LB-877

DEFLECTION SYSTEMS WITH REGULATED KICKBACK HIGH-VOLTAGE SUPPLIES FOR TRI-COLOR KINESCOPES

RADIO CORPORATION OF AMERICA

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Approved

Stuart W. Seeley

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Introduction

This bulletin describes a system that provides both horizontal deflection and regulated high voltage for tri-color kinescopes. It employs a horizontal-deflection circuit with a kick-back rectifier, similar to that normally employed in black-and-white receivers, to which means for regulating the high voltage has been added. The circuit is capable of supplying a relatively large amount of regulated high-voltage power, providing a maximum output of 700 μa at 20 kv to the final anode and convergence circuits and 600 μa at 3.6 kv to the focus circuit. Regulation for load changes is better than 2 per cent. The regulation level can be fixed during line-voltage changes, or automatically referenced to the line voltage. In one version a power pentode and a triode are added to the normal tube complement of a black-and-white receiver with electrostatic focus. Another version requires only the addition of a dual triode but is capable of delivering less peak high-voltage power.

Principles of Operation

In an unregulated horizontal-deflection and high-voltage supply system, a substantial increase in beam current causes the rectified high voltage to drop. It also reduces the peak pulse amplitude in the deflection transformer and therefore the energy returned to the output circuit after flyback. This in turn results in reduced boosted voltage, in changes in linearity and size, and in variation of the output-tube plate current. Attempts to regulate the high voltage by systems that automatically alter the screen voltage, plate voltage, or the amplitude of the drive of the horizontal output tube usually result in picture foldover in the center of the raster, changes in size and linearity, and in greatly increased plate dissipation. It was therefore considered advantageous to regulate the high voltage by maintaining a constant load on the horizontal output circuit. One method of doing this is by adding a "dummy" load tube in shunt with the kinescope. The dummy tube's beam current is made to vary in a manner complementary to that of the kinescope. The total current supplied by the rectifier to the dummy tube and kinescope is thus kept constant, and the high-voltage rectifier reflects a fixed load to the deflection circuit.

The basic principle is illustrated in Fig. 1. The dummy load may be a second kinescope, or an RCA type 5890 "Remote Cutoff Beam Pentode Tube", which consists of a kinescope gun and final anode enclosed in a smaller envelope. The dummy tube must be capable of dissipating, during such times as the picture tube is dark, all the energy the kinescope may utilize at full brightness. Fig. 1 shows, for illustrative purposes, a phase splitter that supplies a video signal to the dummy tube opposite in polarity to that supplied to the active kinescope. Thus when the current decreases in the kinescope, it increases in the

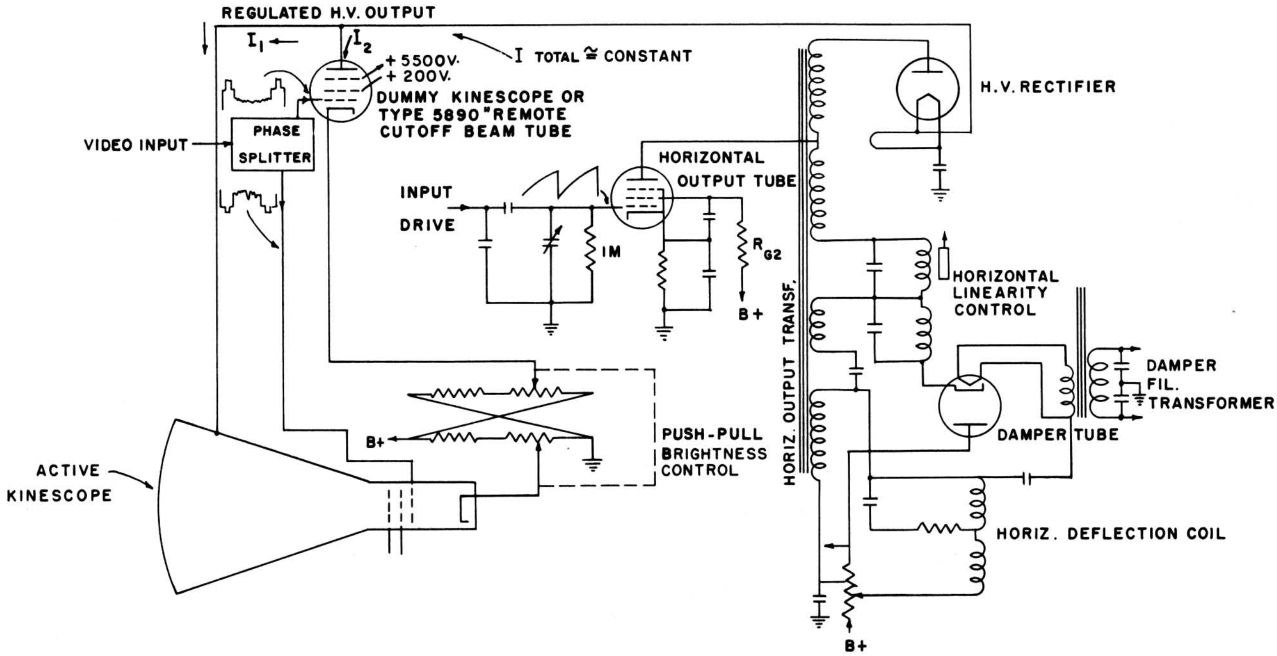

Fig. 1 - D-C type of dummy load tube controlled by inverted video and push-pull brightness potentiometer.

dummy tube so that the total remains unchanged. A push-pull brightness control is similarly employed.

Since the grid voltage-beam current characteristics of the kinescope and the 5890 pentode are not linear, the increase in current in the dummy tube may not fully match the current decrease in the kinescope unless the voltage applied to the grid of the dummy load tube is modified in accordance with these characteristics. Because of the additional circuitry required, this method of regulation was not further pursued.

The high-voltage rise occurring when the picture tube brightness is reduced may be used in another method of control. In this arrangement the rise which is within the regulation limits causes the beam current in the dummy load tube to increase and thus to keep the total drain constant. The resulting percentage regulation can be quite small since the change in output voltage can be kept to the minimum needed to control the dummy tube. This is a very small fraction of the final anode voltage and is usually less than 1 per cent.

Fig. 2 shows how a high-voltage corona regulator may be used to sense the rise in the high-voltage output and apply it to the dummy load tube. The characteristic of the corona regulator is similar to that of low-voltage regulators in that conduction rises sharply when the applied voltage increases above the designed starting voltage. Corona regulators are presently manufactured mainly for experimental applications and consequently are expensive. They are usually designed for low maximum current (less than 100 μa) and low power dissipation. Further information regarding corona regulators may be found in Naval Research Laboratory Bulletins 3140[1] and 3635[2].

If the picture tube brightness is reduced, the rise in high voltage above the starting level of the corona regulator in Fig. 2 appears mainly across the series resistor R_g, which is connected to the grid of the dummy load tube. This causes the dummy tube to conduct, thus effecting the regulation of the high voltage. This method of regulation tends to drain a constant total current from the high-voltage rectifier which reflects a constant load on the deflection circuit. Corona tubes having

[1] NRL Report N-3140, "Voltage Stabilization by Means of The Corona Discharge Between Coaxial Cylinders" by H. B. Blifford, R. G. Arnold and H. Friedman, June, 1947.

[2] NRL Report 3635, "High Voltage Stabilization by Means Of The Corona Discharge Between Coaxial Cylinders" by S. W. Lichtman, March 13, 1950.

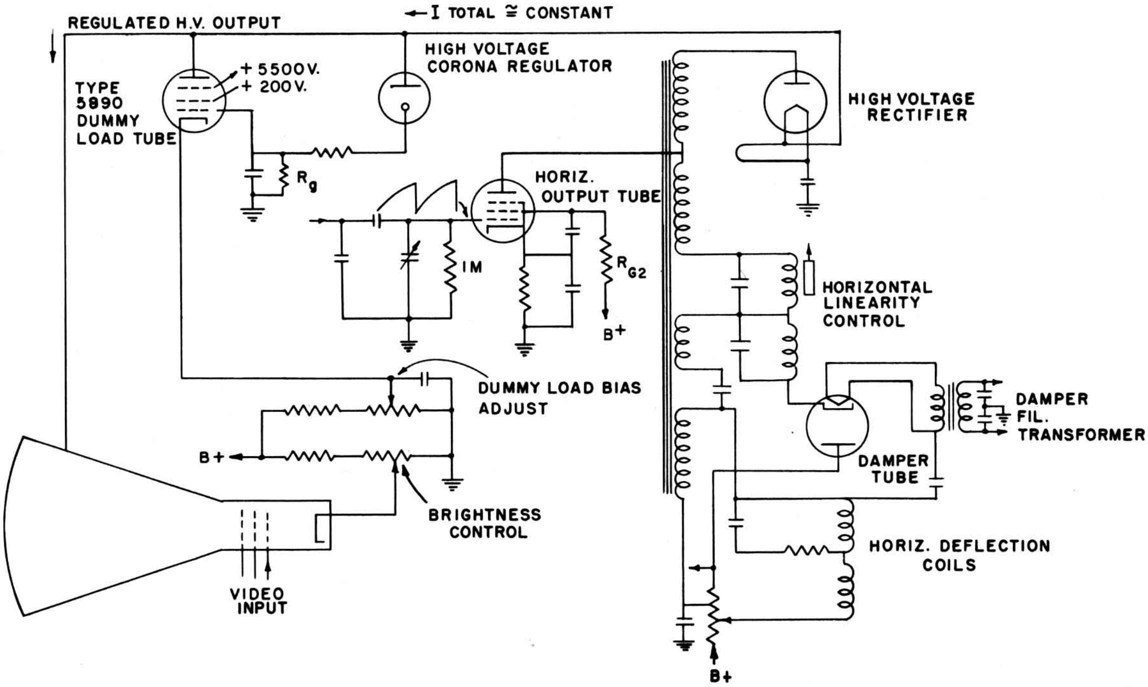

Fig. 2 - D-C type of dummy load tube controlled by high-voltage corona regulator.

good regulation characteristic and capable of larger dissipation have been built for experimental purposes and have served without the addition of dummy load tubes as high-voltage regulators with the characteristic of reflecting a constant total load to the deflection circuit. However, some difficulty was encountered with erratic behavior at high currents.

DC Amplifier Control of the Dummy Load

Fig. 3 shows an arrangement utilizing a commercially available triode in place of the corona regulator shown in Fig. 2 for control of the dummy load tube. A low-voltage d-c amplifier which senses the voltage rise appearing at a tap on a voltage divider connected to the high-voltage output is used for this purpose. The dummy load may be of the "beam current" variety such as the RCA 5890 pentode shown in Fig. 2 or of the pulse type shown in Fig. 4 and described below. When the kinescope beam current is reduced from its maximum value, the high voltage tends to rise. The rise is sensed at the grid of the d-c amplifier (12AX7) by means of the voltage divider. The cathode of the amplifier is biased positively with a fixed reference voltage which is the operating voltage of the neon tube. This initially keeps the amplifier near cutoff. With reduced beam current, the increased output voltage raises the grid of the d-c amplifier so that its plate current increases and causes the voltage across the resistor R_2 to rise. This increases current flow in the dummy load tube which also is initially biased near cutoff by means of the positive voltage applied to its cathode.

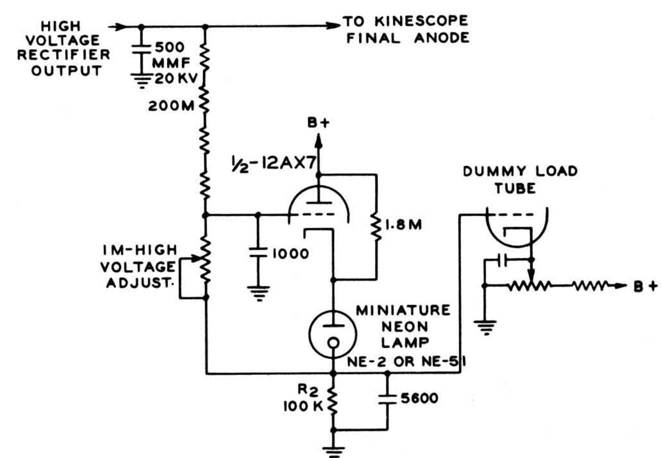

Fig. 3 - A d-c amplifier for control of the dummy load tube.

Pulse Loading vs High-Voltage DC Loading

The dummy load tube in Fig. 4 does not dissipate energy by loading the high-voltage d-c output. It conducts under the influence of the flyback pulses appearing at the driver-tube plate tap of the horizontal output transformer. The transformer tap is coupled to the plate of the dummy load tube by means of condenser C_1. The dummy tube thus loads the horizontal output circuit directly rather than via the high-voltage rectifier. The rectifier supplying current to the kinescope similarly draws current from the transformer during the flyback period. Thus, the rectifier can be considered a load which is parallel to the dummy load tube. Both circuits tend to "clip" the retrace pulse and reduce the energy available to the deflection circuit after flyback. The reduced pulse height largely accounts for lower high-voltage output. Because the dummy load tube is connected to a lower tap on the transformer, it must draw a larger current than the high-voltage rectifier to produce the same loading effect on the output circuit. This larger current should equal N_2/N_1 times the change in rectifier current. N_1 is the total number of turns to the driver-tube plate tap and N_2 the total number of turns to the high-voltage plate terminal.

As previously stated, the rise of voltage across the resistor R_2 permits increased current to flow in the 6BQ6 dummy load tube which has been biased near cutoff by means of the +105 volts on its cathode. Although the grid-to-cathode bias remains high, conduction in the 6BQ6 occurs at the voltage peaks of the very high retrace pulses. This loads the deflection output circuit by "clipping" the pulses, and thus maintains at a constant level the amount of energy returned to the deflection transformer, aswell as keeping the high voltage from rising. The gain of the d-c amplifier almost makes up for the loss in the high-voltage divider and applies a large portion of the high-voltage rise to the grid of the 6BQ6. Although the allowable rise for good regulation is a small percentage of the high voltage, the absolute amount is quite adequate for the 6BQ6 to produce enough loading to prevent the much greater voltage rise that would otherwise occur. In circuits where the peak voltage applied to the plate exceeds 5 kv or where the dissipation requirement is over 10 watts, a tube of higher

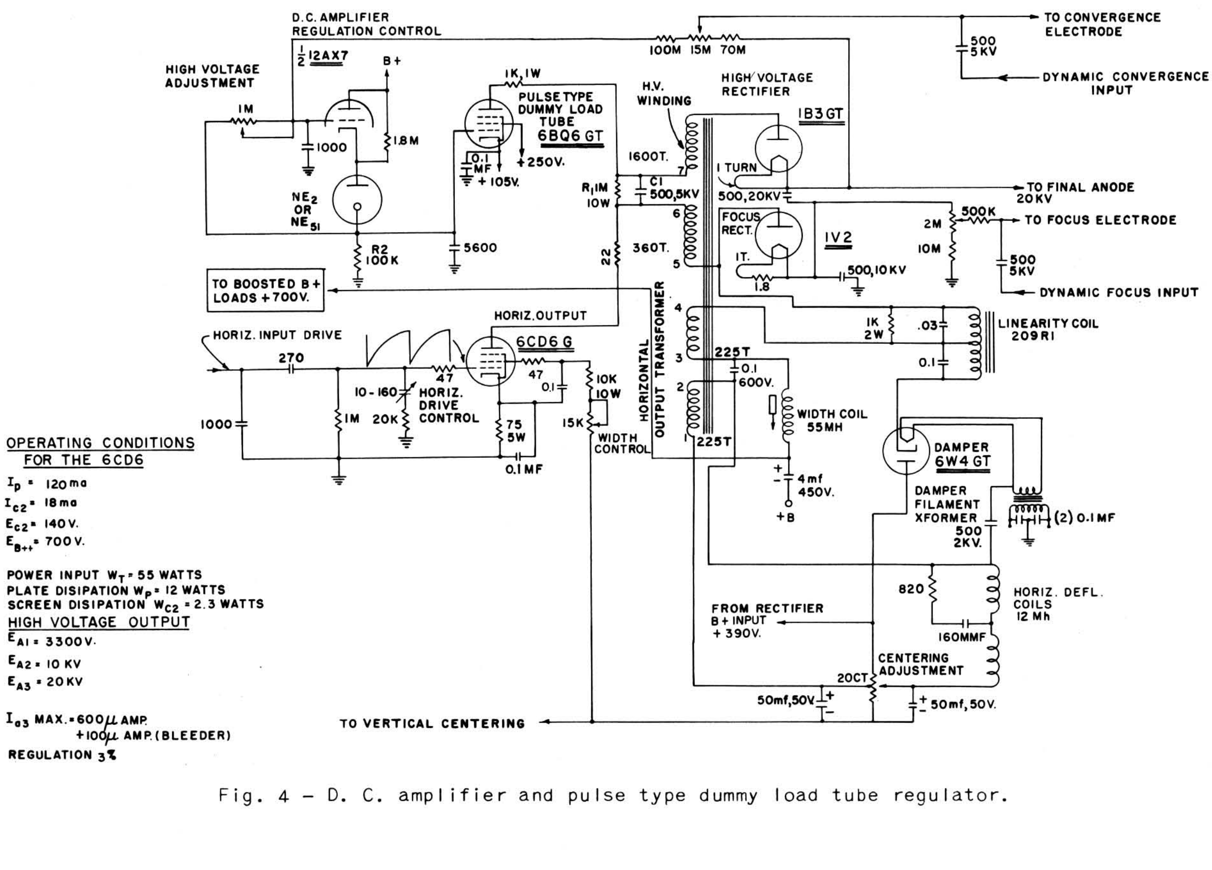

Fig. 4 - D. C. amplifier and pulse type dummy load tube regulator.

ratings, such as the 6BG6G, may be used as the dummy load tube.

Current flows in the high-voltage rectifier when the voltage of the pulse applied to the plate exceeds the voltage of the filter condenser which is connected to the cathode. Therefore, current flows only during that portion of the retrace period when the kickback pulse is at its peak. The energy remaining in the kickback pulse following the cessation of current flow in the rectifier is returned to the deflection circuit via the damper tube. The energy returned in this way produces part of the deflection current supplied to the yoke coils and boosts the B+ voltage supplied to the output tube. The peak-to-peak yoke current thus depends very largely on the return of this energy. Current in the dummy load tube, however, is not restricted by the d-c control bias in this manner. Its plate current vs plate voltage characteristic is typical of a pentode in that the decrease in plate current is relatively gradual with the decrease in plate voltage. Thus when the control bias of the dummy load tube is reduced to effect regulation, the current flow in the first half of the retrace period loads the deflection circuit, reduces the peak voltage generated in the flyback pulse and prevents the rise in high voltage above the regulation level. Continued conduction after the voltage peak, however, tends further to reduce the energy returned to the deflection circuit and causes the picture width to decrease, even though the high voltage is regulated, and even though the output tube plate current tends to increase because of increased power losses.

To remedy this condition resistor R_1 and capacitor C_1 are added in series with the high-voltage winding. The dummy tube current develops a bias across the resistor and capacitor and restricts current flow more nearly to the period of the voltage peak. The bias developed also produces some regulating effect since it is applied to the high-voltage rectifier. The dummy load tube thus regulates by means of pulse loading, which is of primary importance in effecting regulation, and also by means of the bias applied to the rectifier. The bias developed in this manner should not exceed the maximum negative voltage rating of the dummy load tube.

The regulating action produced by the bias across R_1 and C_1 on the high-voltage output, as distinguished from that produced by pulse clipping, can be used to compensate for the loss in output due to the drop in the high-voltage winding and rectifier tube caused by the rectifier current flow. Since the dummy load tube current does not flow through the rectifier and this winding, it may compensate for this drop by additional pulse clipping, which would reduce the picture width, or by means of this supplementary bias produced by introducing resistor R_1 in the path of the dummy load tube current. With the latter arrangement, the width of the picture may be kept constant while high voltage is regulated.

In determining the optimum value of resistor R_1, it will be observed that if R_1 is too small or is omitted, and the beam current is reduced from its maximum value, the final anode voltage will nevertheless remain fairly constant because of the action of the d-c amplifier. However, the width of the picture would decrease, largely because of the reduced peak-to-peak deflection current. The dummy load tube, in its attempt to keep the high voltage constant, "clips" the retrace pulses by the amount required to regulate the high voltage but by continued conduction reduces energy available to the deflection circuit after flyback more than does the high-voltage rectifier when it is supplying full beam current. On the other hand, if R_1 is made too large the width of the picture increases with reduced brightness because the rectifier regulating bias is obtained with reduced pulse clipping, allowing more energy to be returned to the deflection circuit.

The Design of the Deflection Transformer

The remaining parts of the circuit are similar to those in deflection circuits commonly found in black-and-white receivers. The horizontal output transformer used is of the autotransformer type because closer coupling is possible for given inductance windings than in an isolation type. The transformer was designed to give greater second anode power and better regulation than normally produced in such circuits. Since the initial regulation improves when the ratio of stored energy to dissipated energy is increased, the use of higher circulating power seemed desirable. The stored energy at the end of each sweep is given by $W_o = \frac{1}{2}L\hat{i}^2$ where L is the inductance reflected back to the yoke. This inductance includes the secondary inductance of the transformer which is in parallel with the yoke and which must be energized to the same peak-to-peak voltage. The peak current supplied to the parallel inductances is represented by $\hat{i}$. Thus, if a low-inductance transformer is used, and a substantial amount of power is circulated in it as well as in the yoke, an advantage is secured in regulation. Another alternative is to employ a yoke of relatively low deflection sensitivity (wide-angle yoke) so that a large peak deflection current and therefore large stored energy is utilized.

The deflection transformer shown in Fig. 5 was designed for use with the 45-degree (XT6875) tri-color tube deflection yoke having horizontal coil inductance of 15 mh. The transformer inductance was made low relative to the yoke--6.0 mh at the yoke tap. The leakage reactance is proportionately low in such an autotransformer. In contrast, the transformer inductance at the yoke tap in conventional circuits is considerably larger than the yoke inductance.

The low reflected inductance also permits the use of a high-voltage step-up winding to the rectifier which reflects a relatively large capacitance back to the yoke without resulting in an excessive retrace time. Thus with this arrangement the use of a single rectifier to produce the high-voltage output is possible. Before adding the regulator the high voltage at zero load is 27 kv. With a 700-μampere load it drops to 20 kv. The regulator is set at the lower level and prevents any voltage rise above this value when the beam current is reduced.

The design of the deflection transformer requires consideration of size, core losses, copper losses, and adequate insulation of the high-voltage coil. Fig. 5 shows a transformer design that was employed with the circuits shown in this bulletin. To obtain the required low value of inductance for a given size, a single U-shaped core was used instead of a

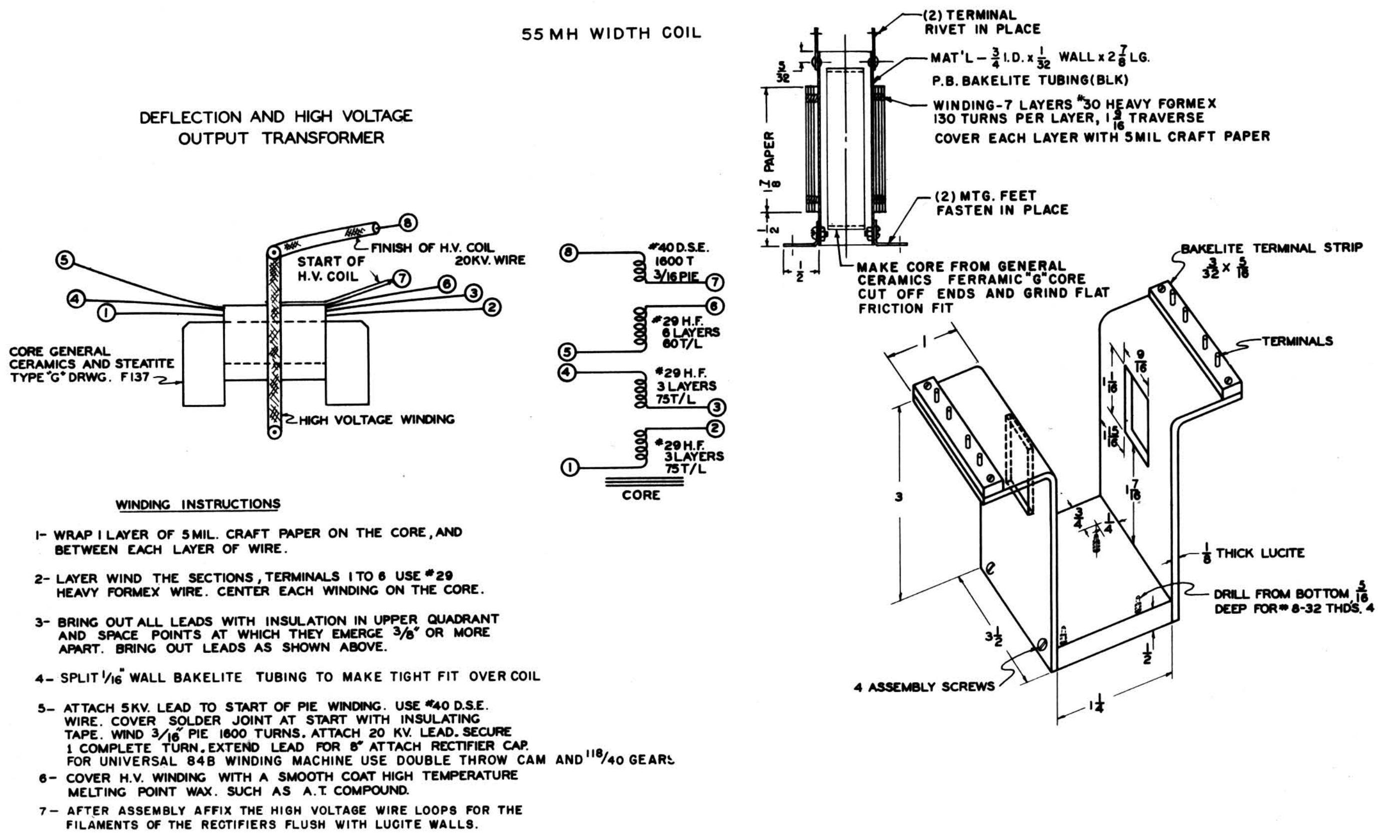

Fig. 5 - Deflection transformer and width coil construction.

pair as is normally employed to make a closed magnetic circuit. Thus the magnetic circuit is largely through air. The use of the corepermits a reduction of the number of turns and the amount of copper required for the desired inductance and therefore minimizes copper losses. Further reduction in the number of turns and the use of both cores was not feasible because of increased core losses due to saturation. Furthermore, enclosing the high-voltage coil in the relatively small window space of a pair of commercially available cores introduces serious insulation problems. However, cores of greater cross-sectional area and with windows larger than conventional may be used, but result in a larger transformer. The single core with the coil windings on it was mounted in a compact lucite transformer housing. This construction allows for adequate clearance and insulation surrounding the high-voltage coil, which operates with 20-kv pulse voltage, and thereby avoids corona and breakdown which otherwise would be a danger.

While the coils shown in Fig. 4 are wound directly on the core they may be wound on a close-fitting round coil form if the end of the core is first cut off and then cemented in place during assembly. Alternatively, a cylindrical ferrite core of equivalent reluctance may be substituted for the U-shaped core.

The transformer coil information for the circuit shown in Fig. 4 is given in Fig. 5. Similar transformer coils are used in Figs. 7 and 9 except for the number of turns, which is shown on these drawings. These result in more deflection when operating with lower B+ voltage, but supply somewhat reduced high voltage.

The output-tube grid drive should be adjusted almost to the point of picture foldover. The picture width and the high-voltage power output are at a maximum whereas the driver tube and damper tube currents are at a minimum value. To decrease these currents further, the transformer inductance may be increased. This may be done by adding pieces of ferrite about 1 inch long to one or both ends of the core. The reduction of power input in the latter case, however, results in less high-voltage power, but greater picture width. The circuits shown in Figs. 4, 7 and 9 should be adjusted so that the damper tube and driver tube currents are within tube ratings.

In addition, the width coil, shown in Fig. 4 in shunt with the yoke, may be used in conjunction with the output tube screen grid voltage control for adjusting picture width. The construction of the width coil is shown in Fig. 5. It stores a portion of the total circulating energy of the deflection circuit. When the shunt inductance is decreased, by moving the core partially out of the coil, the picture width is reduced, but the output-tube plate current and the available high-voltage power are increased. On the other hand, when the screen-grid voltage is decreased, the picture width as well as the output tube plate current and the available high-voltage power are reduced. By adjusting both the inductance and the screen-grid voltage, the picture width can be set as desired while maintaining the high-voltage power output, and keeping the driver tube and damper tube currents within ratings.

The lower section of the output transformer is used for centering, and both this section and the yoke operate at B+ potential. The width coil however, operates at the boosted B+ voltage. This voltage, which is available from the lower end of the width coil, is used as the plate supply for the horizontal and vertical blocking oscillators and is also supplied to the kinescope screen grids. The width coil may be replaced by a 100 K (5 watt) resistor with some sacrifice in boosted B+ voltage, and high-voltage power output.

This method of adjusting the circuit may be used to determine experimentally the design values of the components to be employed in a horizontal deflection and regulated kick-back high-voltage supply circuit of this type. A trial transformer, whose inductance can be varied by adding core sections is used. The output tube, the damper tube and B+ supply for this test, should be more than adequate to deliver the desired peak-to-peak current to the yoke coils, as well as the additional current to be circulated in the low-inductance transformer and width coil. The circuit is adjusted so that the yoke current is suitable for full width at the design value of the final anode voltage, and the deflection transformer and width coil are circulating enough additional power to yield the desired high voltage when second anode current is increased to the desired maximum value. The circulating current can now be measured and then the required transformer inductance and the inductance of the width coil, if one is to be used, can be determined. Similarly the output tube, the damper tube, and the B+ supply necessary to circulate this current can be selected. The means for regulating the high voltage are then added to the circuit.

The power circulated is greater in the circuits illustrated than in conventional circuits in order to increase the high-voltage power output. Nevertheless, it is supplied by means of a tube complement no greater than the minimum commonly used for black-and-white receiver deflection circuits, except for those added for regulation. The total power input required for deflection and high voltage is substantially less than if an r-f supply is employed for the high voltage. The total plate and screen current is 140 ma when the B+ supply is 390 volts. Note that the 6BQ6 is used in this circuit, and in the circuit shown in Fig. 7, in a manner for which tube ratings are not available. Further experience is needed at this time to determine whether the tube is suitable for this purpose. It may be replaced by a 6BG6G for more conservative design.

Gating Amplifier Control of the Dummy Load

A gating pulse amplifier is shown in Fig. 6 that may be used in place of the d-c amplifier shown in Figs. 3 and 5. The gain of the 12AT7 gating amplifier is varied by the d-c voltage applied to its grid. The grid voltage in turn depends upon the high-voltage output and also upon the 135-volt negative supply because of the voltage divider connecting these points in the circuit. Thus the negative supply serves the same purpose as the fixed bias voltage supplied by the neon tube connected to the cathode of the 12AX7 in Fig. 3. The divided high voltage must exceed the bias of the negative supply, to put the gating amplifier in operation. It will be noted, however, that now the bias is not fixed, but varies with line voltage since it is supplied from a nonregulated source. Thus the high voltage is regulated at a level that depends upon line voltage rather than being independent of it. This feature is desirable in receivers using unregulated B supplies. When the line voltage drops, the B+ voltage delivered to the deflection circuit in such receivers drops accordingly. This would normally result in a decrease in both vertical and horizontal deflection. Also under these conditions the high-voltage supply would not be capable of delivering the normal peak current at the nominal final anode voltage and loss of regulation, change of picture size and some defocusing would result at peak picture brightness. In addition, in some tri-color tube receivers the lower B+ may reduce the output of the dynamic convergence circuits with possible color separation. When the regulation level follows line voltage, the changes in picture size and the possibility of deconvergence of the three beams in the tri-color tube can be minimized. Similarly, with reduced line voltage if the high-voltage regulating level is adequately reduced, a higher peak beam current can be supplied with good regulation when brightness is varied.

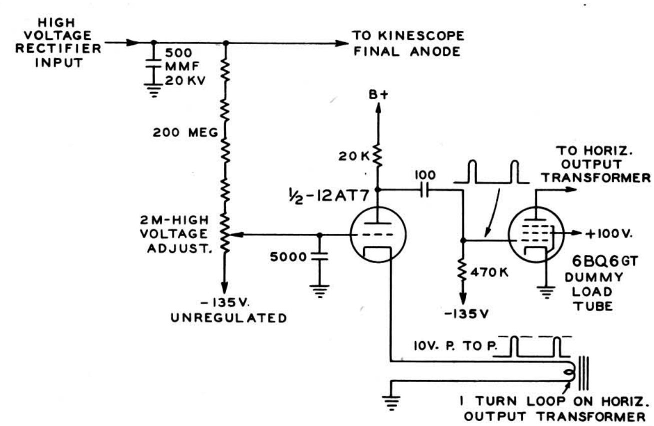

Fig. 6 - A gating pulse amplifier for control of the dummy load tube.

In the arrangement shown in Fig. 9 the bias voltage for the gating pulse amplifier is obtained from the grid of the blocking oscillator. This method may be applied to the circuit in Figs. 6 and 7. The grid self bias of the blocking oscillator was found to vary with line voltage and was used in place of a negative supply which was not available in this receiver. The high-voltage divider connected to the grid of the blocking oscillator should be sufficiently high in resistance not to upset the normal operation of the oscillator. If, in an alternative arrangement, the cathode of the gating pulse amplifier returns through the winding that pulses it to B+, and the low end

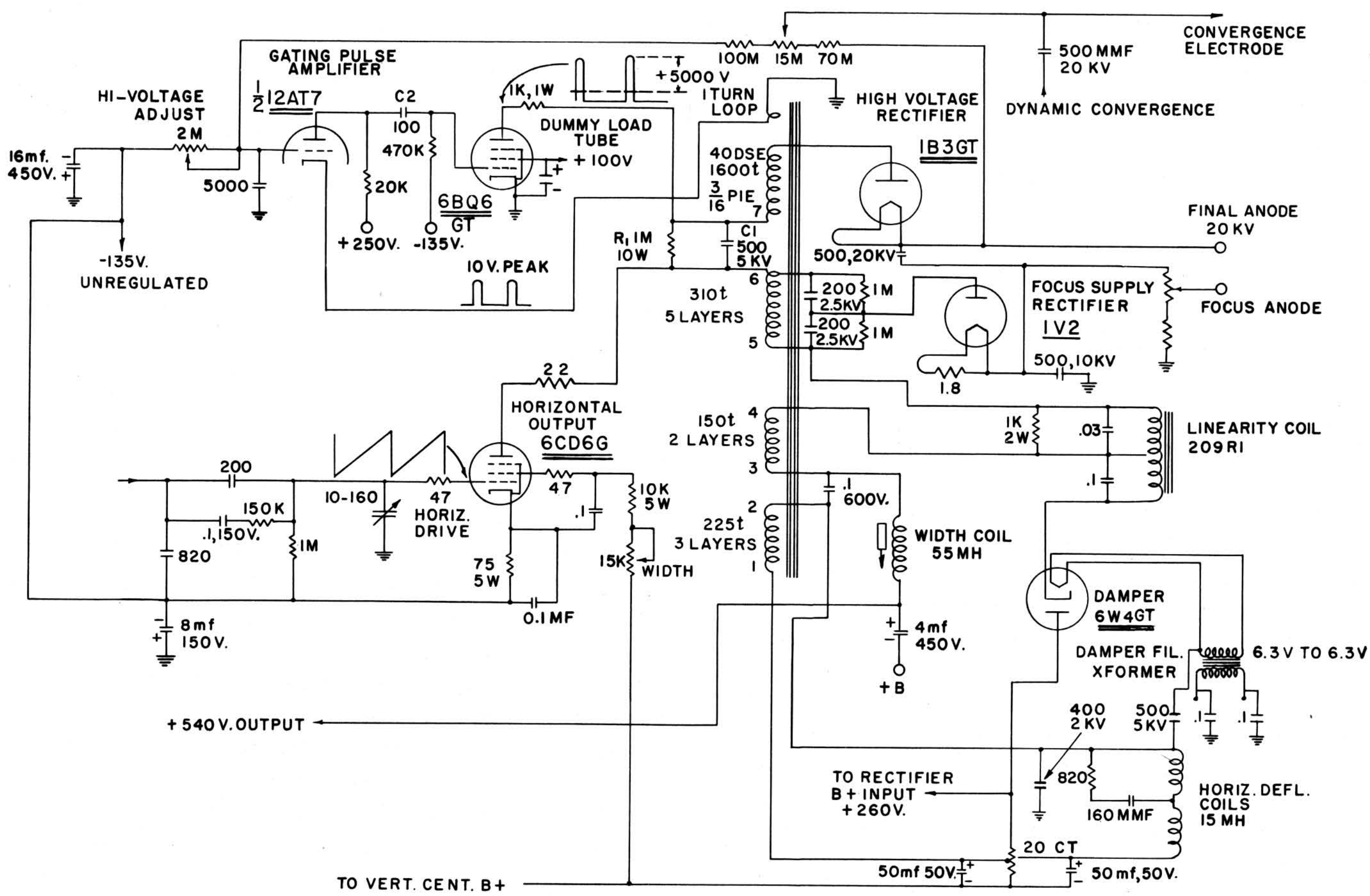

Fig. 7 – The gating pulse amplifier and pulse type dummy load tube regulator.

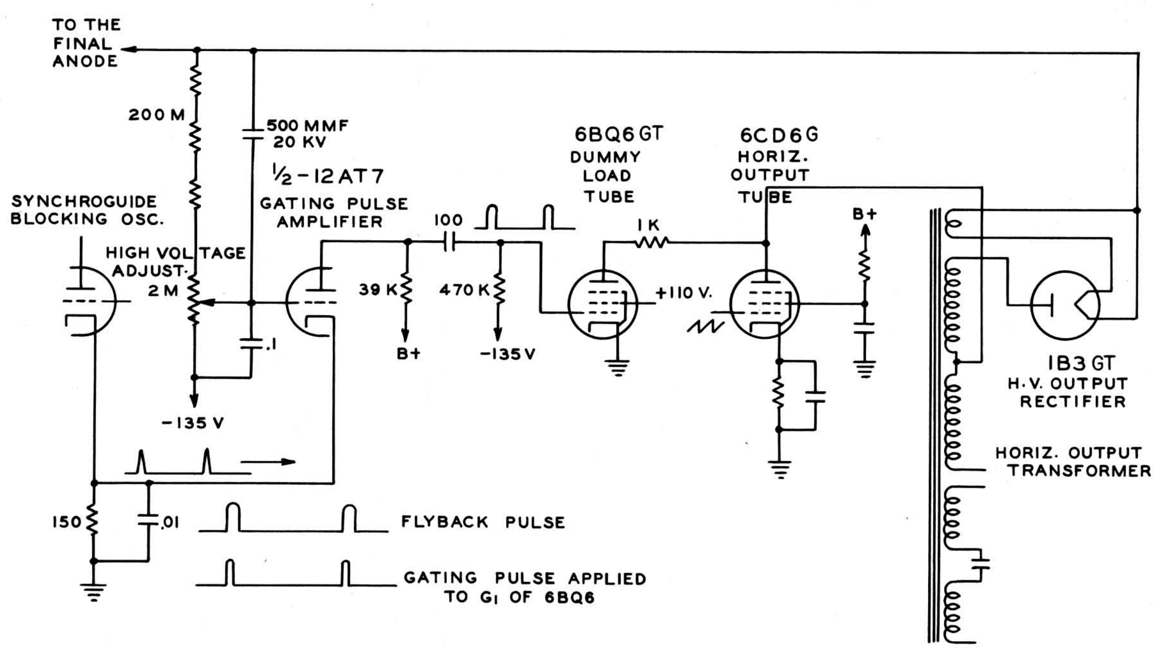

Fig. 8 – A method for gating the pulse amplifier during the first half of the flyback period.

of the high-voltage divider is returned to ground, the B+ supply then acts as the reference voltage. Because of the relatively large reference voltage excellent regulation can be achieved. A separate transformer or heater winding must be employed for the filament of the gating pulse tube. The plate load resistor should be returned to the boosted B+.

Operation of the Gating Amplifier

Referring to Fig. 7, as the picture brightness is decreased the high voltage tends to rise. The rise is sensed at the grid of the 12AT7 causing increased plate current and increased drop in the plate load resistor. Pulses of positive polarity obtained from a one or two turn winding on the transformer are applied to the cathode. The amplitude of these pulses is sufficient to drive the tube to cutoff and causes the plate voltage to go to B+ during these periods. Thus, at the plate, gating pulses are generated whose amplitude is determined by the grid voltage which in turn is controlled by the high-voltage rise. These pulses are coupled to the grid of the dummy load tube via C_2 causing it to conduct during this period and thereby to effect the regulation desired.

The circuit shown in Fig. 7 is being used in an experimental tri-color tube receiver. The regulation achieved is better than 2 per cent. Photographs of this unit are shown in Figs. 10 and 11.

Gating during the First Half of the Flyback Period

When the gating pulse applied to the dummy load tube is properly timed, so that it restricts current flow to only the first half of the retrace period. The need for resistor R_1 and capacitor C_1 in Figs. 4 and 7 is largely eliminated, permitting the omission of these elements. Such a method of regulation, shown in Fig. 8, may be applied to conventional transformers that have the driver tube output lead connected to the junction of the primary with the bottom of the high-voltage winding. The high-voltage output obtainable at full load is increased by the drop that would otherwise occur in R_1. The peak voltage applied to the dummy load tube is similarly increased.

With this method of pulsing, the current flow in the dummy tube does not continue after the voltage peak. Its effect on the high voltage and the peak-to-peak deflection current is similar to the effect of the high-voltage rectifier current except for the drop in the high-voltage winding and the rectifier. Under these conditions when the output high voltage is regulated and picture brightness is varied, only very minor changes in width are detectable.

To gate the dummy load tube properly the pulse applied to its grid may be obtained by means of the circuit shown in Fig. 8. The cathode of the gating-pulse amplifier is pulsed by inserting a 150-ohm resistor and a 0.01-μf capacitor in the cathode-to-ground lead of the blocking oscillator, as shown in Fig. 8. This method of pulsing may be applied to the circuit of Fig. 7. The pulse obtained in this way is initially too narrow and occurs too early to be effective in loading the deflection circuit, but it is widened and delayed after amplification by the gating amplifier. The amount of delay and widening is determined by the load resistor and the input capacitance of the dummy load tube. A plate load resistor of 39 K was found optimum in one circuit. Should the pulse be inadequately widened it is ineffective in producing regulation. On the other hand, if it is too wide the picture width changes and driver tube plate dissipation increases.

The grid of the gating pulse amplifier in the circuit shown in Fig. 8, as well as in those previously shown must be adequately bypassed in order to prevent capacitive pickup which might otherwise interfere with its control action. The resulting time constant of the control circuit may not be as fast as desired. To increase the speed with which the regulator acts, the 500-μμf high-voltage filter capacitor in Fig. 8 is returned to the grid of the 12AT7. This capacitor and the parallel 200-megohm resistor are now in series with the high-voltage adjustment potentiometer (about 1 megohm) and the parallel 0.1-μf bypass capacitor. These elements form an attenuator network, whose voltage at the tap is approximately a constant fraction of the input from the high-voltage rectifier, for both d-c and low- and high-frequency voltage changes.

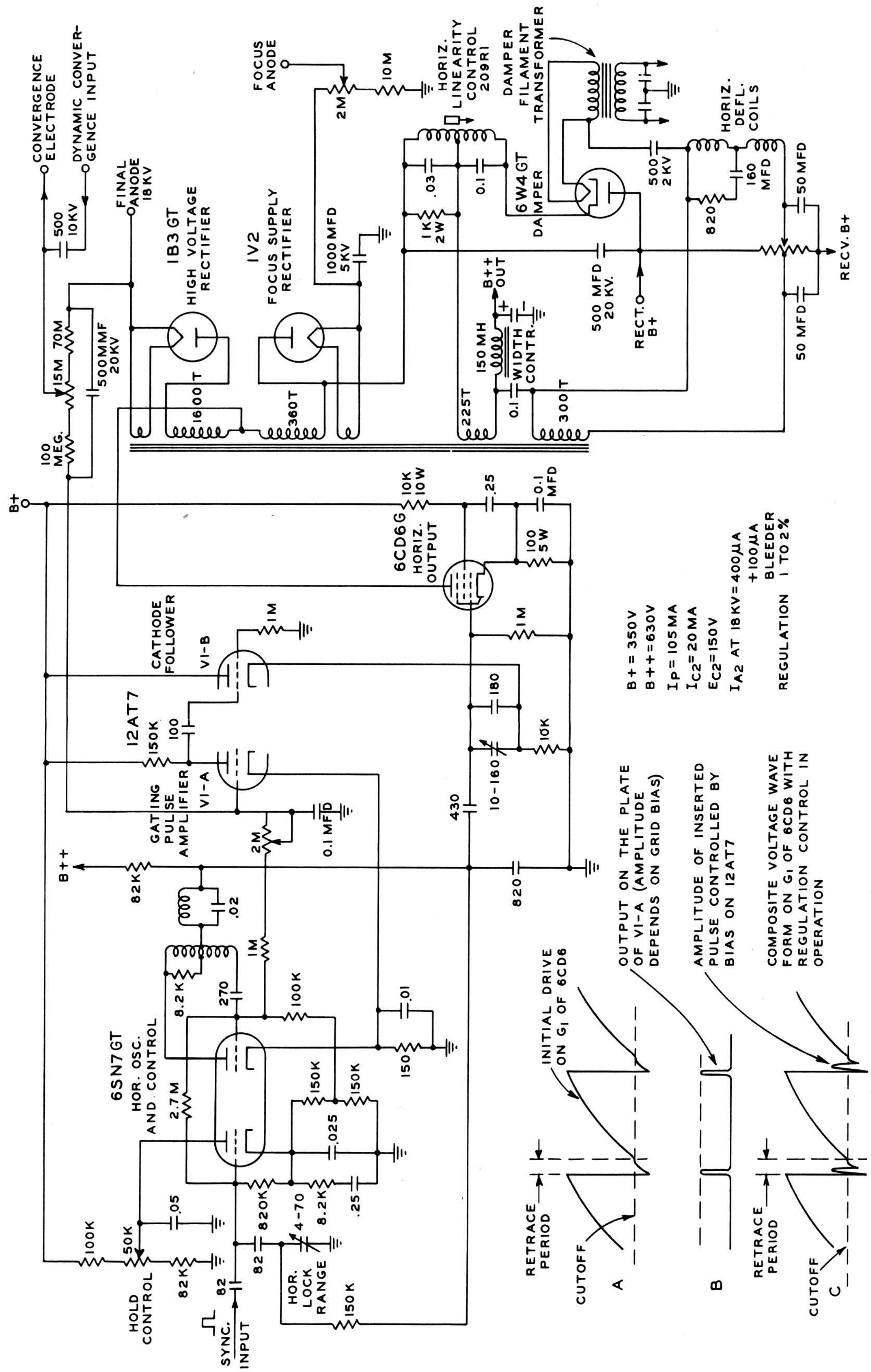

Fig. 9 - Regulated high voltage pulse supply with the dummy load tube eliminated.

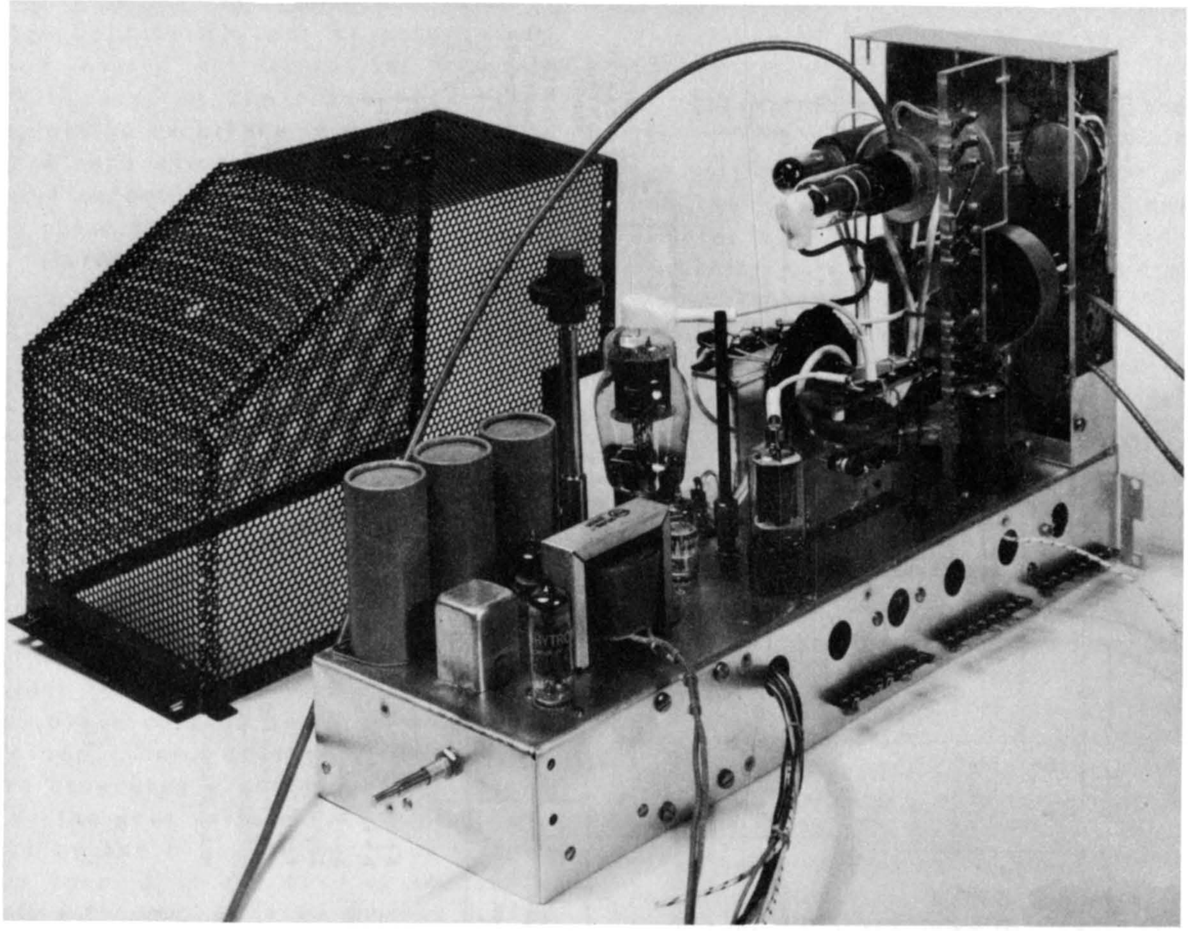

Fig. 10 – Top view of the deflection, high voltage and convergence chassis.

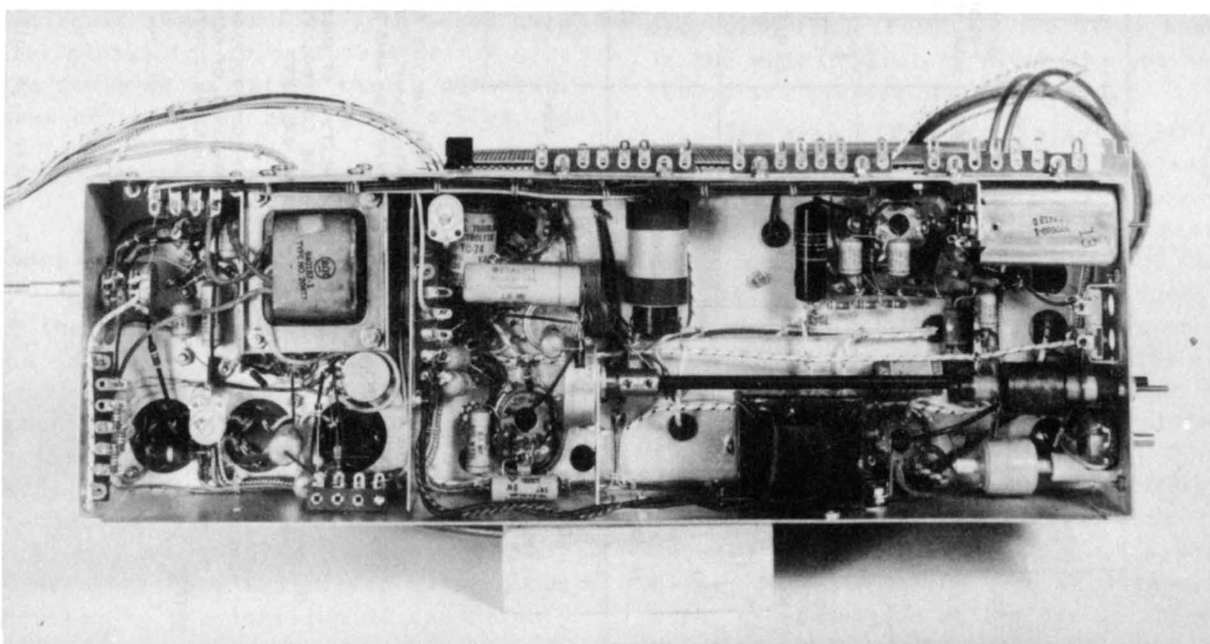

Fig. 11 – Bottom view of the deflection, high voltage and convergence chassis.

Elimination of the Dummy Load Tube

In the circuit shown in Fig. 9 the dummy load tube has been eliminated. The horizontal output tube now serves as the driver for the deflection circuit during the go sweep and as a dummy load tube during retrace. A gating pulse of appropriate width, timing, and amplitude is super-imposed upon the sawtooth input signal at the grid of the driver tube by means of a gating pulse amplifier and a cathode follower. One dual triode is employed for this purpose. In conventional circuits the horizontal output tube is normally cut off during the flyback period. In this circuit it is made to conduct by a pulse added to the input signal shortly after it is initially cut off by the sawtooth drive. This causes it to clip the retrace pulses and to prevent high-voltage rise in the manner of the separate dummy load tube.

Since the dummy load current can no longer be made to flow in a separate path from that of the driver-tube plate current, the resistor R_1 and capacitor C_1 cannot be used. A small change in width, with full change in brightness, may be detected even though the high voltage is regulated. The change in width, however, is substantially less than with non-regulated supplies.

Note that the plate dissipation of the horizontal output tube is now increased by the amount of power formerly absorbed by the separate dummy load tube. When a dark picture is presented, the additional plate dissipation equals the power supplied to the high-voltage rectifier at peak picture brightness. Satisfactory life of the output tube may be impaired if the total dissipation is allowed to be excessive. The 6CD6 plate dissipation, in the circuit shown in Fig. 9, may be somewhat excessive for the condition of picture-tube cutoff, but this circuit is nevertheless presented for purposes of illustration. This arrangement may be used in circuits in which the plate dissipation of the output tube is originally sufficiently below the maximum allowable dissipation to permit it safely to absorb the additional high-voltage power. If the 6CD6 in Fig. 9 is replaced by two 6BG6's, the total maximum allowable plate dissipation is increased from 15 to 40 watts. The peak high-voltage power output and the yoke deflection available in the circuit of Fig. 4 can be obtained with substantially lower B+ voltage (300 volts). In circuits where the damper tube current is increased above the allowable maximum for the 6W4, it must be replaced by two damper tubes.

Morris D. Nelson

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