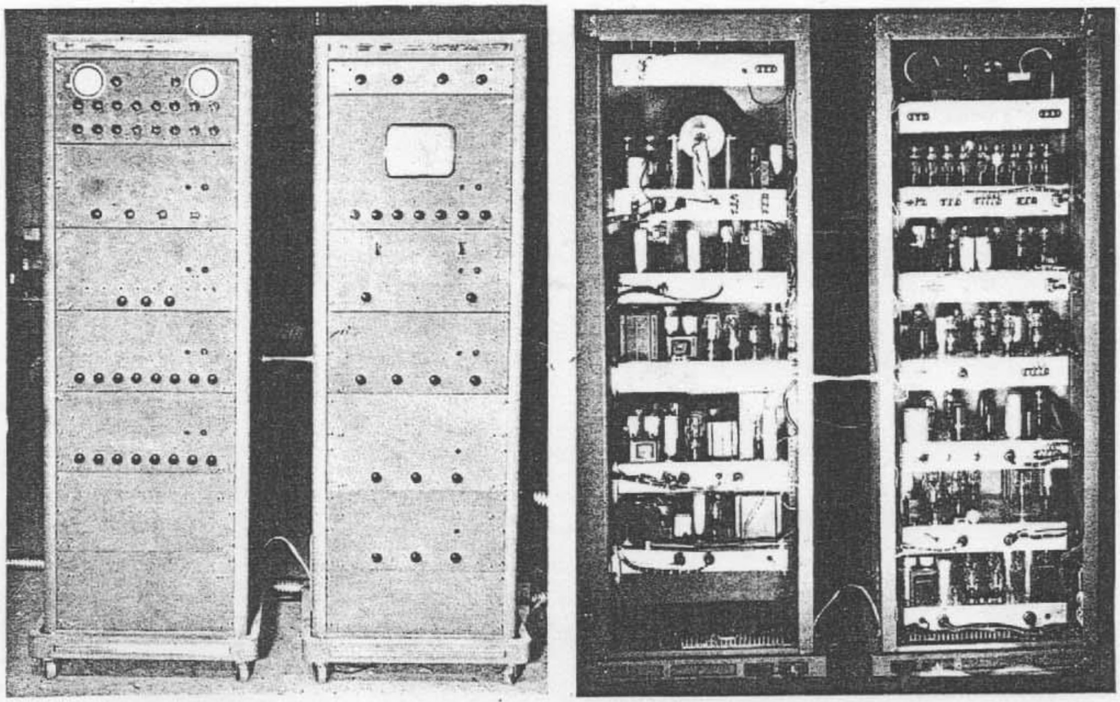

Fig. 1—Front and rear views of the rack assemblies. These chasses contain the complete equipment with the exception of the camera and the preamplifier which is mounted in the camera housing. The generator and auxiliaries contain 157 tubes in all

# A Picture Signal Generator—I

First of a series of articles containing complete design data and circuits required for the generation of the standard R.M.A. T-111 video signal, including camera, sync signal generator, mixing, shading and keystone circuits, monitor, r-f modulator and receiver

By M. P. WILDER and J. A. BRUSTMAN
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AS the public interest and commercial activity in television broadcasting increase, more and more manufacturing organizations in the radio field are faced with the problem of developing the necessary engineering facilities to allow the design and development of suitable transmitting and receiving equipment. The central feature of these engineering facilities is a generator of the standard video signal, which provides a signal waveform similar to that which modulates the carrier of the television transmitter. Such a generator was required by the American Television Corporation as a source of standard picture signal for general receiver development and testing, as well as for the development of a television service for hotels, department stores, and hospitals. The latter purposes made necessary a highly compact and semi-portable unit, including a camera which could be operated some distance from the generator itself.

This equipment is to be described in a series of articles, of which this is the first, in sufficient detail to make possible its duplication by readers who may wish to do so. The equipment is of necessity complicated—there are over 150 tubes in the generator all told—and it is quite possible that few readers will have the opportunity or need of building the complete unit. However, the design and construction of a standard picture signal generator involves virtually every function in television engineering. Thus the reader, who wishes to know how a certain function is performed, or to construct a unit capable of performing that particular function, may find useful information in these articles.

The front and rear views of the generator, complete except for the camera, are shown in Fig. 1. Standard rack-and-panel assemblies are used. The panels at the left (front view) contain the following items of equipment, from top to bottom: oscilloscope for viewing the signal waveforms; sync signal shaping unit; sync signal timing unit; iconoscope

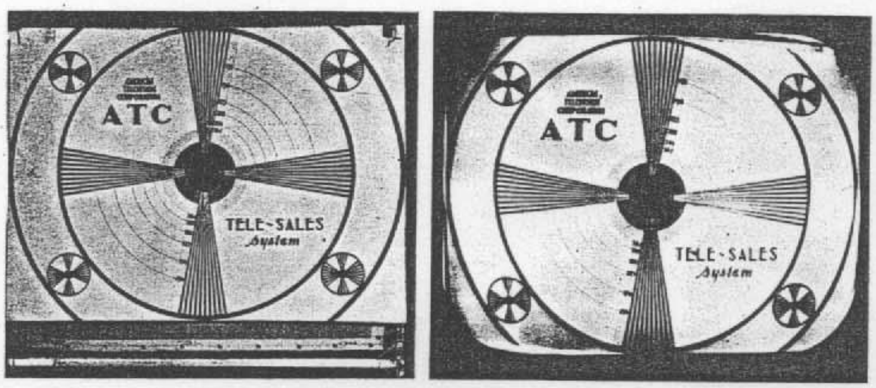
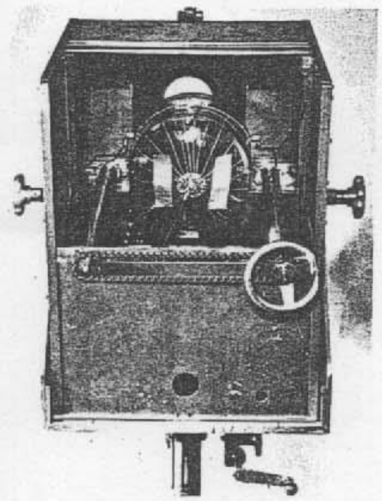
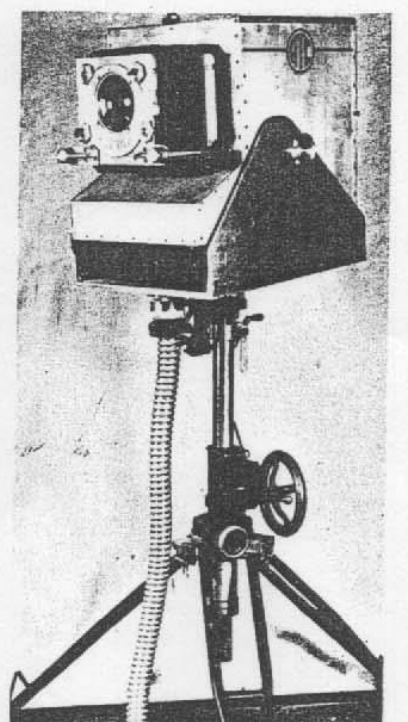



Fig. 2—Left, the performance of the generator as revealed by a test chart, original at the left, reproduction at the right. The horizontal resolution of the reproduction exceeds 450 lines (effective frequency range above 4.5 Mc). The interlacing is free of any observable instability

Fig. 3—Below, the camera. The view from the rear with cover removed shows the iconoscope camera tube and the wire shield





sweep circuits; the shading-correction signal generator; and at the bottom two regulated power supplies. The rack at the right includes a 4-channel television receiver (sight and sound); the 9-inch monitor picture tube and controls; line amplifier; mixing amplifier (which combines the camera signal, sync signals and blanking signals); two regulated power supplies; and at the bottom the sound output channel, and the picture and sound r-f channels.

The performance of the equipment (which operates with the standard R.M.A. 441-line T-111 type of signal, but is flexible enough to allow considerable variation from this standard if necessary) may best be judged from a test pattern, as shown in Fig. 2. The most critical aspect of performance is the horizontal resolution, which exceeds 450 lines. This considerably exceeds the performance capabilities of present-day television transmitters, and is in fact in excess of the maximum resolution which may be transmitted within the R.M.A. ether channel. The video amplifiers are in general flat to 4.5 or 5 Mc, overall, whereas the maximum required frequency for modulation is about 4 Mc.

*Functions of the various parts*

The basic power for the critical units is supplied by five electronically-regulated power supplies (one example of which is shown in Fig. 5), each capable of delivering 280 volts dc, with an internal resistance of one-quarter ohm. Four other conventional sources of power for the oscilloscope, monitor and iconoscope sweep circuits and the television receiver are also provided. The high voltage sources include 7500 volts for the monitor, 1200 volts for the iconoscope, and 1000 volts for the oscilloscope. This is a rather forbidding array of power supplies, but little is saved by trying to consolidate them, and much is gained in flexibility and freedom from circuit interaction.

The timer and shaper units produce the synchronizing pulses in accordance with the R.M.A. recommendations (441 lines 60 fields per second). These, with blanking impulses generated in the same units, are fed to a mixing amplifier which accepts also the output of the camera preamplifier. The mixed video signal is then amplified in a line amplifier, applied to the monitor tube and oscilloscope (the oscilloscope may be connected to any portion of the generating circuits by a plug connection) and used to modulate an r-f oscillator for r-f and i-f testing. Pulses from the synchronization signal generator are available for synchronizing any external equipment, such as remote Kinet viewing-screens in hotel rooms.

To cancel the spurious shading signal generated in the iconoscope, a shading-correction generator produces sine, parabolic, and sawtooth waves at 60 and 13,230 cps, of variable amplitude and capable of being shifted in phase through 360 degrees. The deflection of the scanning beam in the iconoscope is accomplished with conventional blocking-discharge oscillators and amplifiers. Trapezium distortion (arising from the oblique scanning of the mosaic plate in the iconoscope) is corrected in the horizontal iconoscope sweep circuits. The monitor picture tube is of the short 9-inch variety which gives sharp focus,

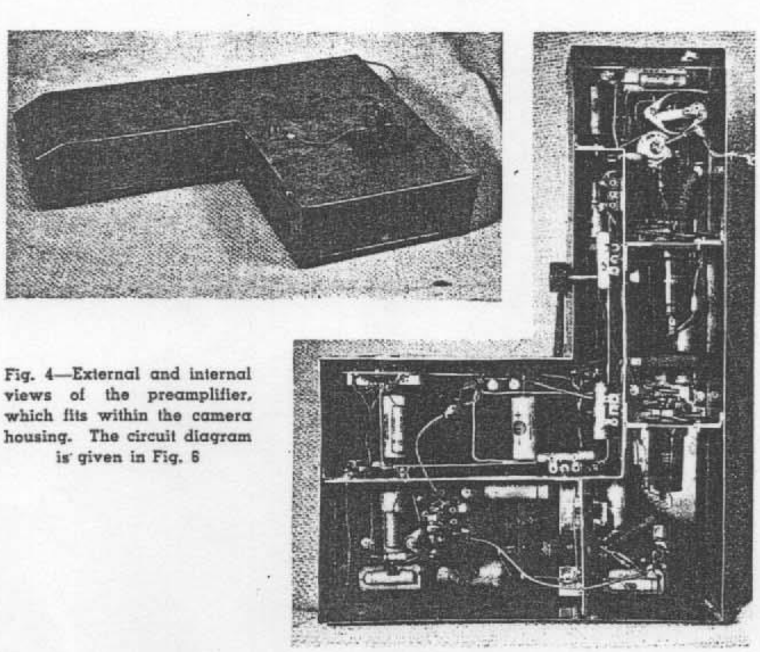


Fig. 4—External and internal views of the preamplifier, which fits within the camera housing. The circuit diagram is given in Fig. 6

and is relatively free from ion blemishes since magnetic focusing and deflection are employed. A four-channel receiver is provided to permit comparisons with the generator output, as well as to provide a source of program when the generator is used as a signal source in hotels, stores and the like. The operation of the completed generator has been found satisfactory in all respects.

In the description that follows, the equipment is arranged in logical order, i.e. the present installment describes the camera, preamplifier, and the auxiliary iconoscope power supplies and sweep circuits. The order in which the various units are constructed in practice may not follow this logical order (for example an oscilloscope should be available before the performance of the preamplifier can be judged accurately) but the usual laboratory test equipment (including an oscilloscope, i-f and r-f signal generator, vacuum tube voltmeter, and beat frequency oscillator) is sufficient to test each item of equipment as it is built.

*Camera and Preamplifier*

The camera, shown in Fig. 3, contains the iconoscope and preamplifier housed in an aluminum shield which also serves as the camera housing. An f/3 lens of 24 cms focal length is used. The preamplifier (Fig. 4) is based after the design of Allen Barco[1] of the RCA License Laboratory.

This amplifier employs a degenerative cathode-coupled first stage to reduce the effect of input capacitance of the grid circuit by a factor $1/(1+g_mR)$ where $R$ is the cathode resistance and $g_m$ is the transconductance of the first tube. A shield made of wire fitted around the bulb of the iconoscope further reduces the input capacitance. The complete circuit is shown in Fig. 6.

[1] Barco, A. "An Iconoscope Preamplifier", *RCA Review*, 4 (1), 89 (July 1939). Fink, D. G. "Principles of Television Engineering". McGraw-Hill Book Co., New York, 1940, page 394.

The effective input resistance in the first video stage is about 300,000 ohms, due to the effect of the degenerative current flowing through the 750-ohm cathode resistor. This high value of resistance results in a more favorable signal-to-noise ratio, since the thermal noise varies as the square root of the resistance, whereas the signal voltage varies (within limits) with the first power of the resistance. The signal voltage at high frequencies, however, is limited almost entirely by the shunt capacitance associated with this resistance. In the circuit shown, the effective shunt capacitance has been reduced to 8$\mu\mu$f. The combination of 300,000-ohm resistance and 8-$\mu\mu$f capacitance results in high generated signal through most of the video range, but the high frequencies are attenuated. The high frequency loss is compensated in the third stage, which has a peaked response in the high frequency region. The second stage is a straightforward shunt-peaked video amplifier.

The third stage is the high-frequency compensating stage. Barco shows that if the load impedance is of the series form $R + j\,w\,M$ and the magnitudes of $R$ and $M$ are properly related to the input resistance and

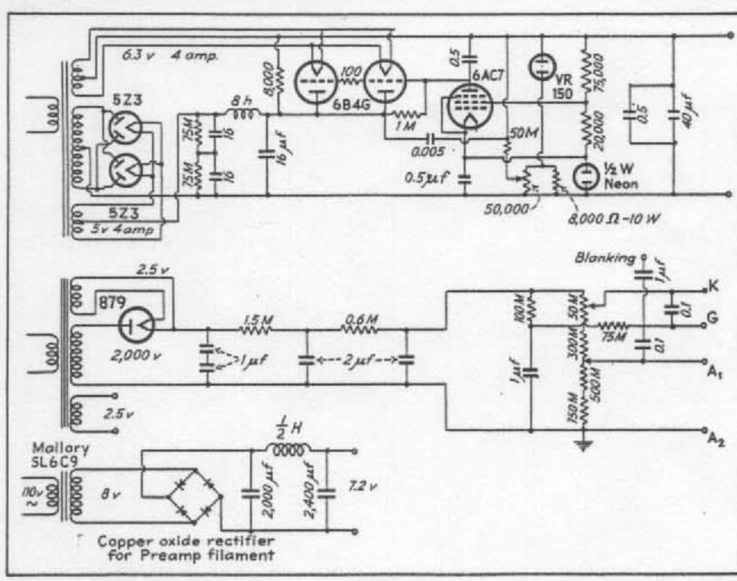



Fig. 5—Circuit diagram of the high-voltage and regulated low-voltage power supplies for the iconoscope, sweeps, and preamplifier

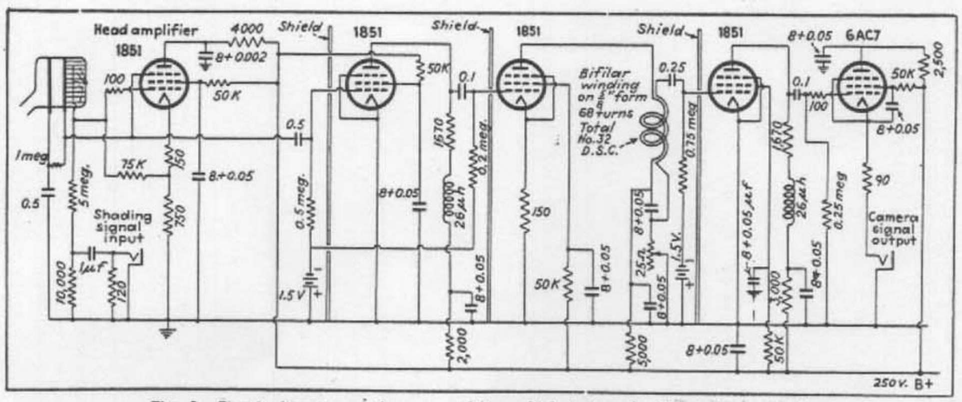


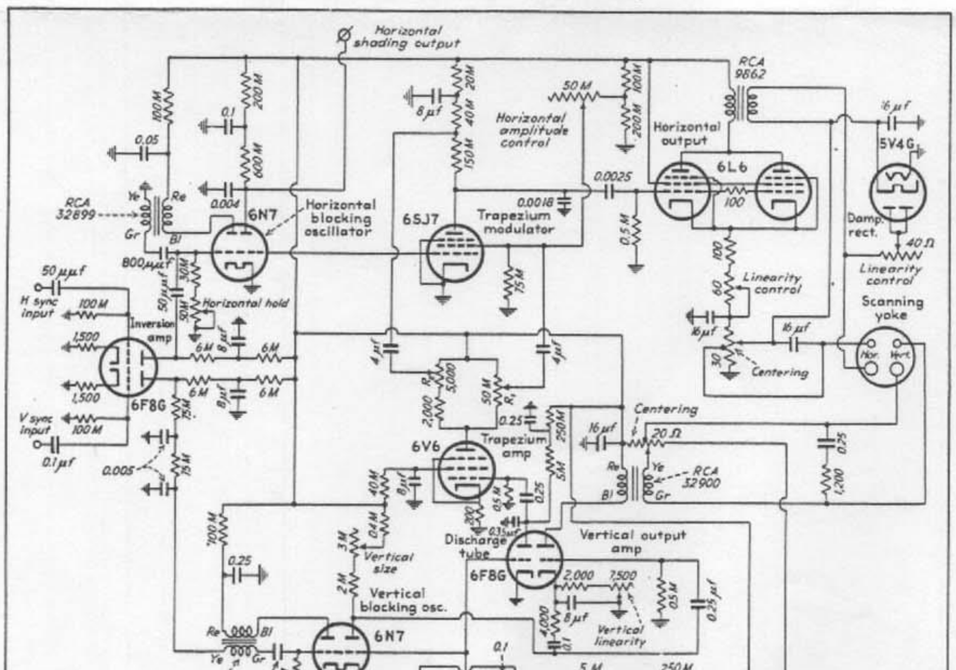

Fig. 6—Circuit diagram of the preamplifier which brings the iconoscope output voltage up to 0.1 volt, while maintaining an overall flat response to 5 Mc

capacitance at the first stage, the response will be of constant amplitude and of linear phase shift through the video band. The resistance $R$, in the plate of the third stage, is made variable and is adjusted for the optimum value by observing the image in the monitor picture tube. A very wide range of compensation is made possible by this arrangement. The gain ratio at low and high frequencies at the output of the first stage is about 400-to-8 whereas the compensation introduced in the third stage is about 8-to-400. The fourth stage is conventional, except that a somewhat larger than normal load resistance is used because the stage is followed by a cathode-follower stage whose input capacitance is lower than normal. The final stage is cathode-coupled to offer a low impendance (about 65 ohms) output.

The construction of the preamplifier is shown in Fig. 4. The first stage appears in the lower left hand corner, and is followed in order by the others. The variable load resistance in the third stage is arranged for external adjustment. The bifilar coil in the third stage may be seen just above the third type 1851 tube. The tubes should be mounted with pins 2 and 7 in a vertical plane to minimize sagging of the grid wires and consequent grid-to-cathode shorts. The amplifier is mounted on bakelite, fitted with the shields and then slipped into the L-shaped case and cover.

Power for the preamplifier is obtained from the electronically-regulated power supply shown in Fig. 5. The heaters of the preamplifier tubes are heated from a 7.5-volt copper-oxide rectifier equipped with a pi-type filter. This d-c heating current materially lowered the hum introduced in the amplifier, and at the same time a convenient source of current for the two bias lights was provided. The bias lights consist of two flashlight lamps which illuminate the interior of the iconoscope from the rear (no light must fall on the back of the mosaic plate, however). The bias lighting materially improves the shading difficulties and hence permits higher contrast in the picture. The bias lighting must be

Fig. 7—Circuit diagram of the iconoscope sweep circuits and the horizontal and vertical shading source



produced with well-filtered direct current. Two strips of scotch tape (visible in Fig. 3) are used to shield the mosaic plate from the bias lights. The iconoscope heater is fed from alternating current. The high voltage supply for the iconoscope must be well filtered, as shown in Fig. 5.

*The Iconoscope Sweep Circuits*

The connection diagram of the iconoscope sweep circuits is shown in Fig. 7. Several distinct functions have been incorporated in this unit. In the first place, two input terminals are provided to receive the horizontal (13,230 cps) and vertical (60 cps) sync pulses from the synchronization signal generator. The 6F8G double triode tube (at left in the diagram) reverses the phase of these signals. The outputs of these triodes may be used in either of two ways. They may drive the blocking oscillators (6N7 tubes above and below, next to the right), or they may be connected directly to the output amplifiers (2-6L6's for the horizontal scanning, one section of a 6F8G for the vertical). The 6SJ7 tube (top center) is used to introduce the trapezium correction. The vertical sawtooth waves from the 6V6 stage are applied through resistors $R_1$ and $R_2$ to the plate and screen of the 6SJ7 modulator tube amplifier. The modulator tube in turn modulates the amplitude of the horizontal sawtooth wave at the vertical sawtooth frequency. This assures wider scanning at the bottom of the mosaic plate than at the top, which compensates for the oblique angle of scanning. The resistors $R_1$ and $R_2$ are adjusted while viewing the picture on the monitor until the image (which has a trapezoidal shape in the absence of the modulation) assumes a true rectangular shape. $R_1$ controls the balance of the correction on either side of the pattern and $R_2$ controls the amount of compensation.

The horizontal output amplifier is conventional, including a distribution (waveshape) control and centering control in the cathode. The 5V4G is the usual damping tube required to damp the residual oscillation at the base of the sawtooth current impulses.

A separate shading discharge tube (6J5) is used to develop the vertical sawtooth for vertical shading correction, from the blocking oscillator. The horizontal shading output is taken directly from the horizontal blocking oscillator. These shading voltages are used to control the shading generator. The sine wave and parabolic shading waves are derived from them in circuits to be described later.

Three separate discharge tubes are used following the vertical blocking oscillator: one for the deflection system, one for the trapezium correction, and one for the sawtooth shading signal output.

*The Deflection Yoke*

The deflection yoke for the iconoscope is shown in Figs. 8 and 9. It consists of two vertical coils in series and two horizontal coils in series, arranged on axes at right angles to the tube axis. The vertical coils consist of 540 turns each, number 28 enameled wire. Each coil is wound in six "pies" or groups of turns of 90 turns each. The dimensions of the winding jig are shown in Fig. 8. The pie sections are kept separate by pins separated $\frac{1}{16}$ of an inch apart as shown in the sketch.

The horizontal coils are wound in a single group of 90 turns, of number 26 enameled silk wire. The thickness of the coil is 0.036 inch. The coils are then formed on a cylindrical mandrel $1\frac{3}{8}$ inch in diameter. The long dimension of each coil is parallel to the axis of the mandrel. The turns on the end of the horizontal coils are bent sharply backward away from the axis of the yoke. The coils are assembled on a bakelite tube insulated with empire cloth, cemented with ambroid cement (wax impregnation is not used), and the whole structure is then wound with three layers of number 26 oxidized and annealed steel wire. Two layers of 0.005-inch thick soft iron sheet also serve satisfactorily.

The timer and shaping unit of the synchronization signal generator will be described in the next installment. The authors wish to express their appreciation to Messrs. Martin, Schiesel, Ekstrand and Shulz for their assistance in constructing the unit and for their many helpful suggestions in its design. They also wish to express their appreciation to Mr. Beverly Dudley of *Electronics* and *Photo Technique* for his excellent photographs of the apparatus.

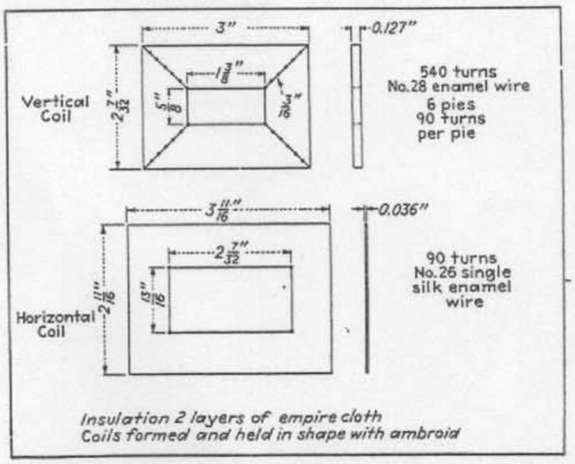



**Fig. 8—Dimensions of the jigs on which the horizontal and vertical deflecting coils are wound. The vertical coils are wound in six pies, separated by the pins on the jig**

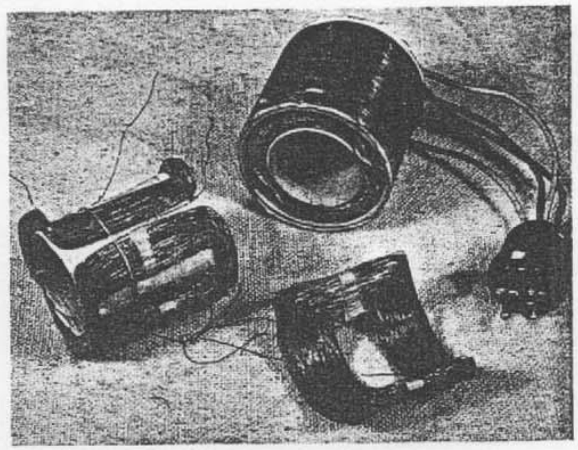


**Fig. 9—The iconoscope deflecting yoke. The coils are wound in a flat plane, then formed on a cylinder, cemented, insulated, and wrapped with soft iron wire**

# A Picture Signal Generator—II

In the second installment of this series the synchronization signal generator, including the timer and shaper units, is described. While designed for the R. M. A. type of signal, the generator is capable of producing various specifications of synchronizing signals

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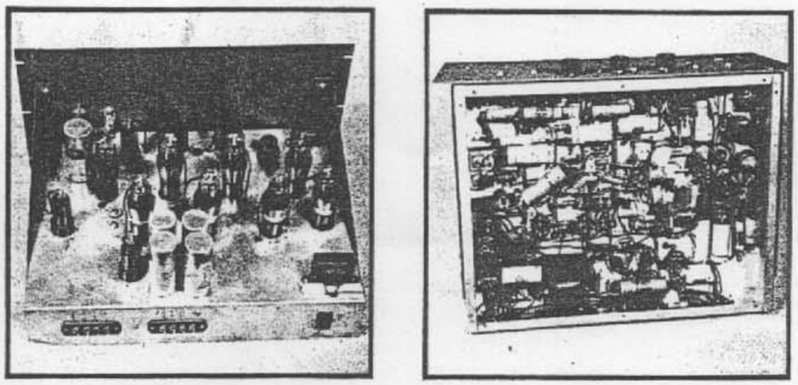


Fig. 1—Views of the timing unit, which generates 60 cps and 13,230 cps pulses which are shaped to form the vertical and horizontal synic signals

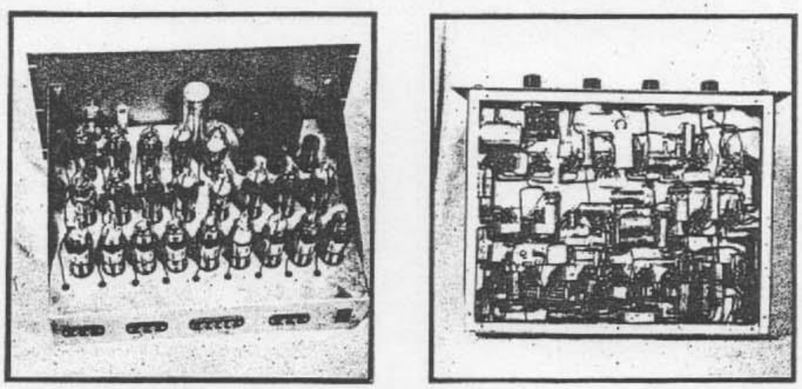


Fig. 2—Views of the shaper unit which generates the horizontal, vertical and equalizing sync pulses, as well as the keying signals, under the control of timing unit

IT is the function of the timer unit in the picture signal generator to generate properly synchronized pulses from which are produced the vertical and horizontal sync pulses as well as to assure synchronization with the power-line frequency when the field frequency is to be related to the power frequency. The function of the shaper unit is to take the pulses transmitted to it by the timer and to shape them to correspond to the requirements set by the standards under which the system is operating. The flexibility of the unit, which was originally designed for the standard R.M.A. pulse, is such that any practical standard signal can be generated by changing a few simple *L-C* and *R-C* components in the timing unit and making the corresponding adjustments in the shaping unit. The authors have found the R.M.A. standard signal the most practical for their purposes and the constants given are those required to generate that signal.

The timer and shaper units used follow closely those developed at the R.C.A. License Laboratory by Harmon B. Deal, and described on pages 402 to 413 in "Principles of Television Engineering" by D. G. Fink, McGraw-Hill Book Co., New York, 1940.

A 13,230 cps sinewave is used as the original voltage source from which all other frequencies are derived. In order that odd-line interlacing will result, the second harmonic of this frequency, 26,460 cps, is divided by means of four multivibrators in the ratios of 7:7:3:3 to sixty cps. This frequency is in turn compared with the local 60 cps of the power lines by means of a double diode discriminator circuit, in a manner similar to that employed in the familiar a-f-c circuit. Should there be a difference in frequency or phase between the 60 cps generated by the power company and that produced by the sync generator, a voltage is produced of an amplitude proportional to the difference in frequency between the two, and of a sign depending on whether the locally-generated 60 cps is leading or lagging the power line frequency.

This voltage must be well filtered to remove all traces of 60 cycles or any other frequency which might have been superimposed on it and applied to change the transconductance of a control tube so that the control tube's input capacitance varies as a function of the voltage delivered to it. This change in capacity will change the frequency of the 13,230 cps sinewave oscillator in the direction of balance. Balance will be achieved when the 13,230-cps wave, after frequency multiplication and division in the timer, appears as a 60 cps wave which is the same phase as that of the power line. At this point the discriminator circuit supplies a constant bias to the control tube and it no longer alters the frequency of the 13,230-cps master oscillator. Should either the 13,230-cps oscillator or the 60-cps line frequency tend to shift to another slightly different frequency the discriminator circuit and control tube circuit will cause the timer to hunt for a new balance but as this action is going on continually, balance is, with rare exceptions, constantly maintained. It is essential after obtaining the 26,460-cps sinewave from the master oscillator that all traces of the original 13,230-cps wave be removed. This is accomplished by suitable filters.

It is one of the requirements of odd-line interlace that odd multiples of 26,460-cps be used for frequency division. It was found essential in this timer to employ a minimum of 4 steps of division in order to assure good interlace. Buffers are provided between stages and adequate decoupling is used throughout. If the decoupling is not adequate, all the frequencies present in the timing generator will appear in scallop-like patterns on the vertical edges of the picture.

For convenience in alignment a jack is provided in each buffer stage. The last multivibrator in the chain produces the 60 cps field frequency. The 3000 $\mu\mu$f variable condenser in the plate circuit of the last multivibrator determines the vertical blanking pulse width. This saves a shaping operation later on. An electronically-regulated power supply provides power for the timer and a second unit of identical design supplies power for the shaping unit.

In adjusting the unit it is necessary to first adjust the Colpitts oscillator to 13,230 cps by means of a beat frequency oscillator. Then the 26,460-cps filters should be adjusted to a maximum output at 26,460 cps without any 13,230 cps ripple being present. The 60, 180 and 540 cps multivibrators should then be set against a 60 cycle time base on an oscilloscope. The 13,230-cps sinewave oscillator tube should be removed for this test as it will simplify adjustment. On the oscilloscope, against a 60 cps time base the output of the final multivibrator will appear as one pulse. The 180 cps multi-

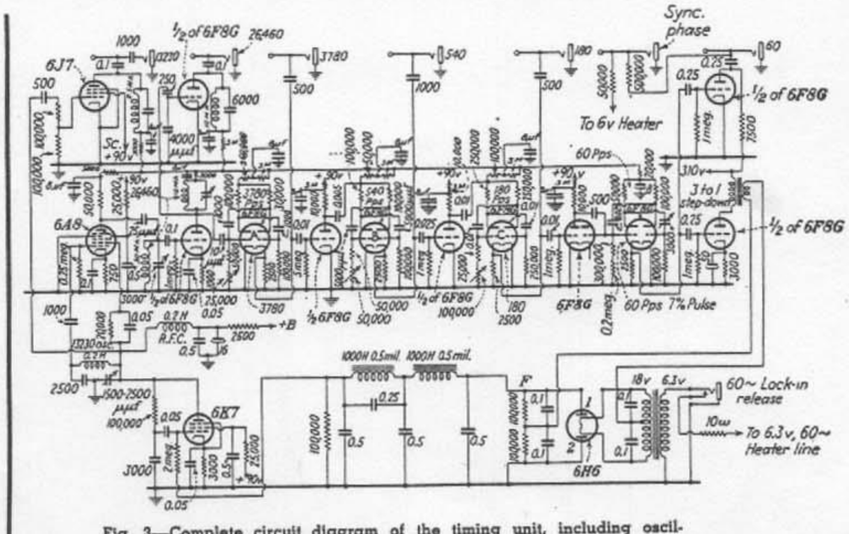



Fig. 3—Complete circuit diagram of the timing unit, including oscillator, doubler, multivibrators, and frequency-control discriminator

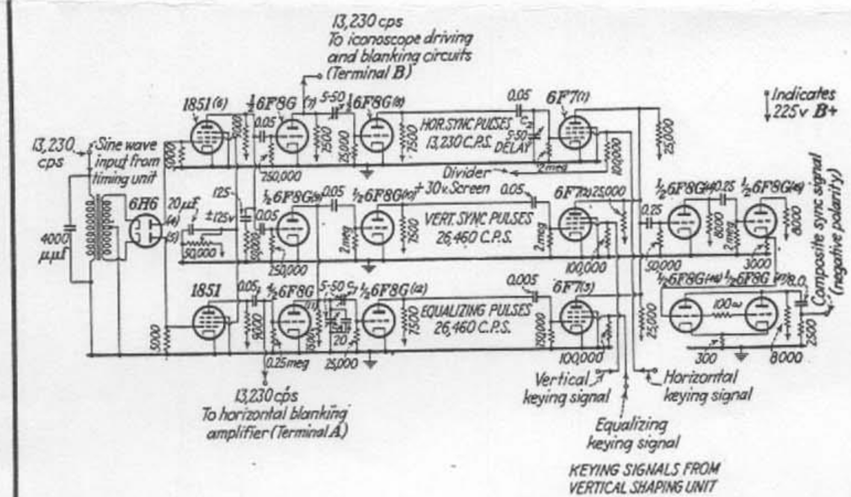



Fig. 4—Horizontal section of the shaping unit. Under the control of the timing unit, the composite synchronizing signal is assembled by means of keying signals

vibrator will appear as three, and the 540 cps oscillator as 9 pulses. The 3780 cps output will appear as 54 pulses and will therefore be too difficult to count on most oscilloscopes, so should be set by a beat-frequency oscillator.

The sine oscillator which was previously set to 13,230 cps should be set in operation by inserting the 6K8 oscillator tube. As a final check remove the automatic interlock by inserting a plug in the last jack. The oscillator can then be adjusted slightly to produce 60 cycles of very nearly the same phase as that of the local 60 cycle mains without the discriminator circuit. When this plug is removed the discriminator will take over and hunt a few seconds, finally settling down to a steady interlock with the power line frequency. Severe line surges will disturb the balance momentarily.

*Shaping Unit*

The shaping unit shapes the two fundamental frequencies 13,230 cps and 60 cps, the latter already present with a duration of 7 per cent of 1/60 of a second. These two voltages are operated upon by tubes performing four functions: clipping, narrowing, integration (delaying) and keying (inserting).

Clipping is accomplished in a vacuum tube by driving its grid negative beyond the plate-current cutoff point. This results in a flat topped voltage wave across the plate circuit resistance. More than one wave may be applied simultaneously

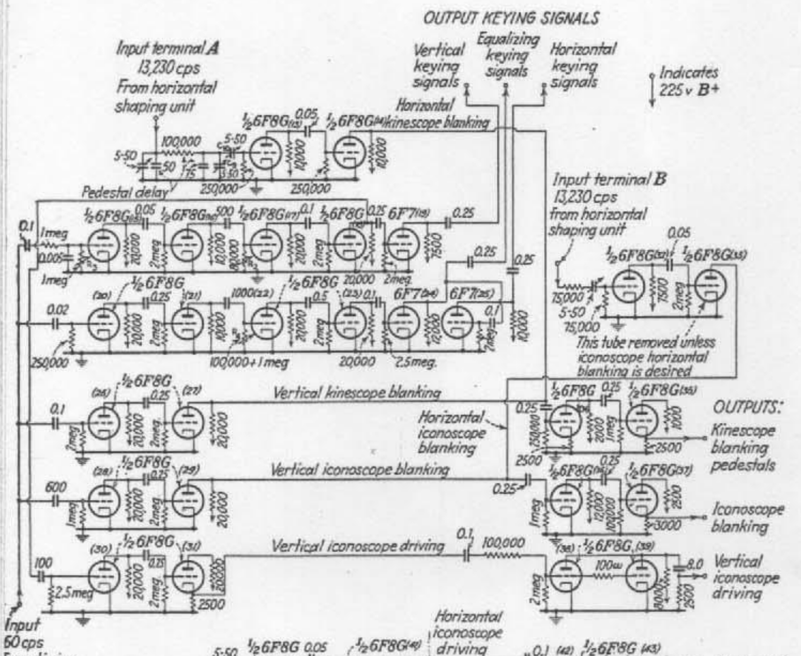



**Fig. 5—Vertical section of the shaping unit, which accepts 60 cps from the timer and generates keying and vertical blanking signals**

and clipped in turn. If this waveform is again clipped in another stage and if the driving voltage is high and the cut-off sharp, a wave with steep sides will result. The duration of the pulse can also be determined by clipping at a desired point on the sloping side of a sinewave, amplifying the resulting waveform and clipping again to obtain a square waveform.

Narrowing may be accomplished by passing a pulse through a small condenser followed by amplification and clipping to restore the square wave shape. Delaying or integrating circuits are those that discriminate against high frequencies. In general they are used to delay an amplified pulse with respect to its original. The desired result is accomplished by passing a pulse through a series resistor to a shunt capacitor. The shunt capacitor shapes the leading edge of the pulse by attenuating the high-frequency components. Subsequent clipping of this tilted wave results in squaring it up again. The front edge of the wave is thus delayed by the amount of time it takes the wave to build up to the clipping voltage.

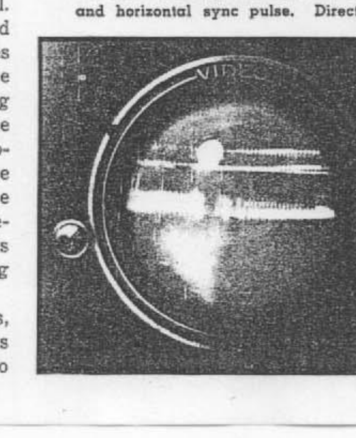
After the synchronizing pulses, equalizing pulses and blanking pulses are formed, it becomes necessary to key them in or out at their proper places in the complex picture signal. This can be accomplished by applying pulses of the proper width to the screen grids of three pentodes feeding a common plate circuit. When it is desired to "key in" equalizing pulses it is necessary of course to "key out" the sync pulses. By adjusting the width of a vertical pulse it is possible to key in the six desired equalizing pulses while keying out the sync pulses. To do this it is necessary to remove the sync pulses by bucking out the screen voltage of pentode No. 1 (see Fig. 4) with a negative pulse and to apply screen voltage to pentode No. 3 with another pulse of opposite sign. Pentode No. 2 has vertical sync pulses of the proper width and shape on its grid and operates only when the other two pentodes have been removed from operation by removing their screen voltage. Four other signals are available from this unit: horizontal iconoscope drive, vertical iconoscope drive, iconoscope blanking pulse, and kinescope blanking pulse.

### *Operation of Shaping Circuit*

Referring to the diagram of Fig. 4 the 13,230 cps input is applied to the cathodes of the two diodes 4 and 5 in phase opposition through the transformer (a Western Electric 77A repeat coil is satisfactory). The outputs must be symmetrical and the transformer of high quality. The resulting waves are clipped in the grids of the two following pentodes and the width adjusted by the 50,000-ohm potentiometer. These pulses have a duration of slightly less than one half period. One chain of tubes 6, 7, and 8 shapes and narrows the pulse to the desired width before applying it to the grid of the first keying pentode (1). This tube will pass these pulses unless its screen is keyed negative, that is, unless either equalizing pulses or vertical pulses are being inserted.

The next chain of tubes, 9 and 10 operates at double frequency since both halves of the output of the diode are present. These pulses are shaped to form the equalizing pulses and the vertical sync pulses at 26,460 cps. The width of these pulses is set by the differentiating condensers. The pulses are then applied to the grids

**Fig. 7—Complete video signal waveform as viewed on the oscillograph: left, vertical sync pulse and blanking pedestal showing 6 equalizing pulses before and after vertical pulse; right, two complete lines, showing camera signal, pedestal and horizontal sync pulse. Direction of increasing time is from right to left**



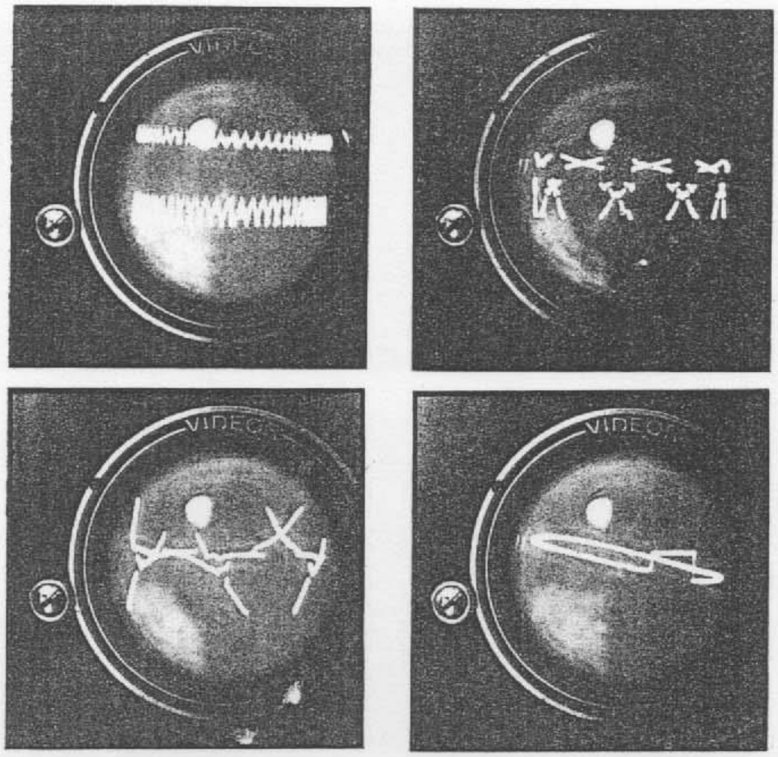



Fig. 6—Oscillograms of the output waveforms from the various multivibrators, using 60 cps sinewave sweep: upper left 3780 cps, upper right 540 cps, lower left 180 cps and lower right 60 cps

of pentodes 2 and 3. These pentodes operate only when their screens go positive. It is obvious that instead of the serrated vertical pulse, any kind of a vertical pulse could be applied, for example, the DuMont 500 kc vertical sinewave pulse.

The pulses appearing in the plate circuits of the three pentodes are not in general of even height and must be clipped and trimmed before passing on to an output circuit as shown. The 60-cps output of the timer is properly narrowed and clipped by the three rows of tubes 15 through 25 in Fig. 5 to produce the proper width pulse to key in the equalizing and vertical pulses or, after a phase reversal, to key out the horizontals during the assembly of the vertical pulse.

The bottom three pairs of tubes, 26 through 31, are also excited by 60 cps pulses which are shaped to provide vertical kinescope blanking, vertical iconoscope blanking and vertical iconoscope driving pulses.

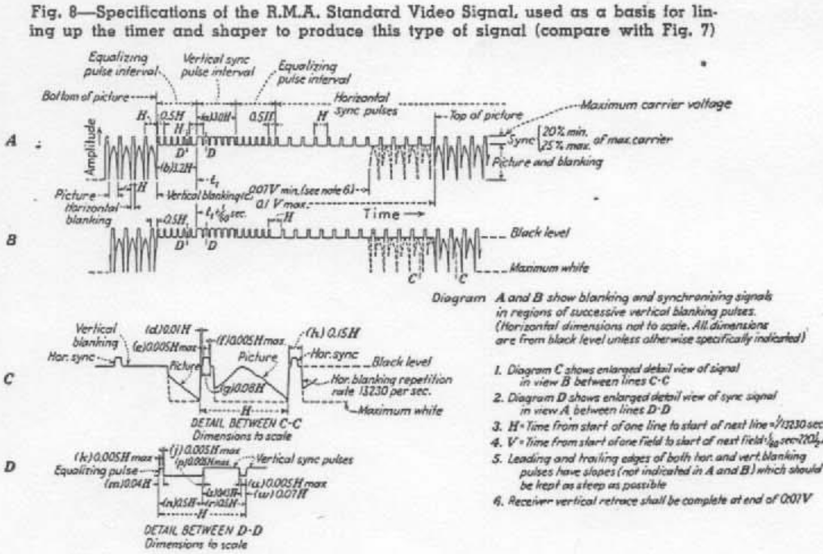
Suitable tubes and circuits are provided to form a low impedance output circuit, tubes 32 through 39. A train of shapers and clippers excited by 13,230 cps is provided to supply horizontal iconoscope driving, in tubes 40 through 43.

The alignment of the keying pulses proceeds as follows: Adjust the width of the vertical keying pulse by setting $R_2$ in the grid of tube 17 until 6 broad pulses appear in the output of tube 3. The delay is adjusted by $R_3$ in the grid of tube 15 until 6 equalizing pulses precede the vertical pulse. Finally, $R_4$, the narrowing circuit of tube 22 is adjusted until six equalizing pulses follow the last broad vertical pulse. A good oscilloscope at the output of tube 47 will show the complete synchronizing signal. It is essential that the leading edges of the three components making up this signal be exactly coincident. Variable shunt condensers $C_2$ (tube 1 grid) and $C_7$ and $C_8$ (tube 12 grid) can be adjusted until coincidence occurs. The width of the horizontal synchronizing pulse, and of the preparatory pulses can be adjusted by means of series variable grid condenser of tubes 8 and 12.

It is important to note that the blanking signals (pedestals) are not formed from the same square pulse from which the synchronizing pulses are made, but are made from the output of diode 4 which leads in time the latter pulse by ½ the horizontal period. This pulse is then delayed in the network preceding tube 13 until the pedestal leads the synchronizing pulse by the required one per cent of the horizontal periods. The amount of delay may be varied by the trimmer $C_8$ and the width set by the trimmer $C_{10}$. The driving pulse circuits employ the same technique. The iconoscope blanking signal is usually narrower than the kinescope blanking and obtained from the kinescope blanking pulses. The rise and fall of all leading and lagging edges can be set to 0.5 per cent of the horizontal period thus meeting the standards set by R.M.A. All outputs are from 100-ohm sources so the wave forms will remain substantially unchanged after passage over reasonable lead lengths. Horizontal iconoscope blanking is not used in this unit.

The next article in this series will describe the mixing amplifier, line amplifier, shading source, including adjustments, and power supply.

Fig. 8—Specifications of the R.M.A. Standard Video Signal, used as a basis for lining up the timer and shaper to produce this type of signal (compare with Fig. 7)



# A Picture Signal Generator—III

In this third installment the mixing amplifier, which combines the synchronizing, blanking, and picture-signal components, is described together with a line amplifier. The shading-signal generator, which produces compensation for the dark-spot is also discussed

By J. A. Brustman and

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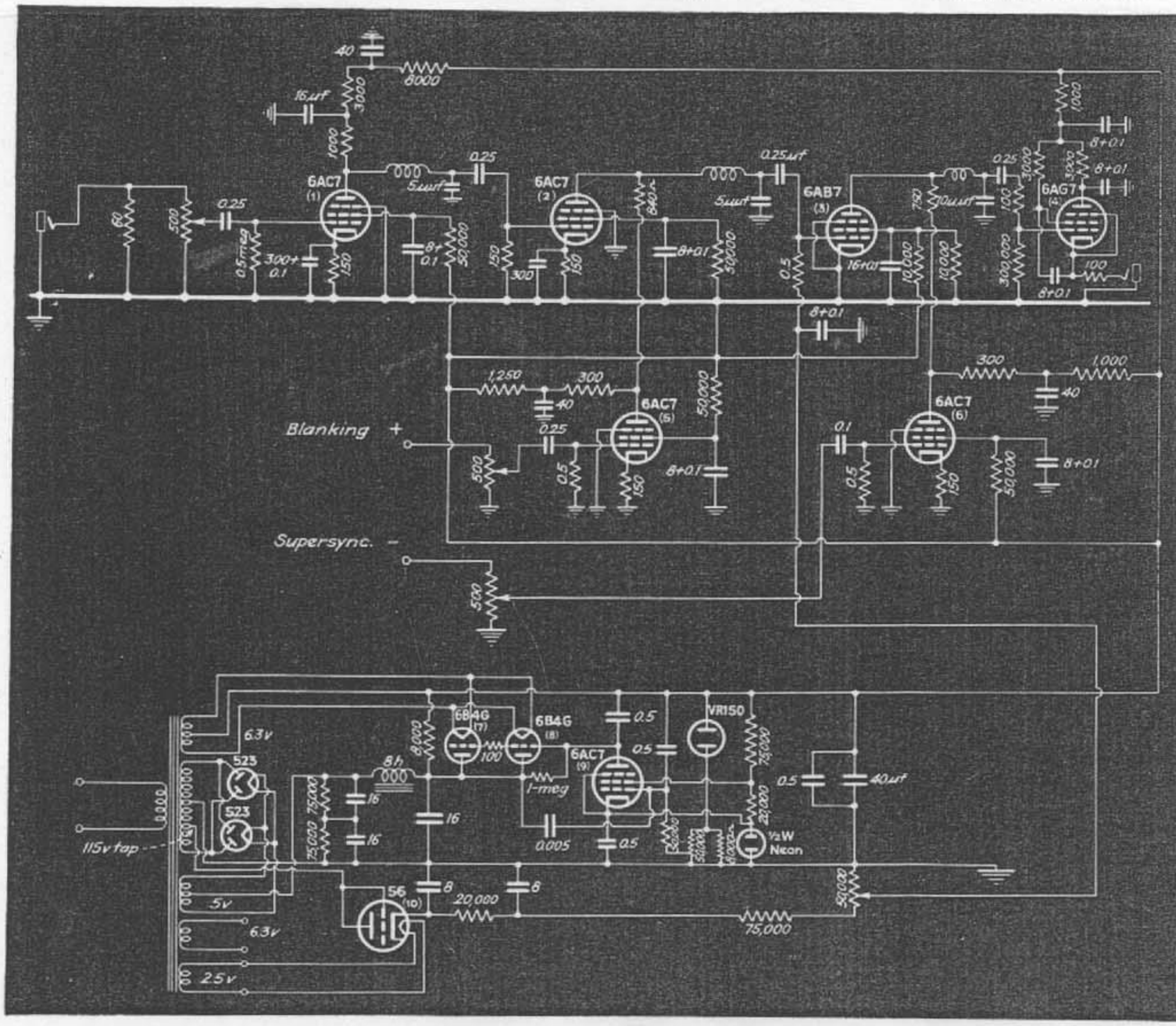
IT is the function of the mixing amplifier to assemble the various components of the video signal, with the exception of the shading voltages. The shading signal is best inserted in the video preamplifier where it can be inserted at as low a level as possible. The major portion of the amplitude characteristic of subsequent amplifiers may then be devoted to the amplification of the corrected video signal without danger of overload and the resultant loss in picture contrast, which would occur if the shading signals were inserted at a later point near the end of the video amplifier chain.

Shading signals are necessary to suppress spurious signals inherent in the operation of the conventional iconoscope. These signals must be neutralized or bucked out by voltages of similar waveform but opposite in phase. The shading unit to be described in this article is capable of developing a wide variety of waveforms all equal in frequency to either the line or the field frequency.

Fig. 1—Mixing amplifier and regulated power supply. The power supply shown also serves the shading-signal generator



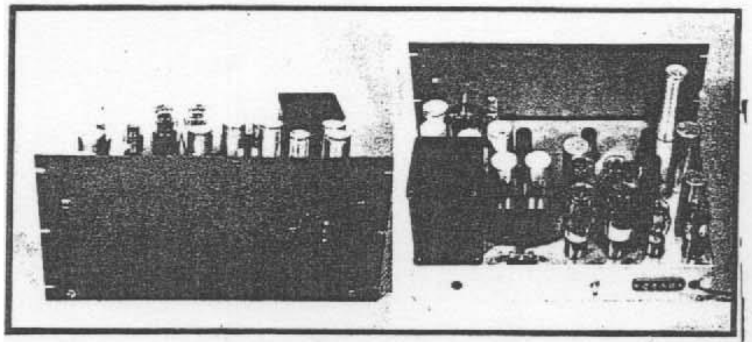
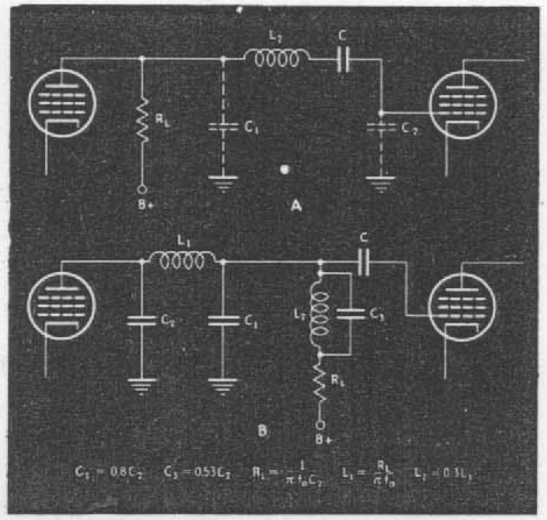


Fig. 2—Front and rear views of the mixing amplifier chassis and its regulated power supply. This equipment combines the sync signals, blanking signals, and the output of the camera into the video signal

Fig. 3—Coupling circuits for video amplifiers (A) series peaking, (B) combined coupling network



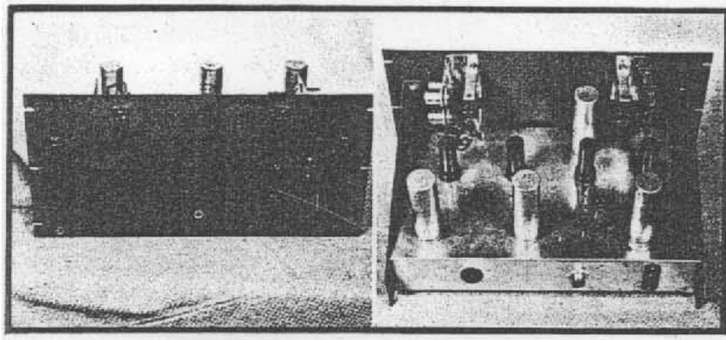



Fig. 4—Left, front and rear views of the line amplifier. The switches allow the selection of either the televison receiver or the output of the local camera and generator

These may be controlled as to amplitude and phase and assembled for insertion in the cathode circuit of the first tube of the preamplifier. The proper waveform will be dictated by whatever is necessary to balance dark spots appearing on the picture monitor tube and at the same time allow maximum contrast or range of tones in the picture.

The picture component of the video signal, complete with the shading signals, is obtained from the output impedance of the cathode-coupled stage (cathode follower) in the camera preamplifier and transmitted by coaxial cable from an apparent 60-ohm source to the input of the mixing amplifier. The output of the camera preamplifier is of the order of 0.1 volt. It is applied to the grid of tube No. 1 in Fig. 1 and controlled as to amplitude by the potentiometer across the sixty-ohm terminating resistor.

The first stage in the mixing amplifier serves to amplify the output of the preamplifier and apply it as a negative signal to the grid of the second tube in whose plate circuit the blanking pulses will be inserted. The polarity of the blanking pulse on the grid of tube 5 is positive. The plate of this tube is connected part way up the load resistor of tube 2. It is quite important to assemble signals in the proper phase relation. Furthermore, as we wish to clip the top off the blanking pulse in tube 3 by driving its grid beyond plate current cutoff, the blanking pulses must be negative in sign. It will be noted that series peaking of the high frequencies and anode compensation of the low frequencies by suitable choice of decoupling resistors and bypass condensers is used (see Kimball and Seeley, *RCA Review*, January 1939). The supersync is added in the plate of tube 3 by insertion in the plate circuit of tube 6 again by the common anode resistor method. The amplitudes of both blanking and supersync are determined by potentiometers in the grid circuits of tubes 5 and 6.

The output of type 3 plus the supersync is then applied to the grid of the output stage, then cathode-coupled to the grid of the line-amplifier first stage. It will be noted that a separate grid-bias rectifier is included in the regulated power supply. The B supply is similar to that shown in Fig. 5 of the first article of this series. It is reprinted here in the interest of clarity as there were several drafting errors in the circuit diagram shown in the first article.

The line amplifier consists of three stages and a cathode coupled output stage which feeds the final two stages as well as two other sources such as the kinets, in different parts of the laboratory and the r-f modulator and oscillator on 45.25 Mc for the receiver design test department. The output stage feeding the kinet is unique in that it employs a very high load resistor for the band width of 6 Mc. This is possible by employing an M-derived ½-section plus a full constant-K section filter. If this type of coupling is employed careful measurement of all $L$, $C$, and $R$ values is necessary. If a similar filter is employed the circuits in Fig. 3B should be used. This filter is suitable for an output stage but not recommended for more than two cascaded stages since cumulative phase shift will become excessive and no longer proportional to frequency.

*Formulas for series peaking*

The circuits in Fig. 3A show representative "series-peaking" circuits used in the video amplifier. Among the conditions which apply to the use of this circuit are:

(1) For the best operation of this filter $C_2/C_1 = 2$. (2) The load resistor can be placed on either side of the filter and should be placed on the side with least capacitance. (3) The load resistance is

$$R_L = \left(\frac{1.5}{\pi f_c C_t}\right)$$

where

$$C_t = C_1 + C_2$$

and $f_c$ is the maximum video frequency to be amplified. (4) The inductance $L_2$ equals $0.67\ C_t\ R'_L$. The phase shift, according to Kimball and Seeley, is $\frac{.0113}{f_c}$ seconds at frequency $f_c$, in Mc. The capacitances must be measured accurately by a Q meter or some other method and additional capacity added to $C_1$ or $C_2$ to make $C_2/C_1 = 2$.

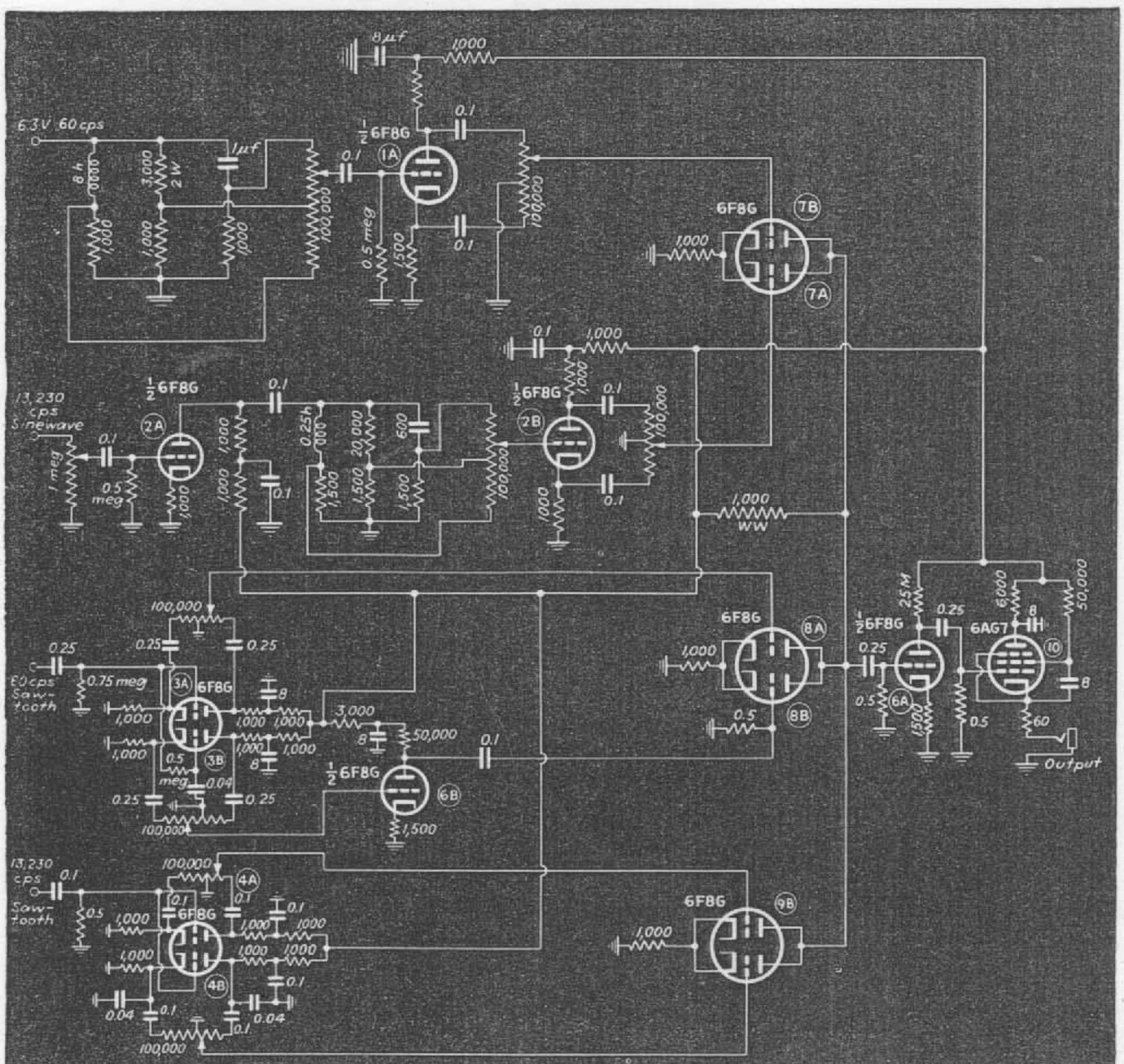
The formulas given in Fig. 3B apply to the elements of the M-derived plus constant-K low pass filter, referred to previously.

The filter may be reversed but the side containing the load resistor section should be placed across the smaller residual capacitance. As an example for a 4.2 Mc cutoff, the values are $C_2 = 15.2\ \mu\mu f$, $C_1 = 12.16\ \mu\mu f$, $C_3 = 8.1\ \mu\mu f$, $R_2 = 5000$ ohms, $L_1 = 579\ \mu h$, $L_2 = 113.7\ \mu h$.

*Shading Signal Generator*

Three fundamental wave forms are available for shading: (1) 60 and 13,230 cps sine waves whose phase may be shifted continuously

**Fig. 5—Diagram of the shading-signal generator, which produces synchronized sawtooth, sine, and parabolic waves to remove the dark spot signal from the iconoscope output**



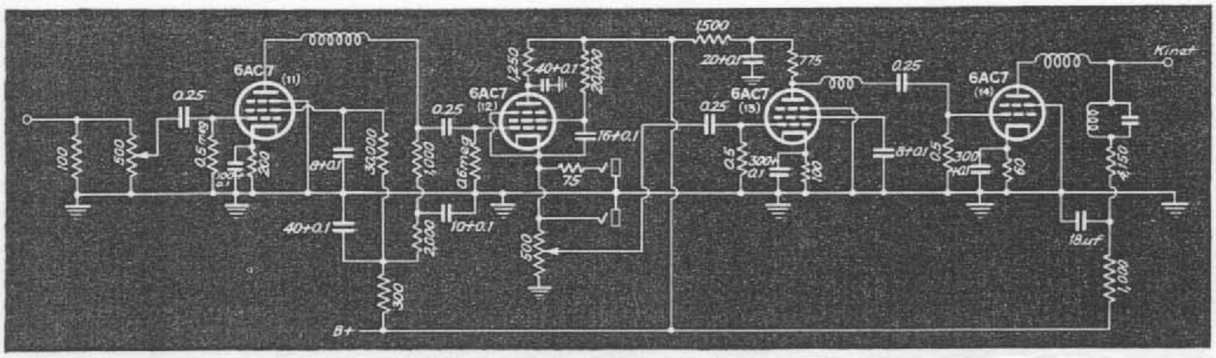



Fig. 6—The line amplifier which increases the level of the composite video signal so that it can control a picture tube directly

Fig. 7—Rear view of the shading-signal generator. Eight double-triode tubes are used to develop the correction signals to remove the dark spot

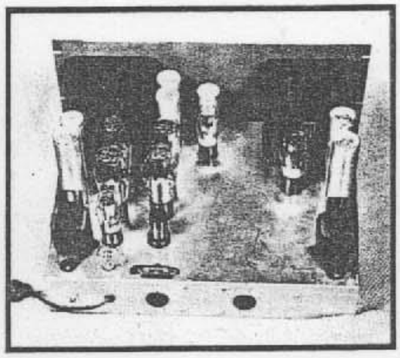


Fig. 8—Rear view of the power supply which provides voltages for the shading-signal generator, as well as for the iconoscope sweep circuits shown in Part II

Fig. 9—Mr. H. C. Kreinick of the American Television Corporation staff, televised by the equipment and reproduced on the monitor screen

through 360°, (2) 60 and 13,230 cps parabolic waves whose signs and amplitudes are reversible, (3) 60 and 13,230 cps sawtooth waveforms whose signs and amplitudes are reversible. In the grid circuit of triode 1A, Fig. 5, is a network of $L$, $R$, and $C$ so arranged as to shift the phase and amplitude of the 60 cycle ac arriving on the grid by means of a potentiometer. In the cathode and plate circuit of 1A a potentiometer will allow control of the amplitude and phase. The output appearing ultimately on the grid of tube 6A along with all other wave forms.

Triode 2A amplifies the 13,230 cps sine wave output of the timer and applies it to a net work for phase shift by a potentiometer across its output in the grid of triode 2B where phase and amplitude can again be shifted 180° before passing on via 7A to the assembly point at the grid of 6A.

Sixty cycle sawtoothed waves from the iconoscope sweeps, see Fig. 7 article No. 1 this series, is applied to the grid of 3A to appear as a sawtoothed wave whose amplitude is reversible and continuously variable, before applying to triode 8A for assembly and reappearance with all others at 6A. At the same time this sawtooth is predistorted in the grid of 3B to obtain a parabolic wave which is passed on to tube 6B and amplified in like manner to 6A. The amplification is required because in distorting the waveform the amplitude is lowered and must be raised to the equivalent level of the other waves appearing at 6A.

Triode 4A has appearing on its grid a 13,230 cps sawtooth wave which is adjustable in similar manner to the others in the plate of 4A and appears with all others on the grid of 6A. The 13,230 cps sawtooth waveform is also predistorted to a parabolic form but in a somewhat different way. In this case in the plate and cathode circuits to form a parabolic wave which is passed on via 9A to meet the others at 6A. The output of 6A enters on the grid of a cathode follower for impedance transformation in tube 10 and appears in its cathode at the point marked output. A study on an oscilloscope of all these wave forms at their origin and on through their respective paths will be self explanatory. Final adjustment and utilization will depend on the particular scene that is being shaded. The proper adjustments being determined by trial and error. Aptitude for this adjustment develops with surprising speed.

The next article in this series will be on the monitor tube sweeps, power supply, and the waveform oscilloscope.

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Editor's Note. In addition to the correction above noted to the regulated power supply diagram appearing in Fig. 5, Part I of this series, which is shown correctly in Fig. 1 of this installment, a correction should be made to the diagram of the high voltage power supply for the iconoscope, shown in Fig. 5, Part I. The polarity of the type 879 rectifier should be reversed so that the anode connects directly to the filter circuit, thus making the terminal marked $K$ negative with respect to the terminals marked $G$, $A_1$ and $A_2$.

# A Picture Signal Generator—IV

After describing the waveform oscilloscopes and picture monitor circuits, the authors discuss the reasons for using a short picture tube of the magnetically-focused variety. Circuits for full deflection of the short tube at a second anode voltage of 7000 volts are described

By J. A. BRUSTMAN

and M. P. WILDER

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THE two most useful instruments to the video control engineer are the monitor picture tube and the cathode ray oscilloscope. No picture signal generator is complete without them. In our unit we found it convenient to use two type 906 cathode-ray oscilloscope tubes. One is used to monitor the video signal and to observe the signal waveform either of one line or of one field. The other tube can be used to study or monitor the synchronizing pulses. A switch on the oscilloscope unit connects either of two time bases (sweep circuits), 60 cps ac or a continuously variable linear time axis from 20 cps to 25,000 cps. The switching arrangement is such that either time base may be used on either oscilloscope tube, but it was not found necessary to have both tubes use the same time base at the same time.

The oscilloscope contains its own power supplies, low voltage as well as high voltage. The sweep amplifier uses a double triode, one half being the amplifier and the other a cathode follower, which affords a convenient means of amplitude control without distorting the saw tooth wave form.

Another amplifier is designed to clip the top off the incoming wave form so that it can be distorted into a pulse to insure rigid synchronization. This amplifier is designed so that a 180° phase shift can be obtained at will. Thus it is always possible to secure the positive polarity of the synchronizing pulses.

The right-hand oscilloscope is designed for studying wave forms applied directly to its plates and does not have an amplifier. The input to the vertical deflecting plates is gain controlled by a simple potentiometer as this oscilloscope is not intended for wide range use.

The chief function of the right-hand unit is to monitor the vertical synchronizing pulse as to its phase relationship with the 60 cps power line frequency, and to check the width of the vertical blanking pulse. It is also possible by means of suitable jacks on the timer unit to observe the wave forms of the four different multivibrators and to compare them to 60 cps to be sure they hold the 7:7:3:3 relationships.

The left-hand oscilloscope contains a three-stage high-gain video amplifier good to 3 megacycles. The input attenuator is a switch set for low, medium, and high inputs to the grid of a cathode follower stage. A variable resistor across the cathode of this tube permits continuously variable control of gain in the video amplifier without damage to the waveform. The length of the lead from this input tube back to the video amplifier in the right rear position of the unit has no loading effect on the input to the video amplifier because of the low impedance of the cathode follower stage. The voltage developed across the output resistor in the final video stage is sufficient for ample deflection of the beam in the vertical direction. A voltmeter is used to monitor the line voltage and also to measure the amplitude of a calibrating voltage which is useful in measuring the actual peak values of the waveforms.

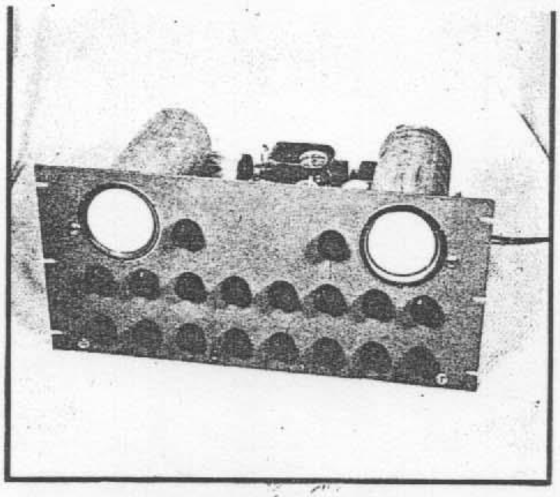
Controls of a semi-fixed variety are provided for intensity, focus, and position of each tube independent of the others. Others for coarse and fine speed, vertical and horizontal gain, and synchronous pulse amplitude are also available. Two input jacks are provided, the left-hand one for the wide range oscilloscope and the right-hand one for the general purpose (or phase monitoring) oscilloscope. This is particularly useful when calibrating the timer against an audio oscillator to be sure the master frequency is 13,230 cps. The complete oscilloscope circuit is given in Fig. 3.

### *The Picture Monitor*

The video amplifier for the monitor was described in detail in the previous installment. The picture tube used in the monitor is of the "short" variety employing magnetic deflection and magnetic focus. The circuit for magnetic deflection of short tubes presented somewhat of a problem as it was desired to use the full 7000 volts of the second anode power supply, so that the unit could be operated in a fully lighted room.

The difficulties of obtaining ample deflection were found to revolve about the scanning yoke and considerable time was spent in developing a yoke suitable for the purpose. This yoke was found also to be entirely suitable for the iconoscope and was used in the camera unit described in Part I of this series. Complete data and specifications for the manufacture of this yoke were given as well as the type and numbers of the transformers to be used with it. The deflection circuit is somewhat different from that used with the iconoscope, however. Ordinary receiving tubes are used within their ratings. The complete circuit is given in Figs. 4 and 5.

Controls have been brought out for all conventional functions such as position, focus, amplitude, and brightness. The linearity adjustment is semi-fixed but can be ad-



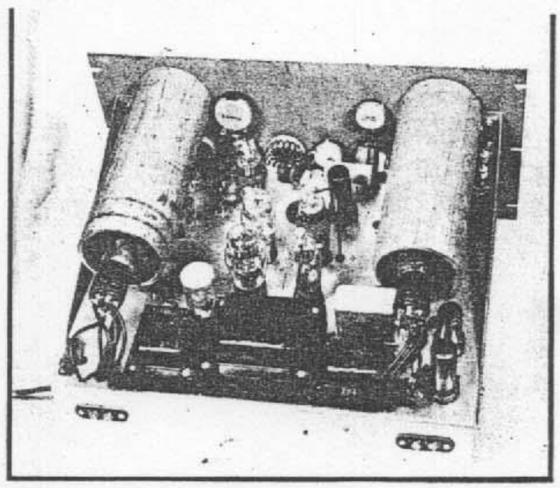
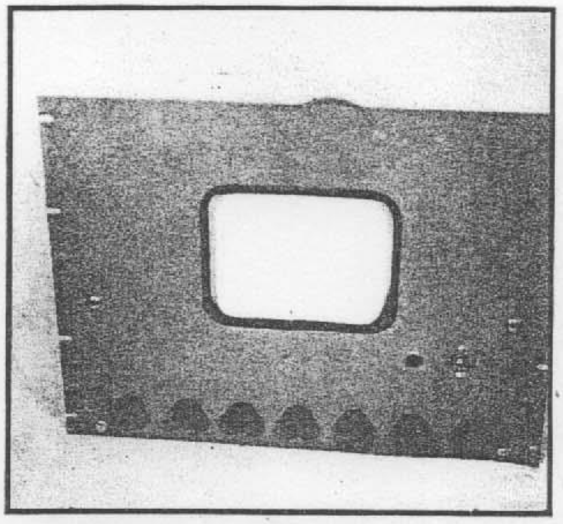


Fig. 1—Front and rear views of the waveform oscilloscopes. The unit at the left is used for observing phase relations in the sync pulses, that at the right for viewing the video signal waveform



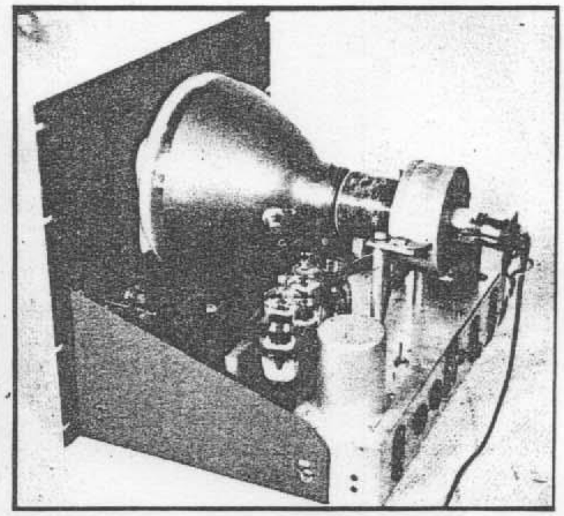


Fig. 2—Front and rear views of the picture tube monitor, which employs a short 9-inch tube using magnetic focus. The yoke and focusing coil are visible in the right-hand view

justed when necessary from the rear with a screw driver. The power supplies are conventional.

*Magnetically Focused Tubes*

In the American literature little has been written about the merits and demerits of magnetically focused picture tubes. This method of focusing was almost universally used in European television receivers before the current war. In this country, however, the cost of the focusing coil, its support and the current it used were viewed as sufficient reason for not carrying out further development of this means of focus. At present, however, the magnetic focus tube is beginning to reappear in a new and favorable light. It is our conclusion that magnetically focused picture tubes are better from a focus viewpoint, cheaper to build and to operate and have a longer life than electrostatically-focused tubes whether electrostatically deflected or magnetically deflected.

Perhaps the outstanding advantage of magnetically-focused picture tubes is the reduction in ion blemish. With this method of focusing the ions are out of focus when the electrons are in focus. Although picture tubes employing electrostatic focus have been made which are almost free from ion blemish for as much as 100 hours, when magnetic focusing is used this same blemish is spread over a large area and the presence of an ion blemish becomes purely academic. In practice it has been difficult to find traces of ion blemish on magnetically focused tubes which have been in service for several years. Tubes made to the authors' specifications have been in service for a year and have shown no evidence of ion spot detectable by the eye during everyday operation. This is only true however at high anode potentials. While other ways to remove completely even the remaining ions have been suggested and put to practice in "ion trap" tubes, the authors have come to the conclusion that straight magnetic focus of a well exhausted tube is the best solution to the ion spot problem.

Magnetic focus tubes are of two general types: tubes in which all focusing occurs after the beam is brought up to full final anode potential and those in which prefocusing takes place electrostatically. The authors prefer the former or simple triode type. This has many advantages over the others, specifically as regards "blooming," simplicity of construction, shortness of gun, fewer parts to be outgassed, and the development of such ion blemishes as

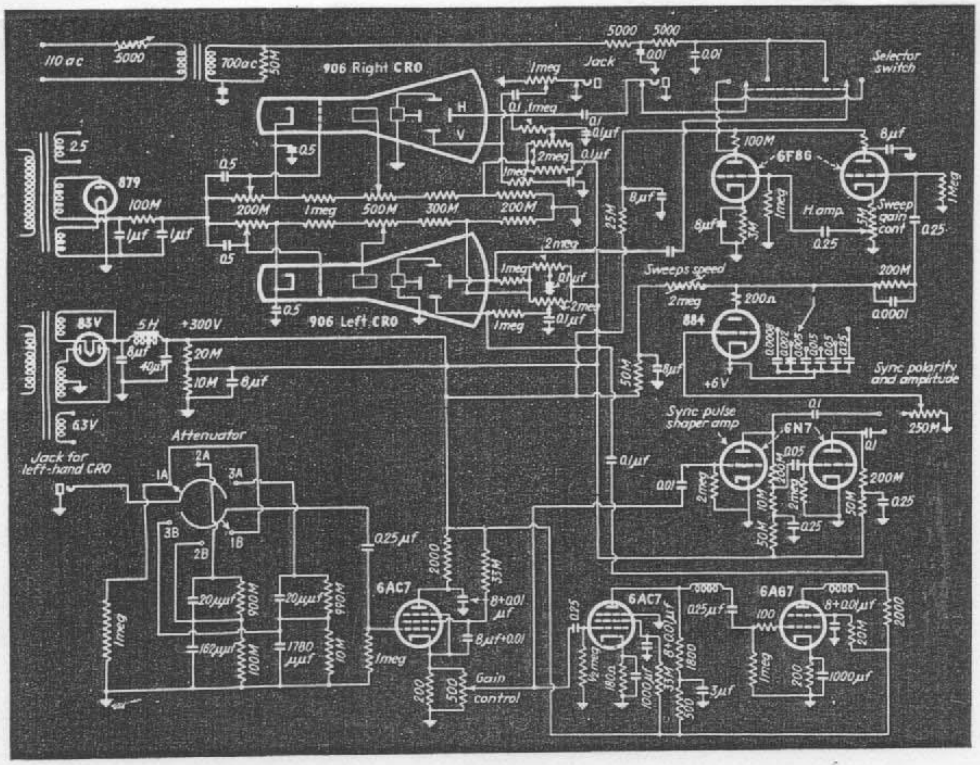


Fig. 3—Complete circuit diagram of the cathode-ray oscilloscope and its associated power supply

may ultimately appear being spread over the largest possible area hence causing a minimum of discoloration. This tube consists of a cathode capped by a cylinder with a small aperture used as a grid containing a .030-inch hole.

The final anode adjacent is the aquadag coating on the inside lip of a glass nozzle pointing toward the grid and several millimeters away. This anode draws all possible electrons from the grid while at the same time fanning the ions out to a circle of maximum diameter. The use of this glass nozzle lengthens the leakage path back to the getter thus reducing the loss of gas molecules with a negative sign from the getter, by electrostatic attraction, a fact which experimental evidence indicates contributes much to the low density of the ion blemish.

This particular design is due to Ediswan in England and had been very completely tested by them prior to England's entry into the war. This design is marked by high efficiency as all the beam current gets to the screen without the possibility of loss to any electrode en route. Also the chance of ions being dislodged from the lip of the electrodes is reduced to a minimum. This, by the way, is a very potent source of negative ions.

"Blooming" or defocusing at high brilliance in this simple triode structure also is noticeably less than in more complicated structures. The control-grid sensitivity is fairly good, twenty volts peak-to-peak being sufficient for good modulation. Other designs similar to a tetrode have higher sensitivity, but none that we have tried show an improvement of greater than two to one. In fact, all that did show better grid sensitivity also showed marked increase in blooming.

The use of European phosphors of zinc and cadmium sulphide activated with silver and air settled against a sodium silicate binder resulted in screens of a markedly improved contrast range. This wider range of contrast plus the low blooming of the magnetic focus tube allows more beam current to be used without compression of the blacks. The life of this material has been found equivalent to the sulphide silicate mixture type. Screen color is easier to hold constant and the screens discolor less under ion bombardment.

The overall brightness of these tubes can be raised without loss of contrast. Comparative tests of light output of these phosphors in comparison with the more common American phosphors show approximately equivalent light output in lumens per watt with no modulation. With modulation, however, they appear several times brighter.

The most important advantage of the short tube is the fact that comparatively large pictures can be obtained in a small shallow cabinet. This type receiver has considerably more sales appeal than a large deep receiver with a picture too small for the cabinet. This purely mechanical advantage can be much offset by viewing the tube in a mirror if the cost of the mirror can be disregarded. Another point to be considered is that mirror viewing is not as satisfactory as direct viewing from the angle of vision, picture-size and picture-brightness points of view. Cabinets with hinged tops are costly and are required when mirrors are used. They also prohibit the use of the set as a table top upon which to place books, flowers, etc.

Another important advantage of the short tube is the fact that less magnification takes place of the virtual cathode (sometimes called the cross over) in view of the fact that the image distance is less. A logical conclusion which can be drawn is that the beam will be smaller at any point along its length for a given terminal spot size in a short tube than in a long one. The cross over or virtual cathode can therefore be larger with a consequent increase in current density in the beam cross-section, which results in achieving a brighter image. Experience and conclusions from the above indicate we can expect short tubes to be actually brighter than long tubes when both have the same spot size on the screen. The authors have found this to be true. The chief disadvantage of the short tube is the difficulty of obtaining sufficient scanning deflection. The defocusing at the corners due to the greater angle of scanning is important but this latter is to a considerable extent offset by the improved focus which is realized by virtue of the low magnification and large object distance.

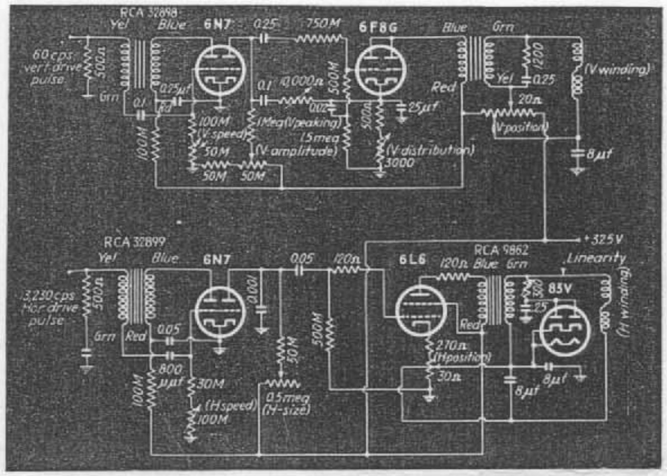



Fig. 4—Sweep circuits for the monitor picture tube, using blocking oscillators and output amplifiers. The scanning yoke was described in the first installment of the series

In the picture generator here described, the problem of scanning has been solved for potentials on the final anode as high as 7000 volts using conventional receiving tubes, within their ratings, in the sweep output circuits.

There are certain circuit and operating advantages and disadvantages regarding magnetic focus and electrostatic focus that must be considered. Magnetic focus requires a magnetic lens exterior to the tube. It may be either an electromagnet or a permanent magnet. The unit itself is actually not very expensive and consists of a simple solenoid approximately an inch thick wound in any fashion desired. The required magnetomotive force of 500 ampere turns can be obtained with a 10,000-turn coil when the total B supply current (50 ma) is passing through it, thus taking very little extra power.

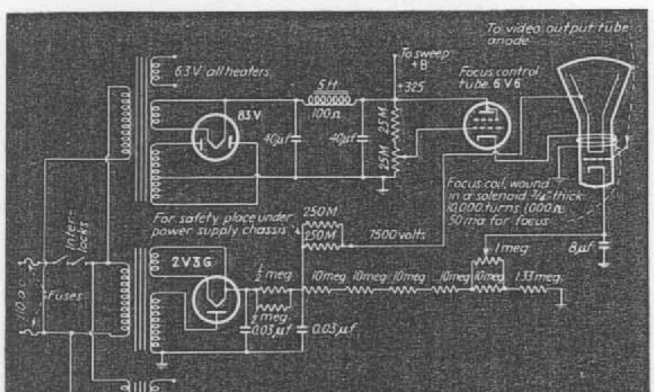
This brings up an advantage of the electrostatic tube over the electromagnetic. Power line changes will cause little or no defocusing in electrostatic focus tubes as they are dependent for focus upon the ratio of the voltages on the first and second anode remaining constant. This will theoretically remain constant if the resistors in the voltage divider remain constant and if the regulation is good. Unfortunately regulation cannot be good unless the voltage divider is of low overall resistance and the filter condensers are fairly large. Poor regulation makes for poor focus stability and makes the change in power line voltage effect on focus about equal in magnetic and electrostatic focus. However, there is a limit to how poor the regulation of an electrostatic focus tube can be if serious defocusing with brightness change is not to occur. On the other hand electromagnetic focus tubes of the triode type take no more power from the high voltage source than is actually being used in the beam, hence good regulation is easy to obtain. It is this fundamental advantage which allows an economic saving in the high voltage source and filter, which goes far toward overcoming the cost of the focusing coil.

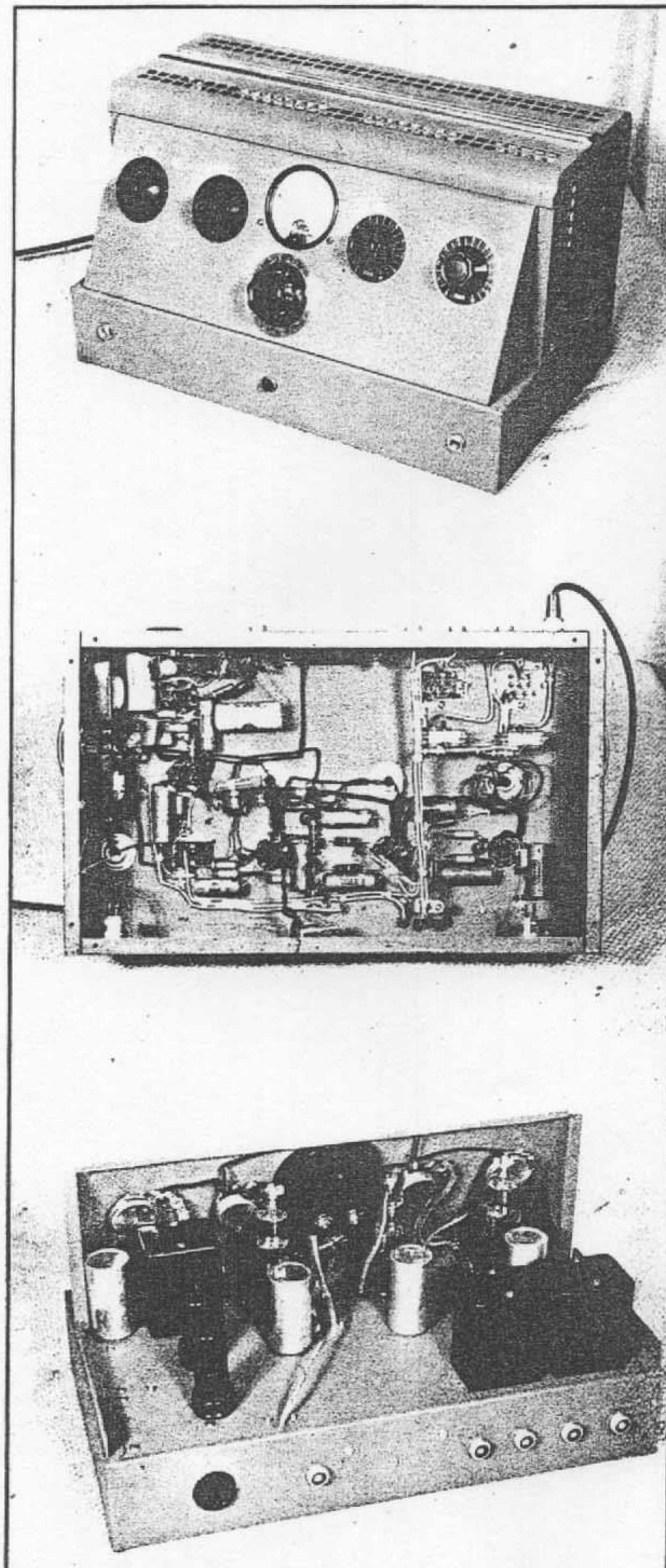
Another difficulty of electromagnetic focus is the twisting of the pattern as the beam passes through the lens. This is minimized by making the lens as thin as possible. An optimum condition is one in which the lens is approximately one-half to three-quarters of an inch thick capped by iron end plates whose magnetic circuit has been completed near the maximum diameter of the iron end plates. The central ring or core should be made of fiber bakelite or some non-magnetic metal. With this lens good focus can be achieved and pattern twist on either side of true focus has no approximate distorting effect on the picture.

Another important advantage of magnetic focus is the ability to shift or center the pattern by tilting the magnetic lens. The limits within which the beam can be bent by tipping the lens and still not effect focus are wide enough to center the pattern easily. This saves some cost in pattern shifting components such as potentiometers, by-pass condensers, resistors, etc.

The next article will describe the television tuner used in this unit to pick up outside television stations for transmission to the kinets or for study on the monitor.

Fig. 5—Power supplies, focusing coil circuit and picture tube connections of the monitor. The control grid of the picture tube is connected to the video amplifier described in Part III





# A PICTURE

By
M. P. WILDER
and
J. A. BRUSTMAN
*American Television Corp.*

A MOST necessary part of all television pick up equipment is the sound equipment. In the signal generator here described the output amplifier and power supply are included in the bottom chassis in the right hand cabinet. The output amplifier employs four 6L6 tubes in push-pull parallel fed by a phase inverter tube on the same chassis.

An output transformer provides proper termination for one to six permanent magnet loud speakers. The audio control unit shown in Fig. 1 contains the microphone preamplifier, the gain indicator, and the mixing and fading controls for several mikes. We found it convenient to have a separate unit for audio monitoring which can be placed on the operators table, along side the left hand cabinet. Both shading and audio monitoring can be accomplished by one operator on all occasions for which this equipment was designed. A second man at the camera is required to center and focus on the subject to be televised. A telephone circuit is provided through a separate amplifier in the preamplifier unit so that the control operator can give instructions to the camera man. This telephone signal is carried along the main cable to the camera on one of the spare conductors and is available at an output jack on the camera. Either a microphone stand or boom is used to place the microphone for optimum pick-up.

**Fig. 1—Front and rear views of the audio control console, showing mixing controls and volume indicator. Talk-back circuits from monitor to camera are included**

# SIGNAL GENERATOR-V

**In the concluding installment, simple modulators are described for developing the picture and sound signals as r-f carriers, useful in testing the overall performance of television receivers. A four-channel r-f and i-f amplifier unit, to allow outside signals to be picked up, is also described**

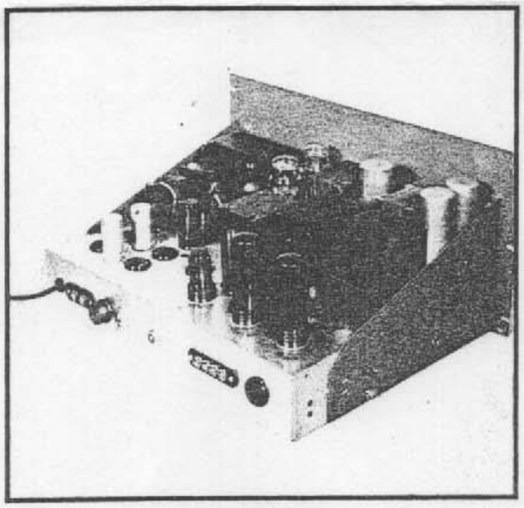


Fig. 2—The modulator chassis. Two 6L7 tubes are used as modulators to develop sight and sound carrier voltages in the range from 45 to 50 Mc

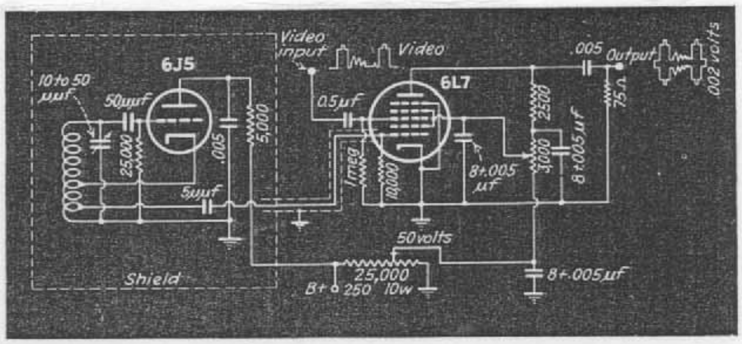



Fig. 3—Circuit diagram of the oscillator and modulator used in the picture channel. The percentage modulation is varied by adjusting the screen voltage

In order to make both the picture and sound available for overall receiver testing it was found desirable to include two r-f oscillators and two modulators, plus such other equipment as would allow the presentation of a modulated carrier signal to the antenna posts of the receivers. These oscillators, of conventional design, are variable over the range from 45-50 Mc. A high-C tank circuit of rigid mechanical construction was employed, but no other unusual precautions were found necessary to insure frequency stability. The oscillators are well shielded and supply approximately two volts of carrier signal by shielded cable to the control grids of the 6L7 modulator tubes. Grid leak bias is used. Video signals from the cathode of a 6AG7 cathode-coupled stage, of positive polarity, are applied to the number three grid through a coupling condenser. A peak-to-peak signal of about 4 to 6 volts is sufficient. A potential of about 50 volts is employed on the plate and screen and the percentage modulation is controlled by varying the screen voltage. The modulator anode voltage is fed through a 2500 ohm load resistor, while the signal is picked off a 72 ohm resistor coupled by a 0.006 $\mu$f condenser to the plate. About ten millivolts across 72 ohms is then available for receiver testing. Other circuits employing pentagrid converters such as the 6A7-6K8-6A8 can also be used in a similar manner. The circuit described, which proved the most satisfactory for this unit, is one suggested by Mr. Earl Anderson of the R. C. A. License Laboratory. A duplicate set up is provided for the sound channel. Both have proven quite satisfactory in operation.

### *The Television Receiver*

In order to complete the flexibility of the signal generator it was felt desirable to include a multi-channel television receiver so that outside programs could be picked up for test and for comparison purposes. It was also felt that if the unit were to be used in hotels or department stores more use for the instrument could be obtained if it were possible to pick up regularly broadcast pictures under conditions allowing maximum control. These pictures could then be distributed throughout the building and thus avoid many of the problems resulting from multiple antennas and the resulting reflections which are difficult to eradicate when several receivers are fed from the same or closely adjacent antennas.

Since power, sweeps, monitor tube and video amplifiers are already provided in the unit, a simple r-f chassis is all that is required. The design of the circuits prior to the first detector follows conventional lines and allows switching for four channels. Both sides of the antenna coil are switched. One side of the grid coil is switched, and an additional coil is placed in parallel with the oscillator for each of the four bands. A single-turn inductance is used to

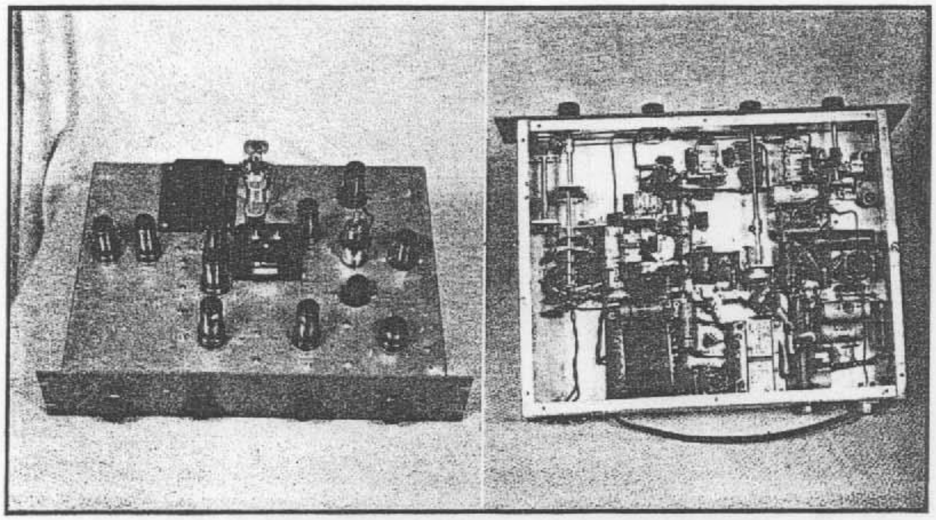


Fig. 4—Top and bottom views of the four-channel television receiver tuning unit, which permits outside broadcasts to be seen on the monitor tube

couple the antenna to the grid coil. This coil should have a value of about 30 millimicrohenries and should be tuned with a mica condenser to the mid-band frequency. The grid coil is damped with 1500 ohms. The pass band is better than 4.5 Mc. This method of coupling is not the most efficient but with a little adjusting of the coupling between primary and secondary will be found quite satisfactory.

The i-f stages have sufficient gain to allow the receiver to reach into the region of 100 $\mu$volts with ease. It is to be remembered that considerable reserve gain is available after the second detector as the full gain of the line amplifier can be employed should this prove necessary. The design of i-f amplifiers for wide bands has been considerably simplified and can now be accomplished by simple double tuned circuits of the correct self and mutual inductances. In fact for the special case of R.M.A. recommended television i-f frequencies very simple but reliable formulas can be used. This is true providing certain definite parameters are chosen. These parameters are fortunately those which experience indicates are the most likely to be required. They are stated as follows: the midfrequency of the pass band is chosen to be 11.25 Mc and the pass band to be 4.2 Mc. The total capacitance plate-to-ground in the case of the primary and grid-to-ground in the case of the secondary must be known. It is then necessary only to divide the number 38,200 by the capacitance to ground in microfarads in the primary and the secondary circuits to obtain the proper value in ohms of the damping resistor to use across each coil respectively. The value of inductance for each coil is obtained by multiplying the number .00558 times the value of the respective load resistor in ohms. The result will be in microhenries. The proper value for the mutual between the coils is obtained by solving the equation $M = 0.352\sqrt{L_p L_s}$, where $L_p$ is the inductance of the primary and $L_s$ equals the inductance of the secondary in microhenries. As an example, by measuring with a $Q$ meter, it is found that $C_p = 16$ $\mu\mu$f and 4 $\mu\mu$f for tuning and $C_s = 26$ $\mu\mu$f and 4 $\mu\mu$f for tuning making $C_p = 20$ total and $C_s = 30$ total. The proper values of load resistance would then be $R_p = 1920$ and $R_s = 1270$, the inductances $L_p = 10.720$ $\mu$h, $L_s = 7.082$ $\mu$h, and the mutual 3.060 $\mu$h. The values decided upon are wound on a $\frac{5}{8}$" form with No. 36 enameled wire and measured by cut and try against a suitable bridge or a $Q$ meter.

If the inductances measure to the correct values and if the coils are spaced approximately a sixteenth of an inch they can be adjusted to the desired mutual by slight movement of one winding with respect to the other on the form. The mutual can be measured by reading the inductance with the coils first in series aiding and then series bucking subtracting the difference and dividing by four. The gain of the stage depends on the minimum total capacitance so great pains should be taken to keep $C_p$ as low as possible. The $C$ total of 50 $\mu\mu$f taken in the example represents poor practice. Much lower values of $C$ total are possible with neat wiring and short leads. The gain of the stage in the example, employing a 6AC7 tube, will be about 8.

### *First Detector and Trap Circuits*

The mixer employs grid leak bias and must have at least two and not more than 4 volts of r-f from the oscillator inductively coupled to the grid. This is accomplished by winding the antenna and grid coil and shunt oscillator coil on the same form. A quarter inch spacing in each case will be satisfactory. Operation is best checked with a good vacuum tube voltmeter. The pass band shape of each stage is altered by means of traps, stage by stage, first at 14.25 Mc then at 8.25 Mc to shape the pass band to reject first the sound channel and then the adjacent channel interference. Sound is taken off the 8.25 Mc trap in the plate of the first i-f stage and amplified by a single 1852 stage. Conventional audio output circuits are used.

The second detector, a 6H6, is used also to strip off or separate the sync pulses from the video signal. The pulses are then amplified in a double triode, the first triode acting

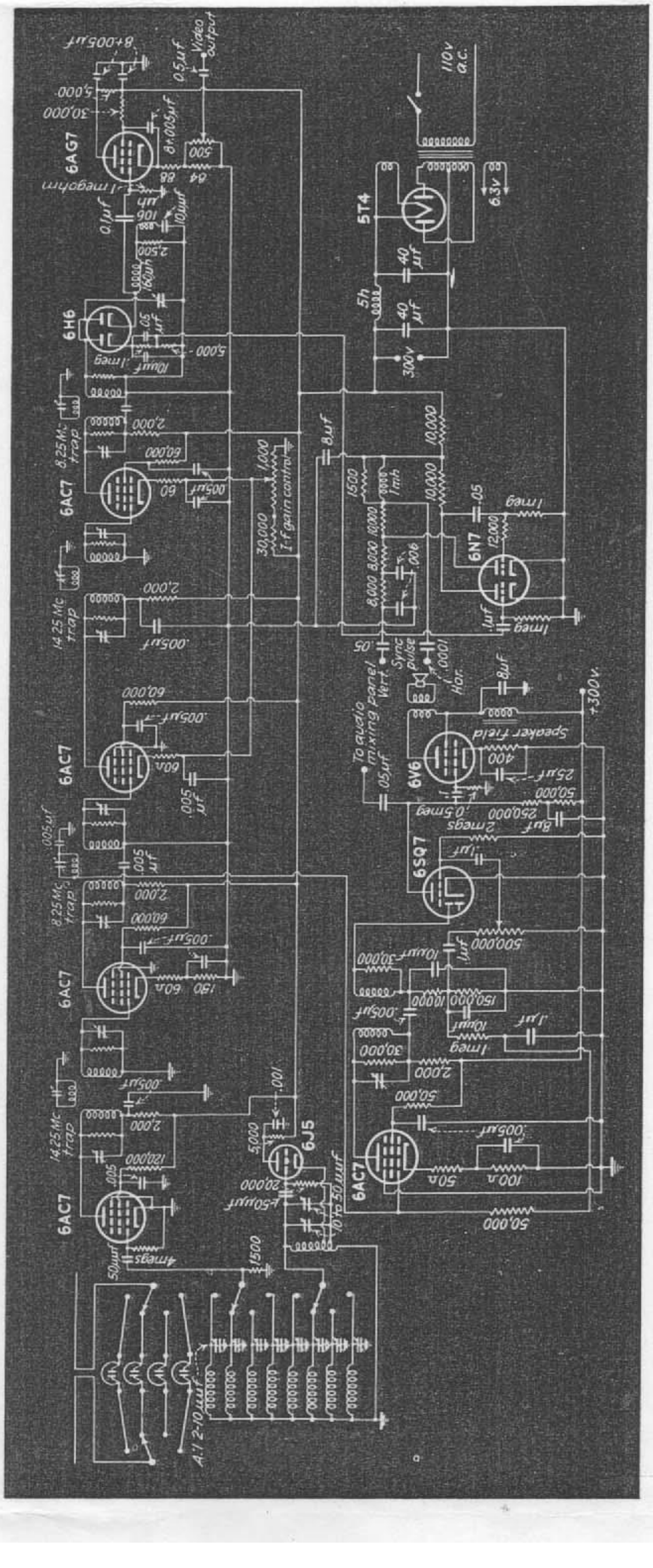



Fig. 5—Complete circuit diagram of the television receiver tuning unit, including r-f, i-f, second detector and sync separator circuits

partially as an additional stripper and partly as an amplifier. The second triode limits noise in its grid. The $L$, $R$ and $C$ networks in its plate circuit separate the vertical from the horizontal sync pulses.

The video output of the second detector diode is passed through a low pass filter to remove any higher frequencies other than video and impressed on the grid of an impedance transformer (cathode-coupled) tube. The cathode of this stage has a variable resistor across its cathode load which allows simple control of contrast without high-frequency attenuation. The d-c component of the video signal is restored in the output stage of the line amplifier by a diode. The i-f gain of the picture channel is controlled by means of the cathode potential applied to the second and third i-f stages.

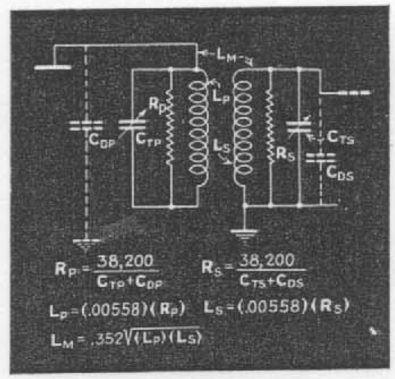



Fig. 6—Design relationships for a wide-band i-f transformer, based on a mid-band frequency of 11.25 Mc, and a bandwidth of 4.2 Mc

In concluding this series, the authors wish to express their appreciation to the management of the American Television Corporation for permission to publish the information and the circuit diagrams contained in the articles.

Editor's Note: The following errors should be noted in Fig. 3 of Part IV of this series: The switch arm is omitted in the plate circuits of the 6N7 sync pulse shaper amplifier. The slider is omitted on the vertical centering control of the upper 906 cathode-ray tube. The 1-meg resistor in the horizontal centering circuit of the lower 906 tube should connect to the slider of the centering control, not to the end of the control as shown. In Fig. 4, the vertical output transformer is R.C.A. type 32,900. The horizontal sweep input resistor should terminate at ground, not at the condenser as shown.