frequency setting does not have to be

(*Continued on page 72*)

A Practical Television Receiver

(Continued from page 25)

changed for different video carrier frequencies, because the sound i.f. signal is of fixed frequency, as in an ordinary superheterodyne receiver.

SYNC SEPARATOR

As has been previously mentioned, the output of the video amplifier includes the video signal and the two synchronizing signals. The function of the sync separator is to separate the high-amplitude horizontal and vertical synchronizing signals from the video signal. The sync separator employs a Type 6F8G twin triode (V_{10}). A small amount of signal from the video amplifier plate circuit is obtained from a resistance-capacitance voltage-divider network and amplified by triode unit "A" of V_{10}. Triode unit "A" also serves to reverse the polarity of the signal, so that the synchronizing pulses appear as large positive-peak voltages at the grid of the second triode unit, "B." Due to these high-amplitude positive peaks, triode "B" becomes partially blocked — the action being similar to that of a grid-leak detector under large-signal conditions. The grid-leak and grid-condenser values are selected so that triode "B" conducts just for the duration of the synchronizing signals, and allows only these signals to appear as plate-current pulses in the output circuit. In this manner, the video signals are rejected and the two synchronizing signals are passed. The synchronizing signals are later separated from each other by the sync amplifiers, which are designated by the term "frequency separator" in the block diagram shown by Mr. Sherman in Part I.[1]

A.G.C. AMPLIFIER

A Type 6F8G (V_{11}) is used for the automatic-gain-control stage. A small portion of the output of the video amplifier is applied to the grid of triode unit "A" of V_{11}. This signal, after amplification by triode "A," is applied to triode unit "B" connected as a diode. Triode "B" operates like a peak vacuum-tube voltmeter. That is, due to the relatively large time constant of resistor R_{51} and condenser C_{72}, the d.c. voltage developed across R_{51} is held near the peak value of the applied a.c. voltage. The peak a.c. voltage depends not only on the amplitude of the synchronizing signals, but also on the average amplitude of the video signals. The a.g.c. voltage developed across R_{51} is filtered in the usual manner and applied as negative grid bias to the r.f. and i.f. amplifiers.

The a.c.-coupled a.g.c. system employed in this receiver does not provide as effective gain control as a direct-coupled a.g.c. system. However, the latter arrangement involves additional complications in the power supply and other circuits.

POWER SUPPLY

The power supply includes a full-wave, high-vacuum rectifier (Type 5T4) and a conventional, low-resistance, two-section filter. A choke-input type of filter is used to provide good voltage regulation. The output of the filter is rather heavily loaded in order to keep the d.c. plate load of the 1852 video amplifier small. It is essential to minimize the voltage variations across R_{60} caused by fluctuations of d.c. load current with a.g.c. voltage. Front and back views of the supply, mounted on a 5¼ by 19-inch relay-rack panel, are shown in the photographs.

CONSTRUCTIONAL DETAILS

The various parts of the receiver are mounted on a standard panel of one-eighth inch sheet aluminum, 8¾ by 19 inches, designed for relay-rack mounting in a cabinet. Some details of the mounting of the different units which go to make up the complete television receiver can be seen in the photographs. The receiver chassis mounts vertically, at a distance (depending on the length of the Kinescope) behind the front panel of the cabinet. Although these photographs show the receiver with the 9-inch Kinescope, Type 1800, they will serve to illustrate the method of assembly, which is equally suitable for smaller cathode-ray tubes such as the 902 and 906. The scanning unit (third from bottom) is of the electromagnetic type, and is not the same as the electrostatic scanning unit described by Mr. J. B. Sherman.

Also shown are photographs giving front and back views of the receiver chassis with all parts mounted, but with the shield cans removed from units of differing construction. The front view shows the r.f. and oscillator-mixer units (in the shield cans) with the ganged, channel-changing switch mechanism at the tops of the cans. The two potentiometers located near the top of the chassis in the rear view are (right) the a.g.c. control (R_{42}) and (left) the Kinescope cathode-bias control (R_{55}). The latter serves to adjust the brilliance of the picture on the Kinescope screen.

In the back view of the receiver chassis the "hand-tailored" units from which the shield cans have been removed are as follows: bottom left, i.f. coupler No. 4; top left, video-amplifier input compensating unit; top center, video-amplifier output network; top right, i.f. coupler No. 1; and bottom right, sound-buffer input network. The lower shield can contains i.f. coupler No. 3; the upper shield can, i.f. coupler No. 2. The holes through which the variable condensers in an i.f. unit are tuned can be seen in the shield can at the lower right-hand corner.

Constructional details of the various coupling units, filter networks, and compensating networks, as well as a description of the alignment, adjustment, and operation of the television receiver, will be given in a subsequent issue.

(NOTE.—*In the design of this receiver, a great deal of care has been given to the selection of components, both electrically and from the standpoint of suitable physical size, and their placement. To aid the constructor, manufacturers' names have been given in each case where the choice of a component is important. A complete chassis layout will be given in the subsequent article.*—EDITOR.)

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Construction and Alignment of the Television Receiver

R.F. and I.F. Coupling Units—Test Equipment—Performance Curves

BY C. C. SHUMARD*

In December *QST*[1] the circuit of the superheterodyne television receiver was given, as well as a functional analysis of the various stages. In this article, the construction of the "hand-tailored" parts will be described. The alignment and operating procedure will be explained in detail.

As even the most casual reader must know by this time, the design of coupling circuits which will pass the extraordinarily wide frequency band necessary for good picture reception is one of the most critical features of a television receiver. In this article, a continuation of the one by the same author in December *QST*, the construction of these circuits is discussed in detail. The exact dimensions given, as well as the carefully worked out alignment procedure, should enable the constructor to get the receiver into operation with a minimum of trouble. In conjunction with the deflection circuits for small cathode-ray tubes described in October *QST*, it constitutes a complete television receiving system. Data on using electromagnetic-deflection tubes and on the new electrostatically-deflected Kinescopes will be given in a subsequent issue.

CONSTRUCTION

R.F. Input Stage Assembly

In photo "A," the lower right-hand unit shows the r.f. and antenna coil assembly, with switch S_1 (refer to Fig. 2 of December *QST*) mounted on a 3-legged bracket above the coil form. Design data for the three coils (L_1, L_2 and L_3) are given in Fig. 4. The coil form is made of thin-walled bakelite tubing. The single-turn antenna coil, wound with No. 14 enameled wire, has its output leads crossed over for a distance of about ¼ inch; the leads then go through separate holes in the chassis to the two-lug terminal strip mounted on the opposite side of the chassis. These leads are short enough to make the antenna coil self-supporting — it is not directly fastened to the coil form, except on the ground lug where the center-tap connection is made. Another view of this unit is shown in photo "B" (at left). The various by-pass condensers and resistors are mounted around the coil form, with very short leads.

It may have been noted that the parts list given in the legend of Fig. 2, December *QST*, is quite specific as to the particular parts employed. Many of the parts were carefully chosen for small physical size, so that they would go in the rather limited space available in the shielded units.

Oscillator-Mixer Stage Assembly

Photo "A" (upper unit) shows the oscillator-mixer coil assembly, with switch S_2 mounted at the top. Design data for coils L_4, L_5 and L_6 (circuit constants are referred to Fig. 2) are given in Fig. 5. The oscillator coils L_5 and L_6, wound with heavy enameled wire, are held in place by the pressure of the wire on the coil form, assisted by the short, stiff output leads soldered to nearby circuit parts. Coil L_4 is held in place by small soldering lugs riveted to the form at each end of the winding. Collodion, used sparingly, also helps to hold the windings in place. The coil form is of the same material as in the r.f. unit.

I.F. Coupling Units

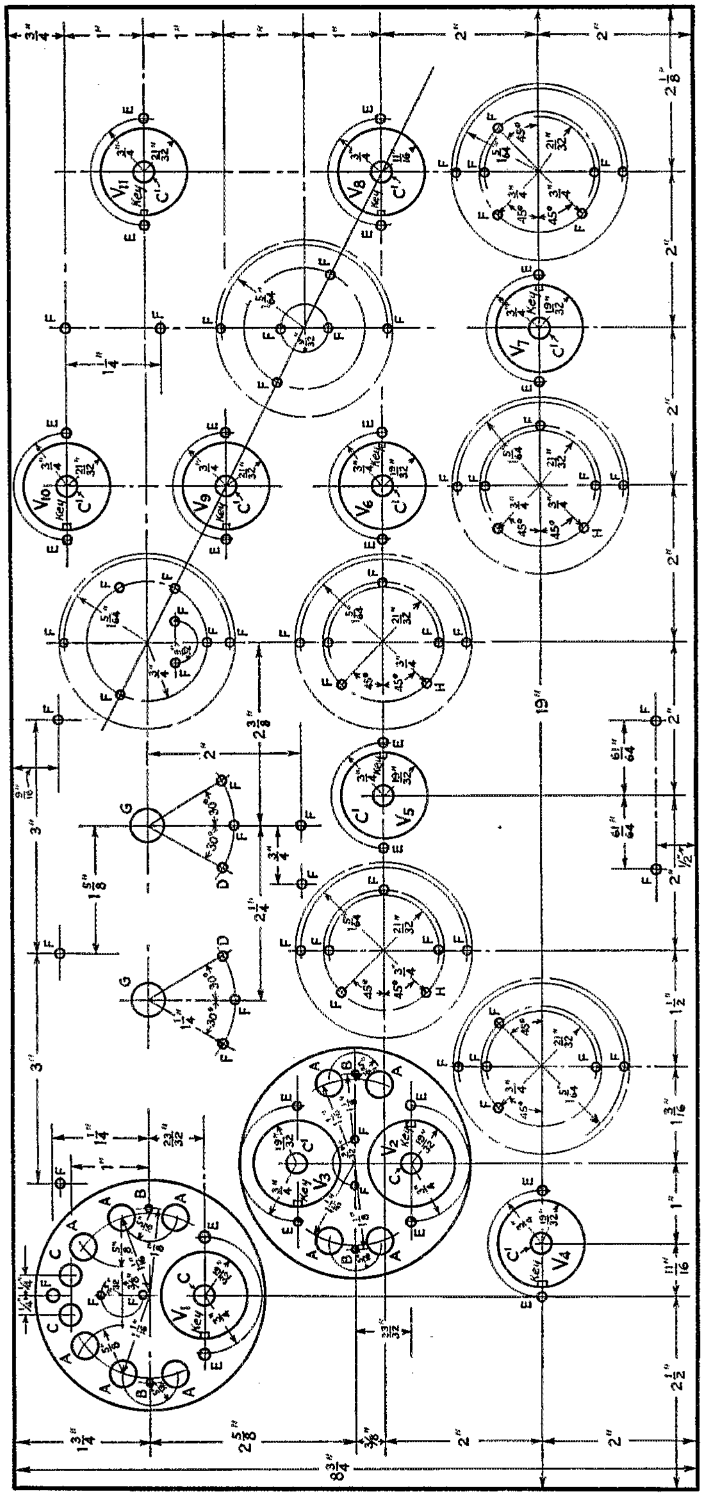
The design of the four i.f. coupling units and of the sound-buffer coil assembly is quite similar, so that it is worth while to make a metal template for the "base plates" used in each of these units. This template, shown in Fig. 6, can also be used to mark the coil forms and shield cans for drilling. The material used for the base plates and coil forms is a special grade of hard rubber, "Radio X2B" compound, made by the American Hard Rubber Company, New York, N. Y. This material is used principally because of its low leakage, which is important in the i.f. coupling units in order to avoid leakage currents through the a.g.c. circuit. The dimensions of the base plates are 3 15/16 by 1⅛ by 3/32 inches.

Photo "C" shows an assembled i.f. unit, with the various condensers and resistors mounted around the coil form and on the base plate. Design details of the i.f. coils are given in Fig. 7, and are exactly the same for all four i.f. units. The i.f. coil forms (3 15/16" long) are cut from solid, hard-rubber rods ½ inch in diameter, made of the same hard-rubber material as the base plates.

* RCA Manufacturing Co., Inc., Harrison, N. J.

[1] C. C. Shumard, "A Practical Television Receiver for the Amateur," *QST*, December, 1938.

FIG. 3 FRONT VIEW DIMENSIONAL DRAWING — TELEVISION RECEIVER PANEL



A — $\frac{5}{16}''$ HOLE
B — No. 44 DRILL
C — $\frac{1}{4}''$ HOLE
D — No. 6 DRILL
E — No. 30 DRILL
F — No. 28 DRILL
G — $\frac{3}{8}''$ HOLE
H — No. 10 DRILL
C' — $\frac{1}{4}''$ HOLE FOR $1\frac{3}{16}''$ KNOCKOUT

Sound Buffer Input-Coupling Unit

The input-coupling unit of the sound buffer stage is constructed very much like the i.f. units, as can be seen from photo "D." Coil design data for this unit (L_7 and L_8) are given in Fig. 8. The coil form is made of thin-walled bakelite tubing, as used for the r.f. coils.

Video Input-Coupling Unit

The two coils comprising the input coupling and compensating unit (L_{21} and L_{22}) of the video amplifier stage are shown in photo "E." Design data for the windings are given in Fig. 9. The coil forms are similar to those used in the i.f. units. The inductance values of L_{21} and L_{22} are important. These coils, in conjunction with the circuit and tube capacitances present, compensate the video input circuit so that the desired video characteristics are obtained. No adjustment of the video input circuit should be necessary if the coil and layout specifications are followed closely.

Video Output-Coupling Unit

Photo "F" shows the output coupling and compensating unit of the video amplifier. Design data for inductance L_{23} are given in Fig. 10. The output compensation provided by L_{23} should be satisfactory where the Kinescope grid terminal is placed close to the video output network. Such placement minimizes the Kinescope input-circuit capacitance.

General Circuit and Wiring Considerations

The wiring of the receiver, in general, should follow good practice for ultra-high-frequency equipment. All h.f. grounds should be made direct to the chassis with the shortest possible leads. All leads carrying high frequencies should be kept reasonably clear of other wiring and circuit components.

The "hot" plate and grid leads of the r.f. oscillator, mixer, i.f. sound buffer, and video stages are wired with single strands of No. 30 wire, insulated with spaghetti tubing where necessary; in some cases, no insulation is used except where the leads pass through the chassis or through a shield can. The use of this small wire, carefully spaced from all grounded parts, is important in reducing unwanted capacitive effects.

One side of the common heater winding is grounded; the other side of the heater supply circuit is by-passed to ground directly at the socket of each r.f. and i.f. stage.

Test Equipment and Alignment Procedure

The exact alignment of a receiver is usually a laboratory operation. However, it is believed that if the specifications which have been given are followed closely, the alignment of the i.f. coupling stages will be the only job requiring special test apparatus. A calibrated oscillator covering the i.f. frequency band and a good vacuum-tube voltmeter are required, in addition to the auxiliary short-wave "sound" receiver mentioned in the preceding article.

Changes in Receiver Constants

Since publication of the television receiver circuit in December *QST*, further work with the receiver indicates that the following changes in circuit constants are advisable in the interests of better performance from the hum standpoint:

Component	*Old Value*	*New Value*
C_{75}	50-μfd., 25-volt elec.	100-μfd., 25-volt elec.
C_{66}	0.01-μfd., 200-v. paper	50-μfd., 25-volt elec.
C_{70}	0.05-μfd., 400-v. paper	0.002-μfd., 400-v. paper

Resistor R_{41} should be eliminated.

Test Oscillator

A test oscillator covering a frequency range from about 8 to 14 Mc., and having an output voltage at low impedance adjustable up to about 0.3 volt, is necessary for the i.f. and sound-buffer line-up. It is, of course, also essential that the r.f. output voltage for a given attentuator setting should remain substantially constant throughout the frequency range employed.

An RCA Type 153 test oscillator [2] was used to align this receiver. In using the Type 153 oscillator, it was considered desirable to make a slight change in its output circuit before starting the alignment procedure. A 40-ohm carbon resistor was inserted between R_{13} and R_{14} (see Figs. 11 and 12). The reason for this will be explained later. Two different methods of coupling the test oscillator to the receiver were employed. For i.f. unit No. 4, next to the detector, a fairly large signal voltage is required because the gain of only this one stage is effective. For the line-up of this stage, the oscillator is coupled to the i.f. tube grid by means of the coupling network C_1, C_2, R_2 and R_3. The lead to C_2 is broken at point "X" (see Fig. 12) and connected with a short lead directly to the oscillator output terminal marked "Medium." The same connection is also used for i.f. unit No. 3, the oscillator signal being suitably reduced by means of the attenuator, R_{12} (Fig. 11). The transmission line shown in Fig. 12 is not used for units 4 and 3, and is left unconnected at both ends during their alignment.

For the line-up of i.f. units Nos. 2 and 1, the transmission line, consisting of a short length of shielded wire having an impedance of about 50 ohms, is connected as shown in Fig. 12. The 40-ohm resistor previously inserted allows both

[2] This is an inexpensive all-wave (100–30,000 Kc.) test oscillator of the type included in the usual service-man's kit. — EDITOR.

the input and output terminations of the line to be made 50 ohms, which approximately matches the line impedance. The use of the line for the two high-gain stages permits the signal voltage to be applied directly between the tube grid and ground, and minimizes pick-up and feedback which might exist with direct wire coupling. The magnitude of the oscillator output voltage cannot easily be determined, but this is not essential. It is more important that the oscillator voltage should be substantially constant over the i.f. band.

Vacuum-Tube Voltmeter

Because of the very high frequencies involved, the vacuum-tube voltmeter employed must have a very low input capacitance. A v.t. voltmeter using a 954 Acorn tube was described in *QST* for May, 1935.[3] An instrument of this general type is suitable for the alignment work. A sensitive microammeter should be used for the indicating meter. One requiring 200 μa. for full-scale deflection is suitable. The v.t. voltmeter should be designed and calibrated for at least two ranges. The maximum voltage for these ranges should be about 0.8 volt and 2.5 volts. Space limitations preclude more complete information on the design of tube voltmeters, but good references dealing with this subject are available.

I.F. Alignment

With the test equipment all at hand, the alignment procedure can be started. The last i.f. coupling unit (No. 4) is, of course, first to be aligned. No connections need be made from the receiver to the scanning unit. As a preliminary, it is advisable to short-circuit the plate of the r.f. tube and of each i.f. tube (except V_7) to the + B lead, by means of a direct wire jumper. Oscillator tube V_3 can be left out of its socket. These precautions prevent any possible output from the shorted stages and do not seriously upset the voltages from the power supply unit. The general procedure is as follows:

[3] The probe type or "gooseneck"; *QST*, May, 1935, p. 90.

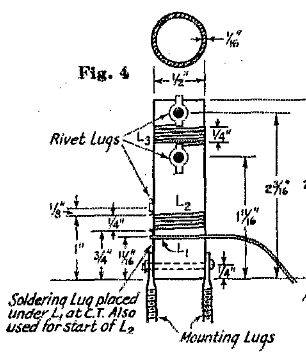
Connect the common a.g.c. bias lead (see Fig. 2, December *QST*) to the − 3 volt end of R_{57}, instead of to R_{54}, so that the tubes will get their bias, temporarily, direct from the power unit. Connect the test oscillator to the grid of V_7, using the coupling method explained under "Test Oscillator." Remove the i.f. shield can, disconnect the high side of C_{63} (the detector plate-circuit condenser) and substitute the short v.t. voltmeter input leads to the 954, from the detector plate to ground. The 6H6 is left in its socket. Set C_{60} to about ¼ maximum capacity and replace the shield can. Adjust the test oscillator for a suitable output and set the v.t. voltmeter on its most sensitive scale. The voltage output or response curve of i.f. unit No. 4 can now be obtained.

For any i.f. stage, the output curve will have two peaks, as in Fig. 13-B, when proper adjustment is made. The frequencies at which the two peaks occur can be used as an "index" of the alignment. Fig. 13-B may be taken as typical of what is desired. The peaks on this curve occur at about 10.6 Mc. and 12.8 Mc., and will show quite plainly as maximum readings on the v.t. voltmeter as the test oscillator is tuned rapidly through the desired frequency range. The frequency range being covered should be mentally correlated with the v.t. voltmeter readings so that the general shape of the curve can be visualized readily without the curve actually being plotted on paper.

For the first trial, some curve such as Fig. 13-A may be obtained. Here, the low-frequency i.f. peak is very large and the high-frequency peak is almost non-existent. This type of curve indicates that the capacitance of C_{60} is too large. Curve 13-C shows the effect of too small a value for C_{60}. Some intermediate setting of C_{60} should give the desired curve, 13-B.

It will be noted that this curve drops more rapidly at the 10.5-Mc. end than at the 13-Mc. end. This is the effect of the series-coupling circuit $L_{19}C_{62}$ (also of $L_{16}C_{54}$, etc.), which should tune to approximately 8.5 Mc. The nominal value of

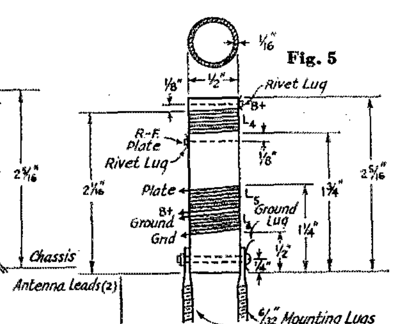
Fig. 4



L_1 = 1-T No. 14 ENAMEL
L_2 = 6-T No. 26 ENAMEL
L_3 = 6-T No. 26 ENAMEL

ANTENNA COIL ASSEMBLY

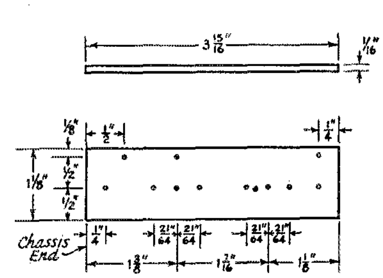
Fig. 5



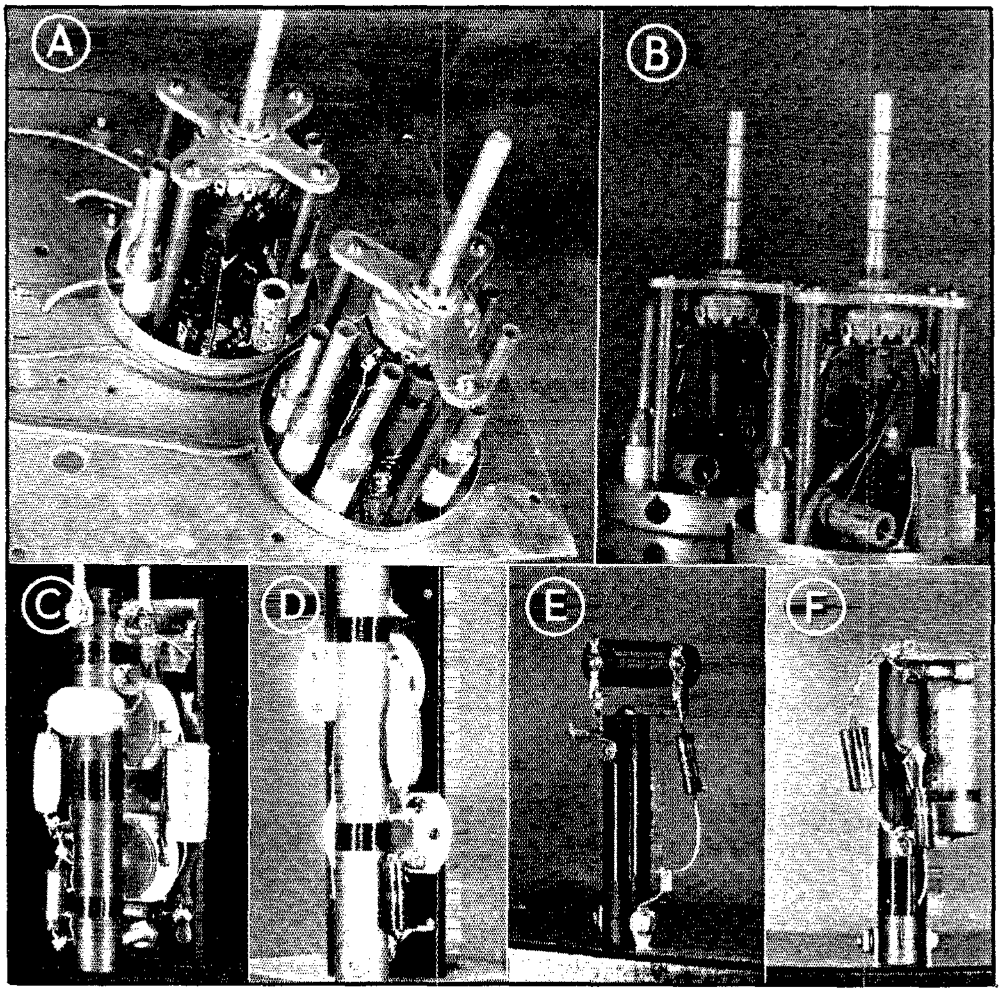
L_4 = 5½T. No. 26 ENAMEL
L_5 = 5 T. No. 14 ENAMEL
L_6 = 5 T. No. 14 ENAMEL

OSCILLATOR-MIXER COIL DESIGN DATA

Fig. 6



TEMPLATE FOR BASE PLATES OF I.F. AND SOUND-BUFFER COIL UNITS



C_{62} (also C_{54}, C_{46}, and C_{30}) is shown in the legend of Fig. 2 as 18 $\mu\mu$fd. If the *actual* value is less than 16.5 to 17 $\mu\mu$fd., the effect is to cut into the 10.5-Mc. end of the i.f. response curve. A value greater than 18.5 to 19 $\mu\mu$fd. will also be detrimental to the band-pass characteristic. Different condensers may be tried if the desired curve cannot otherwise be obtained. The values of the i.f. termination resistors (R_{34}, R_{30}, R_{25}, and R_{20}) are also important, and should not vary from the nominal figure by more than $\pm$ 5 per cent.

For the line-up of i.f. coupling unit No. 3, the grid circuit of V_7 is connected normally, the jumper is removed from the plate circuit of V_6, and the test oscillator is coupled to the grid of V_6 in the same manner as it was to V_7. The v.t. voltmeter is left connected across the detector input circuit for the entire alignment, inasmuch as only overall response curves ordinarily need be taken.

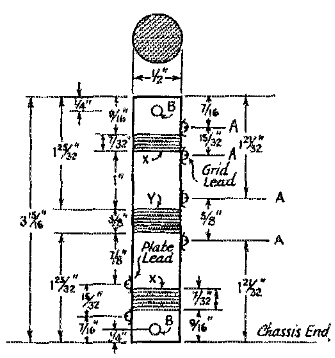
A representative overall curve of i.f. units Nos. 4 and 3 is shown in Fig. 14. The peaks here occur at about 10.5 and 12.5 Mc. This curve is obtained as for i.f. unit No. 4, except that both plate condenser C_{52} and grid condenser C_{55} are adjusted. C_{52} should be used essentially to adjust the low-frequency peak and C_{55} the high-frequency peak, although some effects on both peaks are produced by either adjustment. These effects may be readily checked by tuning the test oscillator fairly rapidly through the proper range and simultaneously observing the rise and fall of the v.t. voltmeter reading. The coupling units are so designed that only a small amount of the capacitance of either condenser should be required. It will be found that the peaks will become more pronounced and more easily checked on the v.t. voltmeter as more cascaded stages are lined up, because the overall curve represents the product of the gains of all the stages in operation.

I.f. unit No. 2 should next be aligned according to the general procedure just described. The jumper across the plate circuit of V_5 should not be forgotten, and must be removed. The test oscillator is coupled to the grid circuit of V_5, using the coaxial line connected as shown in Fig. 12, and condensers C_{44} and C_{47} are adjusted. A typical overall curve for i.f. units Nos. 4, 3, and 2 is shown in Fig. 15.

Before i.f. unit No. 1 is adjusted, it is necessary to align the sound-buffer stage. It has been mentioned that the 1853 sound-buffer tube is used to prevent the oscillator of the sound receiver from feeding into the video i.f. stages, inasmuch as the frequency of the oscillator in the sound receiver is usually close to the video i.f. band. The sound buffer tube is not used for amplification of the sound i.f. signal, but it serves as a coupling tube in addition to its other function. For the alignment, proceed as follows:

Connect the antenna and ground terminals of the sound receiver to the 50-ohm termination (R_{16}) of the sound-buffer transmission line, shown in Fig. 2. Disconnect the sound input lead (coming from the plate circuit of the mixer tube) at R_{13} and connect the free end of R_{13} to the test oscillator, using transmission-line coupling. Set the test oscillator at 11.25 Mc. (with 400-cycle modulation now applied) and tune the sound receiver to this frequency. Adjust C_{33} until the modulated 11.25-Mc. signal is a minimum in the sound receiver. This adjustment should be made at a low output level — that is, with a small oscillator signal and a low receiver volume-control setting — after the signal has once been tuned in. Next, set the oscillator at 9.75 Mc. and tune the sound receiver to this signal. Then adjust C_{35} until the signal is a maximum at a low output level. Repeat the entire procedure once more, starting again with the 11.25-Mc. modulated signal. This

FIG. 7



A = 2-56×3/16 BRASS R.H. MACHINE SCREW AND LUG, TAPPED IN
B = TAP THROUGH FOR 6-32 F.H. BRASS MACHINE SCREW
X = 23 T. No. 32 ENAMEL, L_9, L_{11}, L_{12}, L_{14}, ETC.
Y = 46 T. No. 32 ENAMEL, L_{10}, L_{13}, L_{16}, L_{19}

I. F. COIL DESIGN DATA

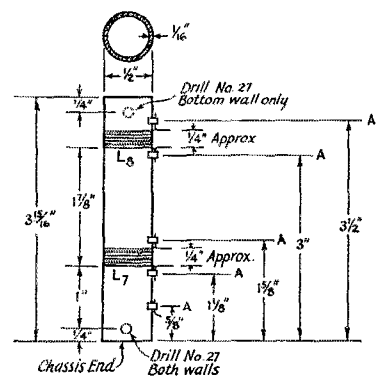


FIG. 8

L_7 = 29 T No. 32 ENAMEL
L_8 = 26 T No. 32 ENAMEL
A = RIVET LUGS, DRILL No. 35

SOUND-BUFFER-COIL DESIGN DATA

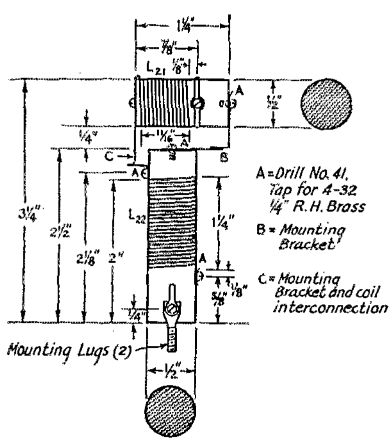


FIG. 9

L_{22} = 280½ T No. 38 ENAMEL
L_{21} = 155 T No. 38 ENAMEL

VIDEO INPUT-COMPENSATION COIL ASSEMBLY

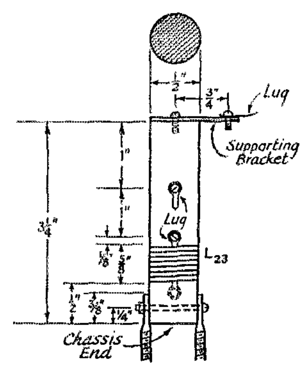


FIG. 10

L_{23} = 88 T. No. 34 ENAMEL

VIDEO OUTPUT COMPENSATING COIL & FORM

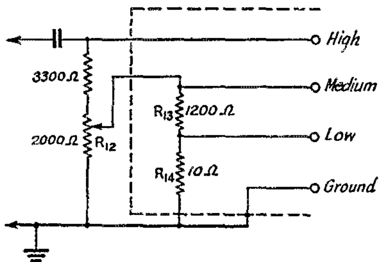


Fig. 11 — Normal output circuit of Type 153 (RCA) test oscillator.

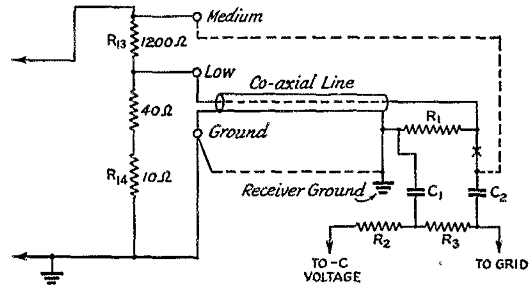
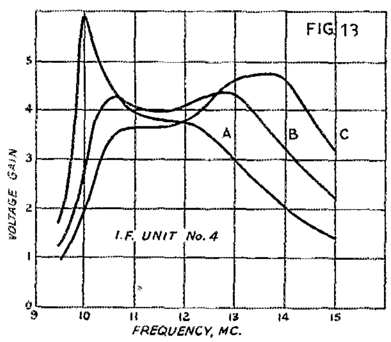


Fig. 12 — Revised oscillator-output circuit and coupling system. The coaxial transmission line is the same material as described for the output of the sound-buffer unit in December *QST*. Values are as follows: R_1, 50 ohms, ½-watt; R_2, R_3, 50,000 ohms, ½-watt; C_1, C_2, 50-μμfd. mica, midget type.

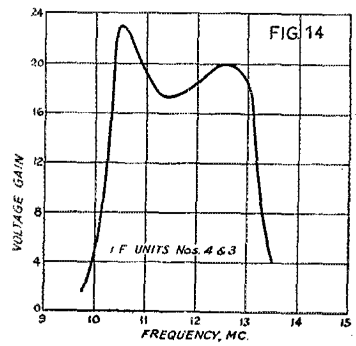
should complete the adjustment of the sound buffer stage, so that its input lead can be reconnected to the mixer plate circuit.

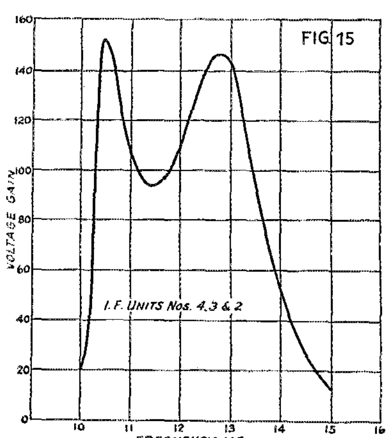
The test oscillator should now be connected to the mixer input and i.f. unit No. 1 aligned, according to the procedure previously described for i.f. unit No. 2. After the proper adjustment of C_{28} and C_{31}, an overall i.f. curve similar to Fig. 16-A should be obtained. The mixer is thus used, for this step of the alignment, as an i.f. amplifier under mixer tube conditions.

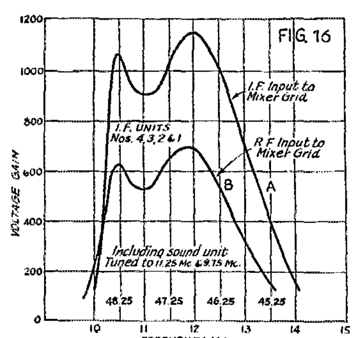
It will be seen that the curve of Fig. 16-A substantially fulfills the requirements for the desired type of i.f. response, according to the theoretical considerations discussed in the preceding article. An effect of the sound buffer stage is to reduce the response variation over the i.f. band and to reduce the i.f. gain in the neighborhood of 13 Mc. This reduction of gain at the high i.f. (low video)

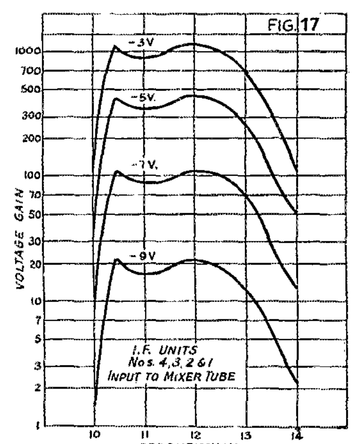


Figs. 13-17 — I.f. response curves at progressive stages in the alignment procedure. Fig. 17 shows the overall i.f. response with different values of grid bias (gain control) applied to the i.f. grids.









end of the video sideband is desirable in order to minimize overlapping of the low video frequencies, as pointed out in December *QST* (see Fig. 1). The tendency for such overlapping or "doubling up" of the low video frequencies is, of course, due in part to the fact that single-sideband reception is employed in the receiver.

The curve of Fig. 16-B gives the overall gain characteristic of the receiver, exclusive of the r.f. and video stages, with r.f. input to the mixer tube used to beat with the inserted oscillator signal. The oscillator frequency for this curve was set at 58.75 Mc.

When the alignment procedure has been completed and the final i.f. response curve has the desired characteristics, the vacuum-tube voltmeter is removed from the detector input circuit. The detector plate condenser C_{63} is reconnected and its rotor meshed about ¼ inch, as measured along the outer edges of the rotor plates. Slight re-settings of C_{63} should be tried after a picture is obtained, to determine if the picture definition can be improved. However, the detector input circuit is sufficiently broad so that the effects of any slight misalignment will be minimized.

G — Photograph of test pattern from an r.f. signal generator on the screen of a Type 1800 Kinescope used with the receiver described.

The four curves of Fig. 17 show the response of the receiver with different values of grid bias on the r.f. and i.f. tubes. In this receiver, the pass band does not vary appreciably with grid bias changes. It will be observed (Fig. 2) that the cathode resistors of the r.f. and i.f. stages are *not* by-passed. The omission of the cathode by-pass condensers tends to minimize input-capacitance variations in the a.g.c. controlled tubes and is an important factor in obtaining the operating characteristics desired of the receiver. The overall i.f. response is practically flat from 10.5 Mc. to 13 Mc., as is shown by the logarithmic gain curves of Fig. 17.

Operation

With the i.f. alignment completed, the picture receiver is ready to be connected to the scanning and Kinescope units. It is important to note that this receiver is especially designed to "tie in" with the electromagnetic Kinescope and scanning units to be described in a subsequent article by Mr. J. B. Sherman. The output terminals shown in Fig. 2 can be directly connected to the electromagnetic units, and the various receiver controls and circuits function just as described.

If, however, one of the electrostatic Kinescope and scanning units shown earlier [4] is to be employed, some variations in procedure are required. In Figs. 3 and 4 (October *QST*) the external connection to the Kinescope grid is marked "Video Input." A 0.5-μfd. d.c. blocking condenser must be inserted in this lead before it is connected to the output terminal of the video amplifier in the picture receiver. With this capacitive coupling, the Kinescope receives its d.c. background-control bias from the Kinescope power pack, as shown in October *QST*, and not from the picture receiver. The receiver terminal marked "To cathode of Kinescope" and bias potentiometer R_{55} (Fig. 2, December *QST*) are thus not used with the electrostatic units. This means, of course, that the automatic background-control circuit in the picture receiver is not put to use, because of the "a.c. coupling" of the video input signal.

After the 0.5-μfd. condenser has been inserted in the Kinescope grid circuit, the picture receiver is connected to the other units as shown in the circuit diagrams, omitting the Kinescope cathode connection at the receiver. The chassis of the various units which go to make up the complete receiver should all be tied together with a good, low-resistance ground strap.

The antenna feeders, assuming a half-wave doublet antenna is used, consist of a twisted pair. The feeder leads are connected to the two antenna terminals provided on the picture receiver chassis. Switches S_1 and S_2 are set in the maximum-capacitance position (on C_3, C_8, C_9 and C_{12}), for a station in the 44–49 Mc. range.

The scanning circuits are put into operation as described in October *QST*, so that the rectangular picture area is scanned.

For locations where a strong signal from the transmitter is available, no particular difficulty should be encountered in tuning in the signal. Usually, an adjustment of the oscillator frequency (by means of C_{12}) will bring in some signal. Once a signal is obtained, the effects of tuning, synchronizing, and the background control will readily be noticed on the Kinescope screen. One of the first steps is to tune the pre-selector and mixer controls until the signal is strong enough to obtain proper synchronization of the scanning oscillators with the transmitter. The background

(Continued on page 116)

[4] J. B. Sherman, "Building Television Receivers with Standard Cathode-Ray Tubes," *QST*, October, 1938.

Television Receiver

(*Continued from page 52*)

control is set to give a suitable average illumination of the entire picture. Further adjustments of the tuned circuits, a.g.c. control, and focusing controls will aid in bringing up the picture detail, until optimum settings are found for all adjustments and controls.

For locations where the signal level from the antenna is apt to be low, the final steps in the alignment of the picture receiver can be helped along by means of a calibrated "5-meter" oscillator, provided with sound modulation. The oscillator, tuned to 46.5 Mc., is loosely coupled to the receiver, which can be tuned to the oscillator frequency by observing the moving, unsynchronized band pattern on the Kinescope. The number of dark (or light) bands observed corresponds to the ratio of the sound modulation frequency (of the test oscillator) to the vertical scanning frequency. The set is tuned by adjusting C_{12}, C_9, C_3, and C_8, in the order named. Maximum sensitivity for a specific setting of the a.g.c. and background controls will be indicated by the least average illumination of the Kinescope screen. The oscillator signal, however, should be kept small enough so that the Kinescope pattern never becomes excessively dark. When the picture signal is applied, the settings of C_3 and C_8 may have to be readjusted for best picture definition. Maximum sensitivity and optimum definition are not ordinarily obtained simultaneously, because the pass band may not be wide enough at maximum sensitivity to pass the full video band — that is, to give best picture definition.

The modulated test oscillator may also be used in the tuning of the sound receiver. If, after the picture receiver is aligned for maximum sensitivity, the test oscillator is tuned 3.25 Mc. higher in frequency, the sound modulation should be quite audible on the sound receiver at a dial setting of about 9.75 Mc. The spacing of 3.25 Mc. between the video carrier and the sound carrier is shown in Fig. 1 in the preceding article. The tuning of the audio signal will be very sharp, due to the selectivity of both the sound receiver and the soundbuffer input circuit. If a tendency for the sound signal to drift is encountered, this may be due to frequency shift in either the sound-receiver oscillator or the picture-receiver oscillator. This effect can be minimized, provided the sound receiver is sufficiently sensitive at 9.75 Mc., by shunting a resistance across the sound-buffer input circuit. This resistance tends to broaden the tuning of the sound buffer stage.

In photograph "G" is shown a picture taken directly from the screen of the type 1800 Kinescope. The video signal, obtained from a Monoscope, was used to modulate a television signal generator, the output of which was fed into the r.f. stage of the picture receiver. Thus, the received picture illustrates the fidelity of which the receiver is capable. In the laboratory model of the receiver built as described, a resolution of better than 350 lines has been obtained with Kinescope Type 1800. This means that the receiver is capable of much better resolution than it is possible to obtain with small Kinescopes such as the 913, 902, and 906 (see page 22, *QST*, October, 1938). However, these smaller tubes will give quite acceptable pictures and will serve nicely the television amateur who is desirous of getting started with the minimum of expense. The picture receiver will justify, at a later date, the use of one of the larger Kinescopes.

The electromagnetic Kinescope and scanning units using Type 1800 Kinescope and shown in the complete receiver photographs in December *QST*, will be described by Mr. Sherman in a subsequent issue.

Bibliography

[1] "The 954 as a Vacuum-Tube Voltmeter," *QST*, May, 1935, pp. 90–92.

[2] "Type 726-A Vacuum-Tube Voltmeter," *The General Radio Experimenter*, May, 1937.