

# THE TELE-TONE COLOR COMPANION RECEIVER

by

Elias Cohen

Tele-Tone Radio Corp.  
New York City

and

Allan Easton

Manager

Communications Engineering Division  
Radio Receptor Company, Inc.

Courtesy Electronics Magazine

The F.C.C. decision which approved the C.B.S. field-sequential system of color television presented to the authors the problem of how best to meet the inevitable demand for a commercial device which, operating in conjunction with already existing black-and-white receivers, would produce good color reception from stations transmitting programs in color. The companion color unit was to bridge the gap between standard monochrome and the new field-sequential color television until there developed sufficient economic justification for complete color or color and black-and-white receivers. In this manner the consumer was protected against complete obsolescence of his monochrome equipment and at the same time could purchase the means of securing color television.

## General Requirements

Several requirements suggest themselves for a system utilizing existing monochrome receivers for production of color pictures.

1) Ease of installation is of great importance. Any complex reworking or rewiring necessary in the monochrome set as handled by a service group would result in non-uniformity of performance between receivers on both monochrome and color operation.

2) When the color adjuncts are connected no appreciable deterioration of performance in standard black-and-white reception should be discernible.

3) The device should operate well and interconnect easily with most types and makes of commercial television receivers.

4) There should be no detracting in physical appearance of the television set. The device itself should meet the usual appearance standards set up for TV receivers.

## Types of Systems

The first system considered, the adaptor-converter combination, did not meet these self-imposed requirements. The adaptor is a unit which when used in conjunction with the monochrome receiver, permits reception of color programs in black-and-white only. The converter is second unit consisting of motor, lens, and color disc which transposes the monochrome, field-sequential display into a full color picture.

The main advantages of this system are:

1) Economy - A minimum of additional parts is used. The monochrome circuitry performs double duty wherever possible and color operation is obtained by means of switching.

2) The same kinescope is utilized for both monochrome and color operation.

The disadvantages of this system are:

1) Installation may be a complex servicing job varying considerably from one type receiver

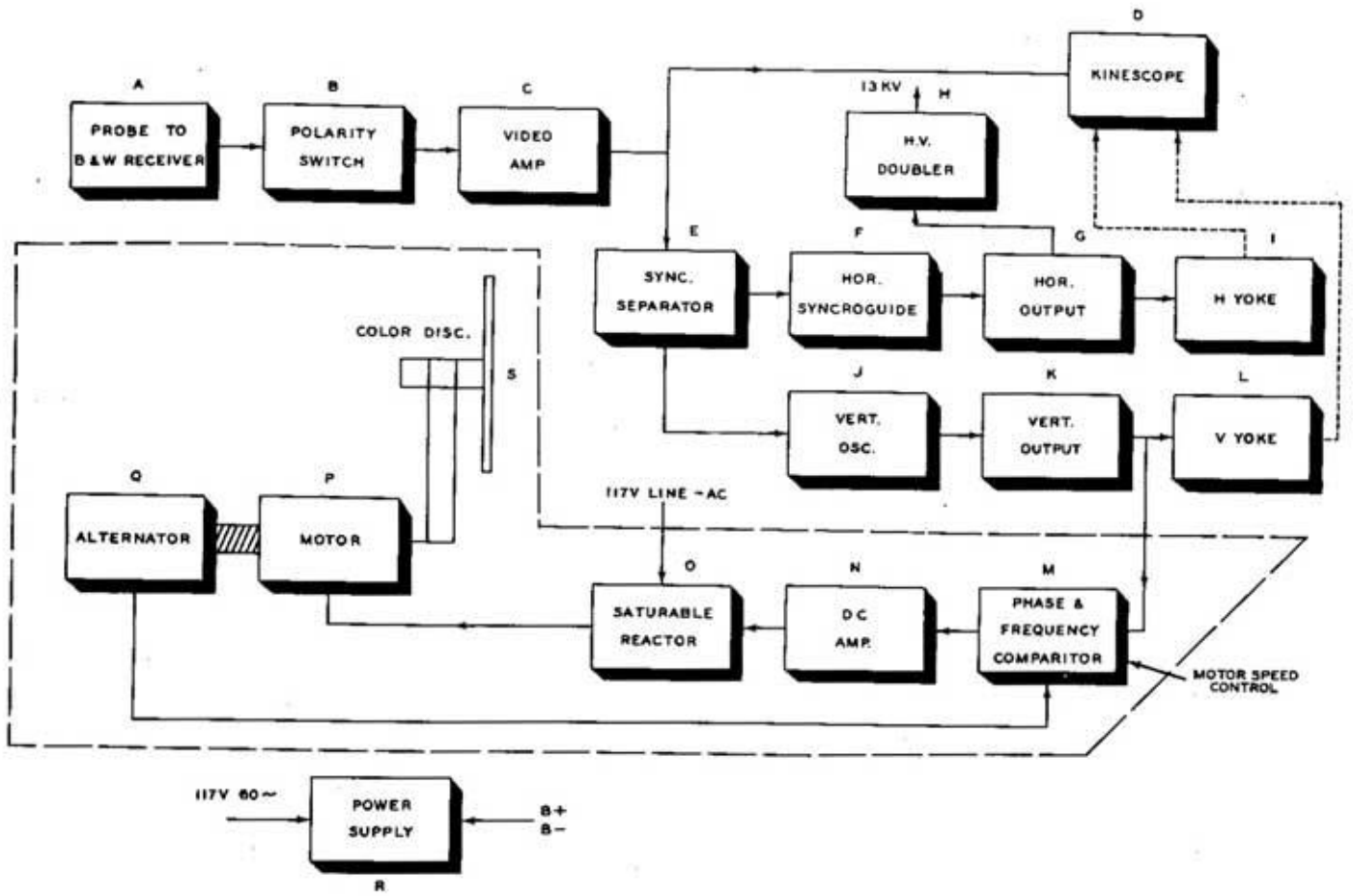


Figure 15. Block Diagram of Telecolor Unit

to another. Approximately one dozen circuits or circuit elements are involved in the switching.

2) At present it is extremely difficult to handle kinescopes larger than 12 1/2 in. by this system.

3) The appearance of the receiver is definitely affected by the conversion.

#### Description of Companion Unit

The standards set by management and engineering pointed out the necessity for a universal package converter of the slave type. This would be a self-contained cabinet enclosed unit which would plug into one of the tube sockets in the existing receiver by means of an adaptor plug without any chassis reworking. This could be a customer rather than a serviceman operation.

The characteristics of this system are:

- 1) Ease of installation.
- 2) The appearance of the cabinet is unaffected by the conversion.
- 3) The size of the kinescope for color is independent of the size and type of kinescope used in black-and-white operation.
- 4) The slave converter will work in conjunction with practically every television set on the market today.

Refer to Figure 15. The slave converter receives a source of composite video signal from the black-and-white receiver through the interconnecting cable and by means of the necessary circuitry including power supply.

The signal is amplified in a two stage video amplifier system (C) and is applied to the kinescope grid (D). A polarity switch (B) in the input circuit accounts for the difference in signal polarity that exists in some monochrome receivers. Part of the output of the video amplifier is fed in a conventional manner to the sync separator circuitry (E) which in turn feeds a syncroguide type horizontal oscillator (F) at 29,160 cycles/sec. and an impulse triggered vertical oscillator (J) at 144 cycles/sec., which in turn drives the output circuitry (I and L). A flyback high voltage system (H) is used with a voltage doubler to supply the high voltage. The color discs are turned by a speed controlled, induction motor (P). The speed control circuitry consists of a balanced phase and frequency comparator (M) which compares the sine wave output of a six-pole alternator (Q) mechanically coupled to the motor with pulses derived from

the vertical output circuitry (K). The control voltage is amplified in a D.C. amplifier (N) which varies the inductance of a saturable reactor (O) and which in turn varies the A.C. voltage applied to the induction motor for speed control.

#### Description of System and Connection to Black-and-White Receiver

The only interconnection to the monochrome receiver is a probe which fits into the video tube socket of the black-and-white receiver and into which the video tube itself is plugged. The probe contains a cathode loaded stage which picks off composite video signal to drive the slave converter video amplifier with negligible loading effect to the monochrome receiver. The color receiver has neither tuner nor I.F. stages. It is called a slave type because it depends for its source of composite video signal on the monochrome receiver. Thus, when the monochrome set is tuned to normal monochrome transmissions they will appear as always on the black-and-white receiver, whereas when the tuner is set for a color transmission it will be viewed on the slave converter. The sound of course always emanates from the black-and-white receiver.

#### Breakdown of Circuitry

##### A. - The Video Amplifier System Fig. 16.

The video requirements while similar to that of a monochrome design are definitely more exacting. Since the composite signal derived from the black-and-white receiver could be either positive or negative depending on the type of receiver, provisions had to be made for switching circuitry so that the polarity of the signal at the color converter kinescope grid was always sync negative. The gain and frequency responses were to be independent of switch setting. The high frequency response was to be 4 Mc wide so that the geometric resolution would be as good as the I.F. response of the black-and-white receiver would allow. A rising characteristic is also desirable to obtain some video overshoot to add crispness to the picture and to compensate for the slight smear present in the transient response of many I.F. systems. The low frequency response has to be approximately 3 db at 48 cycles/sec. which is the primary color rate. Poor low frequency response will result in misrepresentation of the background color tones in the different frames, whereas in monochrome reception it would only result in a slight shading from top to bottom of the picture.

It was considered that a gain of approximately 70 with a drive of approximately 100 volts peak to peak was necessary to have sufficient reserve drive for the 10FP4 kinescope under all condi-

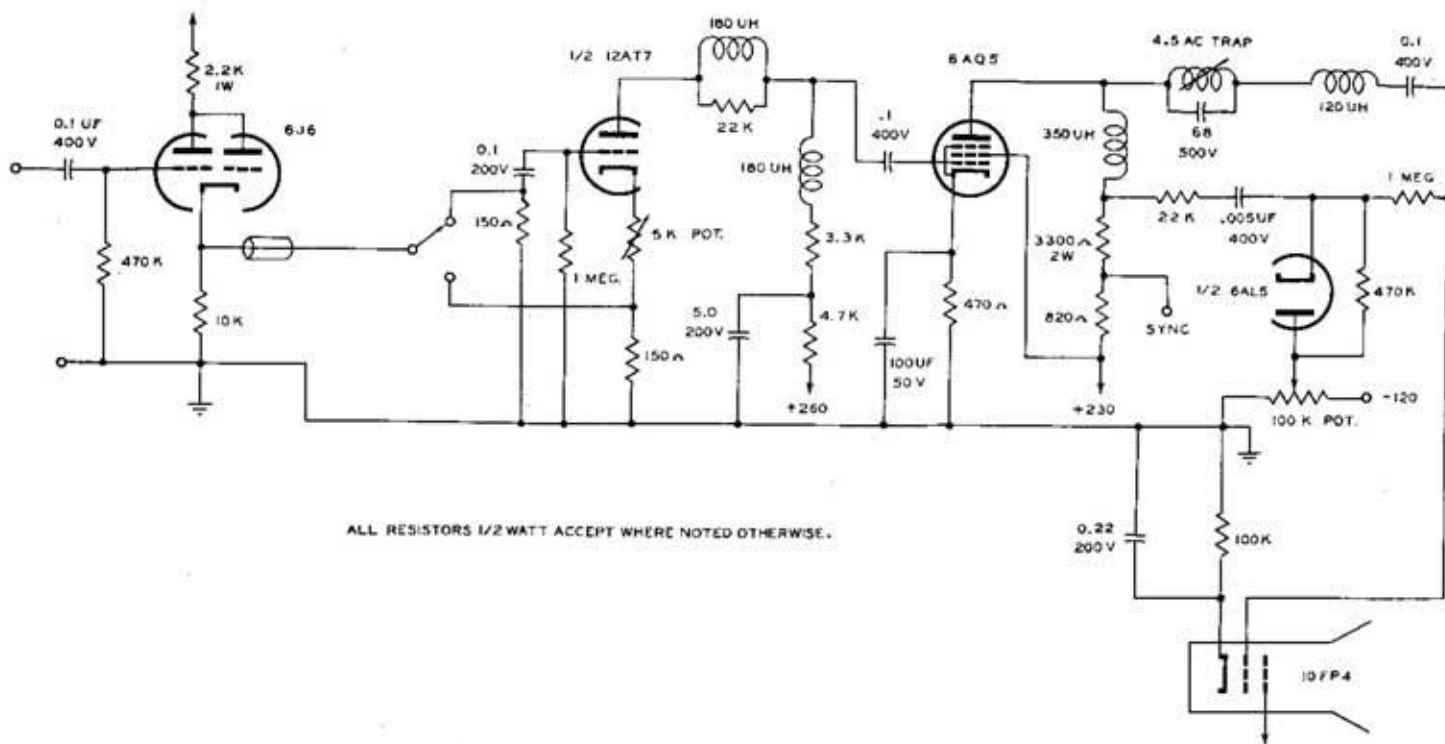


Figure 16. Cathode Follower, Video Amplifier & Kinescope Circuitry

tions of operation. Another aspect to be closely watched in the video system was amplitude distortion which would give rise to color distortion, since different colors are transmitted during different frames and any compression of levels would affect one color more than the others.

Thus, the amplifier has to be substantially linear over its entire range of operation, unlike monochrome reception where non-linearity is often introduced in order to obtain a more pleasing ratio between average and peak brightness at high contrast settings. Since the majority of present black-and-white receivers have inter-carrier sound, provisions have to be made to have good 4.5 Mc. rejection before the cathode ray grid so as to avoid the fine beat affect which would be caused by excessive 4.5 Mc. signal on the kinescope grid.

Figure 16 indicates a simple way in which polarity switching is accomplished. The first video amplifier is either cathode or grid coupled depending on the input polarity. For most installations the tube will be grid coupled because a majority of the black-and-white television sets in use and being built today have their video detector so arranged as to yield a composite video signal with sync tips negative. Contrast variation is accomplished by means of a degenerative control in the cathode of the first video amplifier. The first video is half of a high gain triode 12AT7 tube, and the second video is a beam power output 6AQ5 tube to provide sufficient drive and linear operation. Good frequency response is provided for by the 2 section constant K filter in the first video stage and a combination of series and shunt peaking in the second video stage. Good low frequency response is accomplished by means of the low frequency RC boost network in the first video, and the use of 0.1 uf coupling condensers as well as the maximum possible grid leak resistors wherever possible.

The background control varies the negative D.C. voltage to which the D.C. restorer diode plate is returned.

The 2 stage system is linear, has a gain of approximately 70, provides 100 volts peak to peak drive at a bandwidth of 48 cycles - 4 Mc and has provisions to supply D.C. restored signal of negative polarity to the kinescope grid for either polarity input to the system.

#### B. - Sync Separator

The sync separator requirements are similar to those in monochrome reception, and the type of separator used (refer to Fig. 17) is

a fast-time constant cathode follower type, where a separate diode is utilized to keep sync tips at ground level. This is a standard type and need not be discussed further. There is a definite need for better noise immunity in the color system than in black-and-white transmission. Loss of horizontal synchronization for a few lines is more noticeable than in monochrome transmission because the tearout will appear in the color of the frame during which it occurs. Loss of vertical synchronization is extremely bad, because unless the recovery time is faster than the inertia of the speed control circuit, the color disc will also go out of synchronization.

#### C. - Vertical Deflection

The frame rate which is the frequency at which the kinescope face is scanned vertically, is 144 cycles/sec. Vertical retrace must be accomplished in 0.05 of a field which is approximately 350 usec. This is approximately 40% of the time allotted in monochrome transmission. The self-resonant frequency of vertical output transformers and yoke circuitry now used for monochrome receivers is good enough to permit direct conversion to the new frequencies. (Fig. 17)

A 53<sup>o</sup> - 50 mh vertical yoke is used. The yoke impedance being mainly resistive, the same output transformer can be used to match the yoke to the double-triode 6SN7 vertical output tube with very little loss in efficiency. Refer to Fig. 33. A single triode blocking oscillator is used in the usual manner to act as a combined vertical oscillator and discharge tube. The transition to 144 cycles permits a decrease in plate-time constant to give the necessary drive for the output tube without any loss in linearity. The percentage of step to sawtooth is larger in color operation necessitating a larger step resistor in series with the discharge condenser. The reason for this is apparent when one realizes that the purpose of the additional step to the sawtooth grid drive is to compensate for the voltage drop across the inductive portion of the yoke. The retrace time being much faster than before will cause the voltage drop  $L \frac{di}{dt}$  to be larger.

The problem of interlace is basically a 30 cycle phenomena in monochrome transmission and is therefore relatively unaffected by 60 or 120 cycles power supply and line hum because of its harmonic nature.

In color transmission interlace is basically a 72 cycle phenomena and is easily deteriorated by 60 and 120 cycle hum. Sixty cycle hum for example will cause the pattern to go in and out of interlace at a 12 cycle rate. It is extremely important that the integrated vertical sync pulse

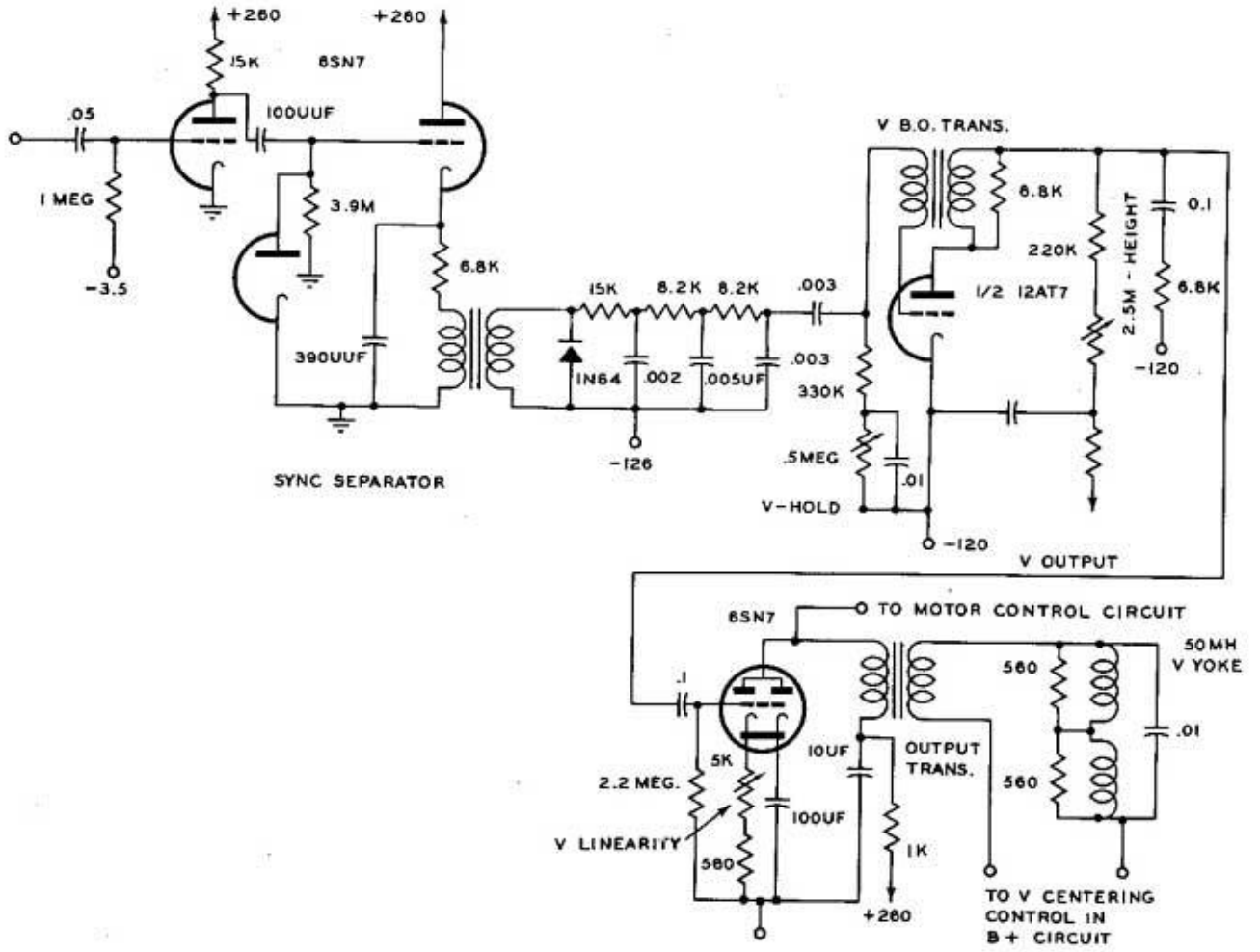


Figure 17. Sync Separator & Vertical Deflection Circuit

be free of all hum voltages. As will be noted in Fig. 16, the output of the sync separator is transformer coupled to the integrating pads to remove the hum voltages from the negative supply. Care must be taken so that the power line leads or filament leads do not come too close to the vertical oscillator circuitry.

The usual care must be taken to remove all horizontal pickup from the vertical oscillator circuitry. This can be helped considerably in the chassis layout by putting the vertical oscillator as far as possible from horizontal oscillator and output circuitry.

The major problem in the vertical circuitry seems to be to obtain good interlace rather than that of height and linearity.

#### D. - Horizontal Deflection & High Voltages

The horizontal scanning rate is 29,160 cycles/sec. (405 horizontal lines interlaced every two frames). This is almost twice the rate used in monochrome transmission. The maximum retrace time allowable is  $0.14 H$  where  $H$  is the period of the horizontal scan. This figure is the minimum value that the width of horizontal sync pulse plus back porch may fall to. This calls for a maximum retrace time of 5  $\mu$  sec. as against almost 10  $\mu$  sec. in monochrome transmission. The losses in the yoke and transformer which are a function of frequency such as hysteresis and eddy-currents tend to cut down the efficiency at this new frequency. A high voltage of 13KV is desirable which in conjunction with a 10FP4 - 53° aluminum backed tube produces sufficient light output in spite of the light losses in the color disc and lens.

The horizontal synchroguide has to be readjusted to operate at the new frequencies and the capacitor across the stabilizing coil is set so it too can operate at the new frequencies.

To improve the retrace time, the horizontal output transformer has much less than the customary number of turns on the high voltage winding. To make up for the loss in high voltage a voltage doubler using two 1B3's, is used. (Refer to Fig. 18) The use of an auto-transformer permits more high voltage and subsequently less retrace time as the secondary winding is now in series with the primary, and H.V. winding to drive the H.V. rectifiers. A device borrowed from the CBS engineering department was to A.C. couple the secondary winding to the primary with the yoke being returned to the low side and the damper tube being returned to the high side. This is in order that we may have electrical centering which normally is not feasible in an auto-transformer type of

system. The filament of the 6W4 is connected through a resistor to the boost voltage. The cathode-to-heater rating of this tube for pulses as well as for inverse peak plate to cathode voltages allows safe operation of the circuit.

Horizontal centering is accomplished by a 50 ohm control which varies the amount of B plus current which goes through the yoke. A tapped potentiometer is used so that this control is bidirectional. The potentiometer is bypassed so as not to change the Q of the yoke or to feed horizontal lock into the B plus circuit.

The power input to the horizontal output 6BG6 tube (370 volts at 70 mils) is 33 watts and is not proposed as the most efficient method of scanning a 53° degree tube operating at 13KV. It does, however, give good linearity, good retrace time, plenty of width and a high voltage of 13KV with a regulation of 500 volts/100  $\mu$  amps.

The yoke used is a 53° - 8.3 mh type with a powdered iron core.

#### D. - Power Supplies

The power supply (Fig. 18) design problem is no different generally from that existing in normal monochrome receivers except for the fact that the maximum allowable ripple voltage on the B plus supply must be severely restricted. The hum voltages whether 60 or 120 cycles are, of course, extremely harmful because of the non-synchronous relationship between the 60 cycle power line and the 144 cycle field rate of the color transmission.

A full wave rectifier 5V4 in conjunction with a condenser input filter yields a positive B plus voltage of 280 volts at 175 mils and a negative supply voltage of approximately 120 volts is obtained across a bleeder resistor between secondary center-tap and ground.

Care must be taken in the physical placement of the power transformer and other iron-core components so as to minimize the effect of any stray magnetic fields on video and vertical circuitry and the kinescope tube itself. Although the rectifier input condenser input circuit is no more elaborate from a filtering standpoint, hum reduction is further accomplished by the utilization of decoupling networks between the power supply and the appropriate circuitry.

#### F. - Motor Speed Control Circuits

An entirely new problem presented by the color television unit is that of motor speed control circuitry.

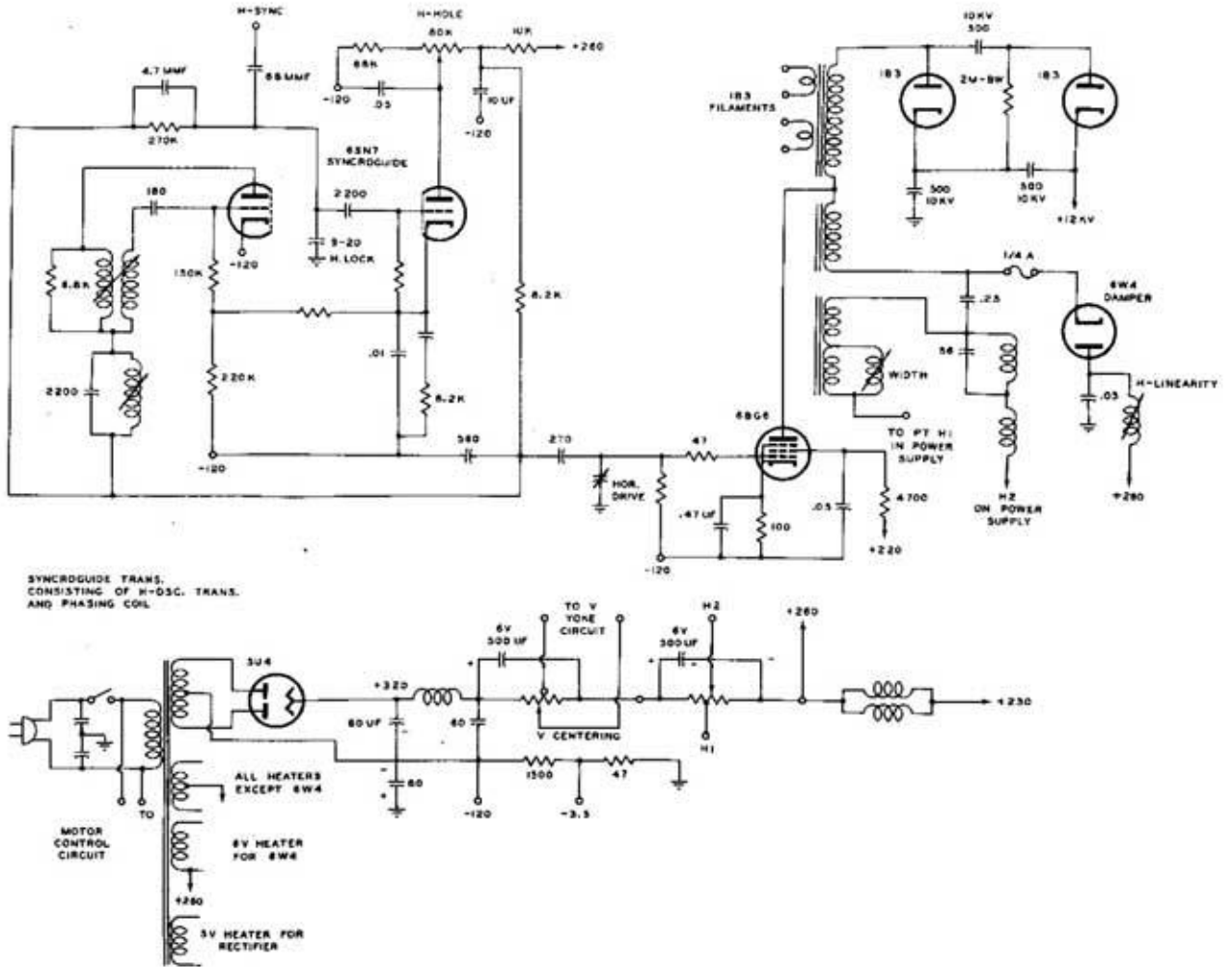


Figure 18. Horizontal Output Circuit & Power Supply



Color presentation is accomplished by means of a rotating filter disc (See Fig. 15), similar to that used in the camera, which is positioned before the face of the picture tube. This disc carries six filter segments (See Fig. 8), two in each of the three primary colors, red, blue and green. The disc rotates at 1440 r.p.m. and is synchronized with the 144 cycle/sec. field scanning rate of the receiver. The image formed on the screen of the picture tube is in white light and this light in passing through the colored filters, takes on successively the three primary colors. The system thus comprises two filter discs rotating in rigid synchronism, so positioned that the filters before the camera and the picture tube always have the same color at any instant. In order to synchronize the position of the receiver filter disc, the speed must be kept at 1440 r.p.m. and the phase must be automatically adjusted by means of synchronizing impulses so that the red light is produced by the receiver only when the red filter is positioned before the camera tube at the transmitter and similarly for the other two colors.

Refer to Fig. 15-Block Diagram of Motor Speed Controls

Refer to Fig. 19-Wiring Diagram of Speed Control Circuits

Speed control is accomplished by means of an automatic phase and frequency control circuit. The driving motor is a 1/20 h.p. split phase induction motor, belt coupled to the color wheel and direct coupled to a six pole alternator which when running at 1440 r.p.m. will deliver a sine-wave voltage output at a frequency of 144 cycle/sec. The frequency will of course be directly proportional to the motor speed. A balanced phase and frequency comparator consisting of a 12AU7 compares the sine-wave output from the alternator to vertical pulses at 144 cycles/sec. field rate. The control voltage generated is applied to the grid of a high gm D.C. coupled current amplifier which utilizes a 6AH6 tube. The plate current of this amplifier flows through the primary of the saturable reactor which saturates the iron core and so varies the inductance of the secondary winding in a manner which is to a first approximation inversely proportional to the primary current.

As can be noted in Fig. 19, the secondary inductance of the reactor is in series with the induction motor across the line voltage. A variation of secondary inductance will vary the 60 cycle voltage fed to the motor and thus control its speed. A color phasing potentiometer controls the D.C. bias and thus controls its speed. An anti-hunt potentiometer controls the amount of feedback from the screen of the control tube back to the input circuit.

The gain and accuracy of the control system must be high enough so that the amount of phase deviation or instability caused by normal line voltage variation or heating effects will not be large enough to permit any trace of the preceding or following color field to be visible.

As mentioned before proper color phasing is obtained only when the color of the filter at the receiver is identical to the one at the camera at any moment. The speed circuitry does not utilize any information which permits it to recognize the various color fields. It is, therefore, possible to be initially synchronized on any one of the 3 color fields when the set is turned on. The ambiguity is corrected by means of a front-control push button which momentarily shorts out the secondary of the saturable reactor thus permitting the color disc to slip free for a short period and lock itself to a new frame.

#### Interconnection with Black & White Receiver

The slave color converter derives composite video signal from the black-and-white receiver. The basic requirements for the interconnecting device were that it be universal in its application so that it operated with all types and makes of black-and-white receivers and that its effect on black-and-white operation due to loading be negligible.

A probe, Fig. 20, is inserted in the input video amplifier socket of the black-and-white receiver. The pin connections are connected to another tube socket at the top of the probe in which the video amplifier tube fits. A 6J6 cathode loaded stage is inside the probe and couples composite video signal from the grid of the video amplifier through 70 ohm cable to the color converter. The input loading of this cathode follower is extremely small. The polarity switch in the video amplifier circuit will accommodate either negative or positive polarity signal. Plate and filament power is fed to the cathode follower from the color converter. The probe is built in four different forms to accommodate either a 7 pin miniature, noval miniature, octal or loctal video amplifier tube in the black-and-white receiver.

The color converter chassis, cabinet, and shafts are insulated so as to avoid shock hazard when used with a black-and-white receiver of the hot-chassis type, that is, in which one side of the power line is connected to the chassis.

#### Overall Performance

The slave color converter unit developed by Tele-Tone provides good color picture on transmissions using the CBS field-sequential system.

