



Pulse-Operated High-Voltage Power Supply for Television Receivers

Cathode-ray tubes in television circuits require high-voltage direct-current power supplies that range in voltage from as low as 2 kilovolts for directly viewed tubes to 30 kilovolts and higher for projection tubes. The current requirements for these services are low, average values ranging from 100 to 200 microamperes for both directly viewed and home-projection kinescopes.

In a television circuit employing a magnetic deflection system, a high dc voltage can be obtained by rectifying the high-voltage pulses that appear across the primary winding of the horizontal-deflection output transformer. This Note explains the operation of such a pulse-operated power supply and discusses in particular the circuit shown in Fig. 1. This circuit supplies both horizontal-deflection power and the high voltage necessary to operate a type 10BP4 kinescope at an anode voltage of 9 kilovolts.

Design Considerations

In a 10BP4 horizontal-deflection circuit that is not also designed for use with a pulse-operated power supply, voltage pulses of nearly 6 kilovolts appear across the primary winding of the deflection transformer when the circuit is adjusted correctly. If these pulses are applied to a diode and rectified, a dc output of approximately 5900 volts can be obtained for the anode. This voltage, however, is not of sufficient magnitude to operate the 10BP4 with good definition and brilliance. In order to increase the voltage available at the transformer primary, extra turns are added to the primary winding, as shown in Fig. 1, so that the primary of the transformer functions as an auto-transformer with a turns ratio of approximately 1.6 to 1. To avoid an appreciable reduction in the Q of the circuit, the distributed capacitance of the additional turns are kept low. Because of the additional primary turns, the high-voltage pulses are stepped up to approximately 9 kilovolts. This voltage is rectified and applied to the anode of the 10BP4.



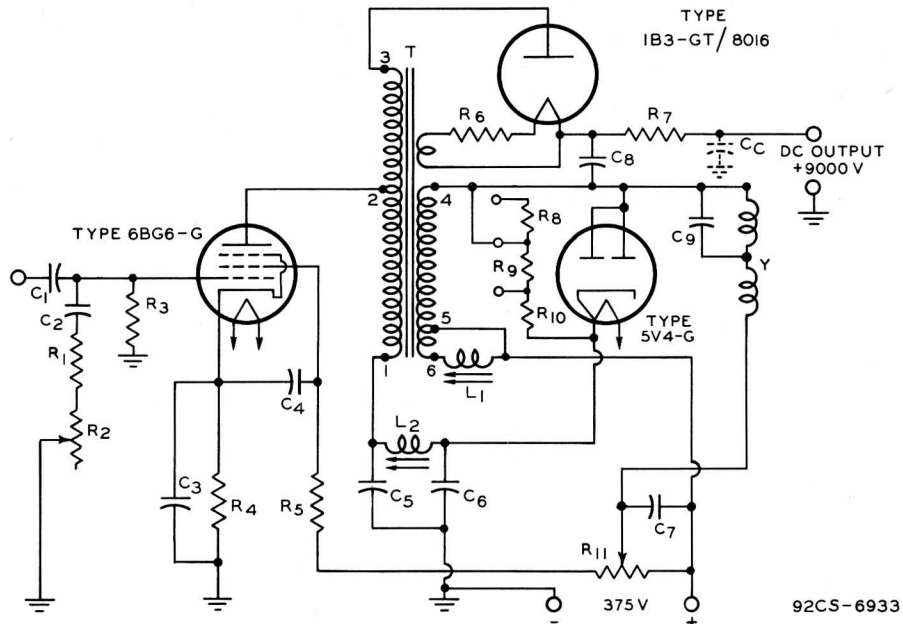
To utilize the negative excursion of the voltage pulse on the secondary side of the transformer and to obtain an additional few hundred volts, the return lead of the rectifier may be connected to the secondary as shown in Fig. 1. Although a negative pulse of approximately 1.5 kilovolts appears across the transformer secondary, the dc output is increased only by approximately 400 volts because of phase shift introduced by the leakage-reactance of the transformer.

The voltage across the primary winding of the transformer has a negative oscillation of approximately 3000 volts immediately following the positive 9000-volt pulse. This negative oscillation produces a pulse of negative voltage of approximately 1900 volts on the plate of the 6BG6-G. This negative voltage will cause the 6BG6-G to produce Barkhausen oscillations which may be radiated, thereby affecting the radio-frequency section of the television receiver. The oscillations will be carried through the circuit to modulate the kinescope grid and will appear as vertical bars at the left edge of the picture. The effects of Barkhausen oscillations, however, will not be observed when the scanning circuit alone is tested. The effect is found only when the complete receiver is in operation and tuned to the higher frequency channels, and when high intermediate-frequency gain is employed. In extreme cases, additional shielding of the horizontal-deflection circuit might help.

The filter circuit of the high-voltage supply consists of a 500- μ mf capacitor, a 750,000-ohm resistor, and a capacitor obtained by grounding the outer conductive coating of the 10BP4. The 750,000-ohm resistor not only acts as a filter element but also minimizes the possibility of severe electrical shock. A person coming in contact with the high voltage would not receive a serious shock from this voltage alone because his body resistance would be low enough to virtually short-circuit the supply and, thus, to reduce the high voltage to a safe value. Although the 375-volt B supply is connected directly to the 1B3-GT/8016, it is not a source of high-voltage danger because its current is also limited by the 750,000-ohm filter resistor.

Because the filament of the 1B3-GT/8016 is approximately 9 kilovolts above ground, a filament-power supply insulated for this high voltage is required. Since the filament power required is only 0.25 watt, it may be obtained from the horizontal-deflection transformer without excessive loading of the scanning circuit. The filament winding consists of two turns of wire adequately insulated. A series resistor of 3.3 ohms is included to provide the proper value of filament current. Different circuits may require other values for this resistor to give the correct filament current.

The power supplied to the kinescope at 9 kilovolts and 200 microamperes, the filament power of the 1B3-GT/8016, and the dissipation of the 3.3-ohm filament resistor place an additional load of approximately 2.3 watts on the scanning circuit. This additional load, as well as power losses in the transformer and rectifier, is well within the power capabilities of the circuit.



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| R1 = 6800 ohms, 0.5 watt | C3 = 0.1 μ f, 400 volts |
| R2 = Peaking Control, 20000 ohms, carbon potentiometer | C4 = 0.05 μ f, 400 volts |
| R3 = 1 megohm, 0.5 watt | C5 = 0.035 μ f, 600 volts |
| R4 = 100 ohms, 2 watts | C6 = 0.05 μ f, 600 volts |
| R5 = 11000 ohms, 2 watts | C7 = 30 μ f, 10 volts |
| R6 = 3.3 ohms, 0.5 watt | C8 = 500 μ f, 10000 volts |
| R7 = 750000 ohms, 0.5 watt | C9 = 56 μ f, 1000 volts, mica |
| R8 R9 = 500 ohms, 5 watts | CC = Kinescope Capacitive Coating |
| R10 = 5300 ohms, 20 watts | L1 = Width Control, RCA Inductor Type #201R1 |
| R11 = Horizontal Centering Control, 20 ohms wire-wound potentiometer | L2 = Horizontal Linearity Control, RCA Inductor Type #201R3 |
| C1 = 3900 μ f, 400 volts | Y = RCA Reflection Yoke Type #201D1 |
| C2 = 150 μ f, 400 volts, mica | T = RCA Transformer Type #211T1 |

Fig. 1. Horizontal-Deflection Circuit and Pulse-Operated High-Voltage Supply for the 10BP4 Kinescope.

In horizontal-deflection circuits that do not utilize the pulse-operated power supply, the pattern width is controlled by varying the screen-grid voltage of the 6BG6-G power tube. In the circuit of Fig. 1, however, this type of control is not practical because both output voltage and pattern width are affected by the value of the screen-grid voltage of the 6BG6-G. As the screen voltage decreases, both horizontal-scanning power and kinescope anode voltage decrease simultaneously and little change in picture width results. In order to control picture width, therefore, without appreciably affecting the dc voltage, a variable inductor (L_1) connected across 15 turns of the secondary winding is used to shunt more or less current from the deflection yoke circuit. Variation of the inductance is adequate to change the picture width because the range required for adjustment is small.



Regulation

The filter capacitor C_3 of the high-voltage supply charges during retrace time and discharges during forward-trace time. The charge time is approximately 6 microseconds; the discharge time is approximately 57 microseconds. Fig. 2 shows the rate of discharge computed for various capacitor values and loads of 50 megohms and 25 megohms. The curves were computed for these load values because a kinescope represents a load of 50 megohms when drawing 200 microamperes at 10 kilovolts and a load of 25 megohms when drawing 400 microamperes at 10 kilovolts. Curve 5 indicates that a 100- μf capacitor will provide sufficient filtering because the voltage drops less than 3 per cent in 57 microseconds of discharge. However, the regulation of the supply and the magnitude of the ripple voltage are affected by the size of this capacitor. Poorer regulation and increased ripple voltage result when the capacitance is decreased. The use of a large capacitor increases the cost of the supply and increases the danger of electrical shock. Fig. 1 specifies of 500- μf capacitor because that size is available commercially, is sufficiently large to give satisfactory regulation, and is small enough to minimize shock hazard.

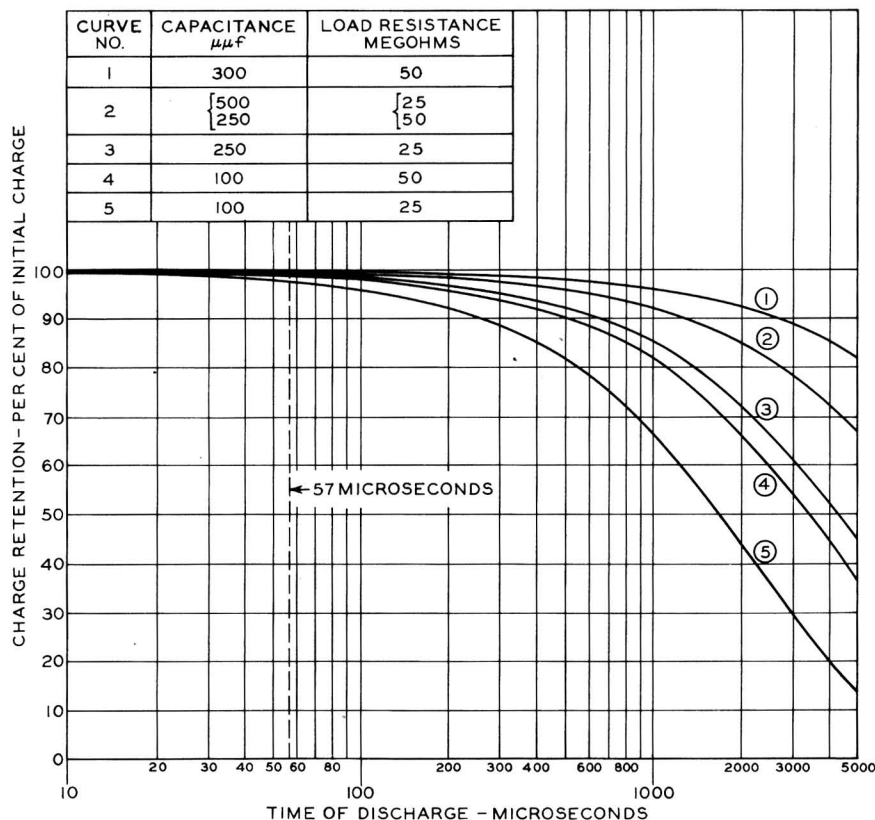


Fig. 2. Computed Rate of Discharge for Various Capacitor Values and Loads.

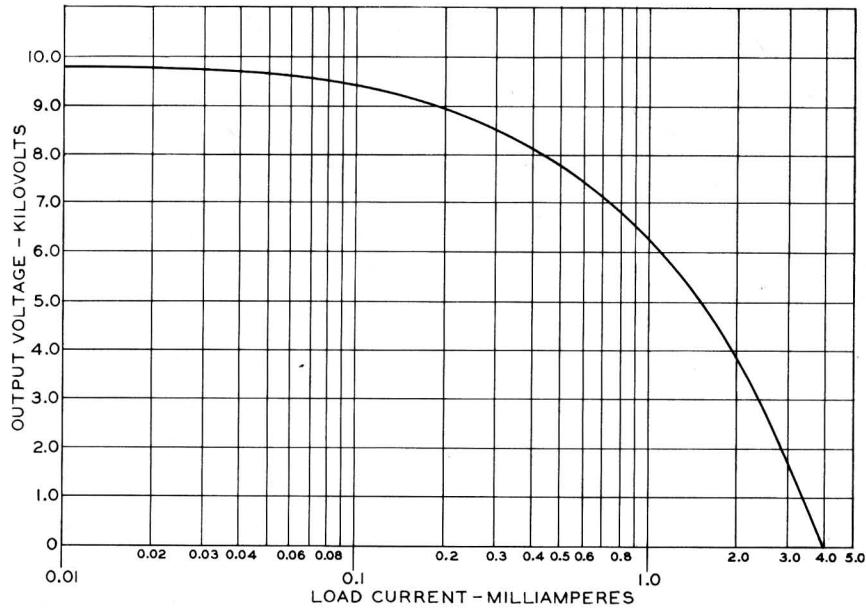


Fig. 3. Measured Steady-Load Regulation Characteristic of Pulse-Operated High-Voltage Supply for the 10BP4 Kinescope.

Fig. 3 shows the regulation characteristic of the pulse-operated power supply of Fig. 1. The characteristic is steeper than that of a well-designed radio-frequency-operated power supply, but tests show that the pulse-operated power supply gives satisfactory results. Furthermore, the pulse-operated power supply does not require a coil and oscillator tube and the additional power and space needed for the radio-frequency-operated supply.

Advantages

Pulse-operated power supplies have a number of desirable characteristics. The horizontal-deflection transformer simultaneously serves as a high-voltage transformer and filament transformer. The inverse-voltage rating of the rectifier tube need be, in general, only about 20 per cent higher than the dc output voltage. Filtering is simplified because pulsing occurs only during retrace periods. If deflection fails, the high voltage also fails and, therefore, no damage to the kinescope screen results. As the load on the power supply increases, both the tube anode voltage and the horizontal-deflection power decrease. As a result, the picture width remains essentially constant with change in load. High voltage for the vertical discharge tube also may be obtained from the pulse-operated power supply by the use of a suitable bleeder. With this arrangement, the amount of vertical deflection will depend upon the high-voltage output, and the picture height, therefore, will also remain essentially constant with change in kinescope anode voltage.



CAUTION

Although the circuit shown in this Note has been carefully designed to limit the amount of current that may be drawn by a person coming in contact with a high-voltage connection, the high voltages appearing throughout this circuit can be dangerous to human life. Always exercise care when working with this circuit and shut off power before making any changes. If it becomes absolutely necessary to work on a circuit while it is operating, take extreme care.

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