LB-960

A CONVERGENCE CIRCUIT FOR THE RCA DEVELOPMENTAL 21-INCH COLOR KINESCOPE

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Approved

Stuart Wm Seeley

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Introduction

The RCA developmental 21-inch color picture tube, Dev. No. C-73685-D, has several features that make improved convergence and simplified circuitry possible. The use of separate internal pole pieces permits individual adjustment of the convergence of each electron gun. The tube employs electron guns mechanically tilted toward a common axis, which reduces the amount of static or permanent magnetic field required; this makes for improved stability of the convergence with line-voltage or high-voltage changes. Similarly, the formed shadow mask and curved color phosphor screen reduce the dynamic convergence required; therefore, errors associated with dynamic convergence are reduced. In the simplified convergence circuitry described in this bulletin the dynamic convergence currents are obtained directly from the horizontal and vertical output circuits without additional tubes. These currents therefore tend to track the deflection with line-voltage changes.

Convergence

If a black-and-white video signal were applied simultaneously to the three electron guns of the color kinescope, and no attempt were made to converge the three images which they produce, the three images would be displaced from each other by distances equal to the separation of the guns in the kinescope neck. However, as stated previously, the electron guns are mechanically tilted to cause the electron beams to converge at the center of the screen. Thus the three images are brought to approximate superposition. Exact convergence of the three electron beams at one point such as the center of the raster may be effected by the three permanent magnets of the convergence assembly and the blue positioning magnet. However, variation in the distance traversed by the three electron beams with deflection causes the degree of convergence needed to obtain superposition of the different parts of the image to vary. Since the distance traversed by the beams increases as they are deflected away from the center of the tube, the degree of convergence needed is reduced. Thus, the convergence needed at any point in the image or any instant in the scanning cycle is a function of the distance of that part of the image from the center of the tube, or of the instantaneous, horizontal and vertical deflection.

To allow for the variation in the distance to the screen, individually adjustable a-c components of magnetic field are applied across each electron gun. This a-c component of field is referred to as the "dynamic" component as contrasted to the "static" component which is introduced by means of the permanent magnets previously mentioned.

Both a-c and d-c components of magnetic field are applied to each electron gun by way of a pair of internal pole pieces attached to each gun as shown in Fig. 1. A converging-coil and magnet assembly which has a dual coil winding with a horseshoe-shaped ferrite core

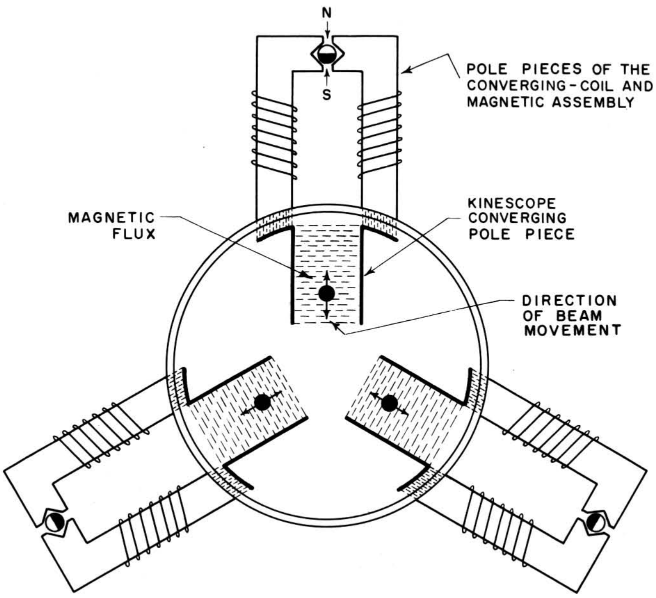

Fig. 1 - Converging-coil and magnet assembly position with respect to the kinescope converging pole pieces.

for each gun, is placed in juxtaposition to the internal pole pieces. Each ferrite core has two sections and a magnet as shown in Fig. 2. The dynamic component of magnetic field is produced by current flowing in the coil winding, whereas the static component is induced in the core by means of the magnet, which is a cylinder of

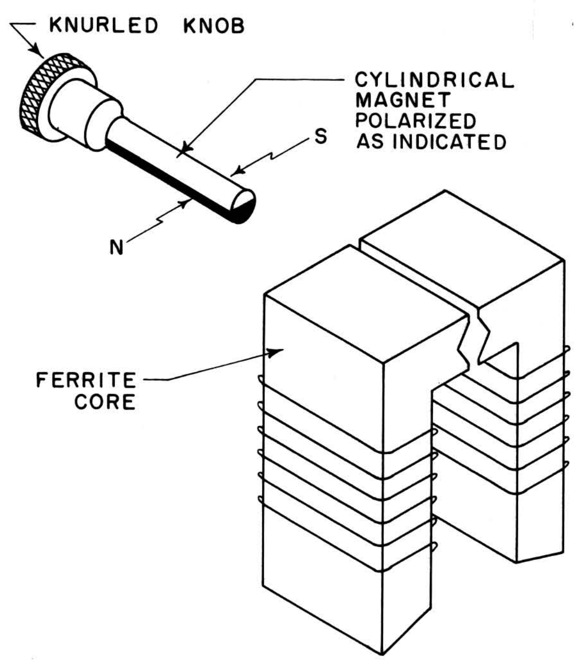

Fig. 2 - Parts of converging-coil and magnet assembly.

small-diameter (see Fig. 2) placed in the slot between the core sections. This cylindrical magnet is polarized perpendicular to its axis. When the N-S poles of the magnet are rotated so that the lines of force are parallel to the two core sections, no differential field is set up between them; consequently there is no field across the internal pole pieces. When the magnet is rotated from this position, a component of its field depending upon the degree of rotation is set up across the core sections and therefore across the internal pole pieces of the gun.

Adjustment of Static Convergence

The path of deflection of the individual beams effected by the transverse magnetic field introduced by way of the internal pole pieces is a radial line toward or away from the center of the screen depending upon the polarity of the magnetic field, as illustrated in Fig. 3.

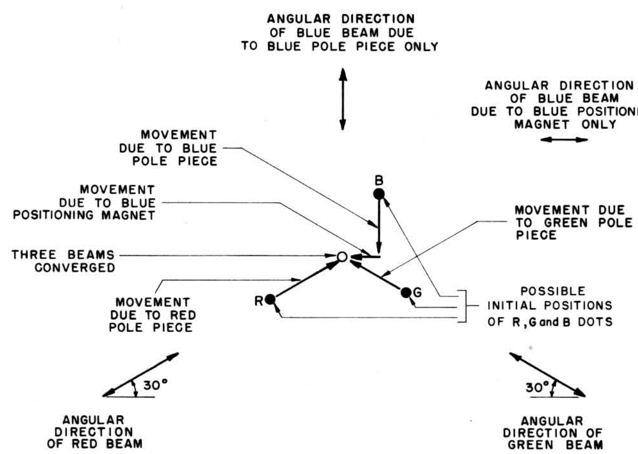

Fig. 3 - Movement of a dot due to adjustment of magnetic field in pole pieces of the converging-coil and magnet assembly, and the blue-positioning magnet.

Thus if the undeflected beams of the "red" and "green" guns which are mounted horizontally side by side in the neck of the tube did not converge at the screen they could each be moved to the point where the two radial paths meet. In order to converge the three beams, the third beam (blue) must be moved to the position already reached by the red and green beams. If the blue radial path, which is vertical, does

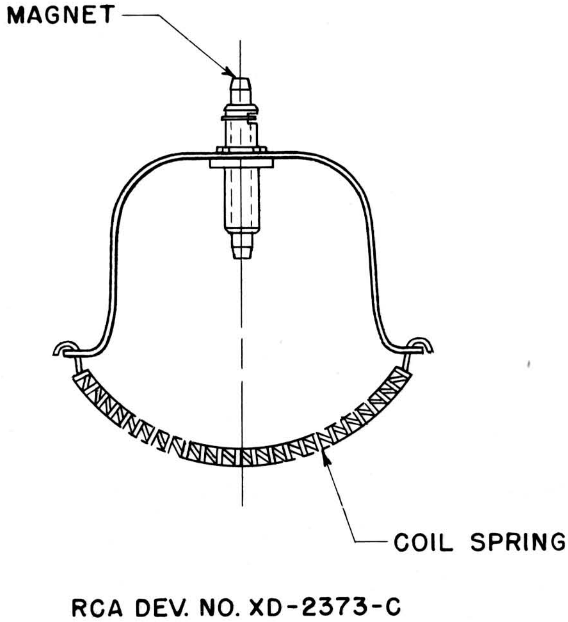

Fig. 4 - Blue-positioning assembly.

not pass through the intercept of the red and green, the beam may be moved horizontally by means of the blue-positioning magnet, RCA Dev. No. XD-2373-C, (Fig. 4) and vertically to the intercept of the red and green paths by means of the cylindrical magnet on the converging-coil and magnet assembly. Thus, all three beams may be converged exactly at the center of the raster, (Fig. 3). When the scanning deflection fields place the beams other than at the center of the screen, the path of motion effected by the convergence coils or magnets is parallel to the radial paths at the center of the screen.

Dynamic Convergence

If a monochrome dot pattern signal is applied simultaneously to all three guns after

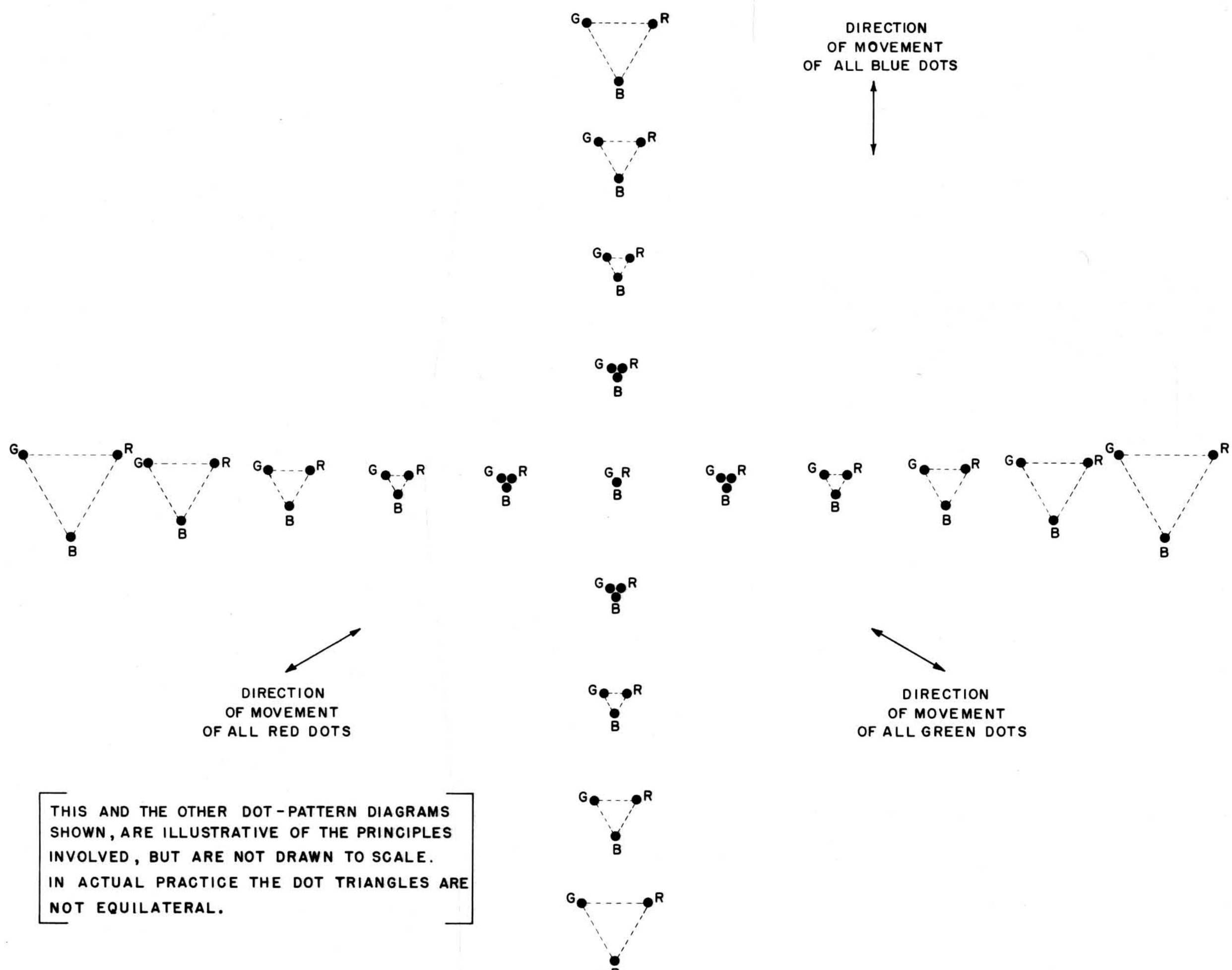

Fig. 5 - Misconvergence of a dot pattern exaggerated for clarity, to be corrected by dynamic convergence currents.

the beams have been converged at the center of the screen by means of the magnets (static convergence only) as described above, it will be found that at all points other than the center of the screen, the beams have been overconverged; that is, the blue beam which started above, now appears below red and green, and similarly red is to the right, and green to the left, as shown in Fig. 5. The a-c dynamic convergence currents are now introduced to the coils to correct the degree to which the beams are converged at any instant in the scanning cycle of the raster, so that convergence of the three beams over the whole area of the screen is brought about.

To a first approximation, the required waveshape of the current in the coils is a parabola of horizontal frequency superimposed upon a similar parabola of vertical frequency, as shown in Fig. 6. Because the circuitry might be considerably simplified, a sine wave of current of horizontal frequency may be considered as a substitute for the horizontal frequency parabola. When the amplitude and phase of this component of convergence are properly adjusted, the horizontal convergence closely approximates that obtained with a parabola but is not perfect.

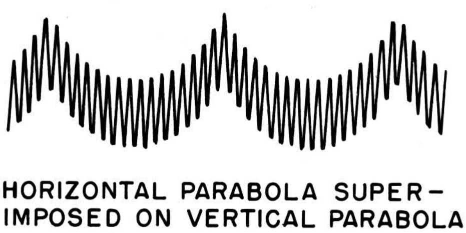

Fig. 6 - Waveform of current required for dynamic convergence.

Fig. 7 illustrates by solid line (A) a typical current wave required to produce exact convergence at every point in the horizontal scan. It is essentially parabolic in form. The dotted line B represents a possible sine wave of current that may be substituted for the parabola with minor errors equally distributed. The dashed line represents a sine wave which is fitted more carefully to the middle four fifths of the raster but with greater error at the extreme edges. The latter adjustment has been found subjectively to produce more acceptable convergence than that shown by the dotted line B.

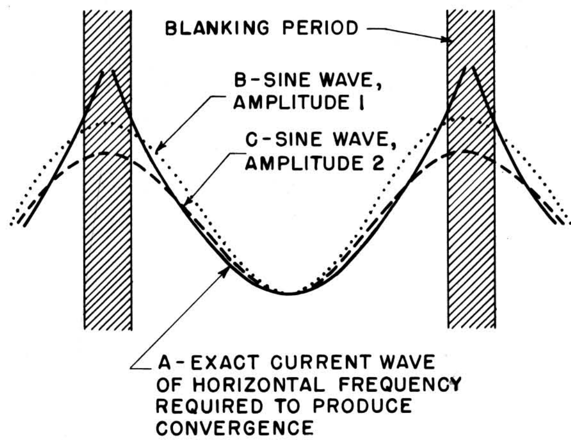

Fig. 7 - Sine wave substitution for parabolic wave.

Circuit Description

A convergence system using sine waves for horizontal convergence has been evolved and its circuit diagram is shown in Fig. 8. The current

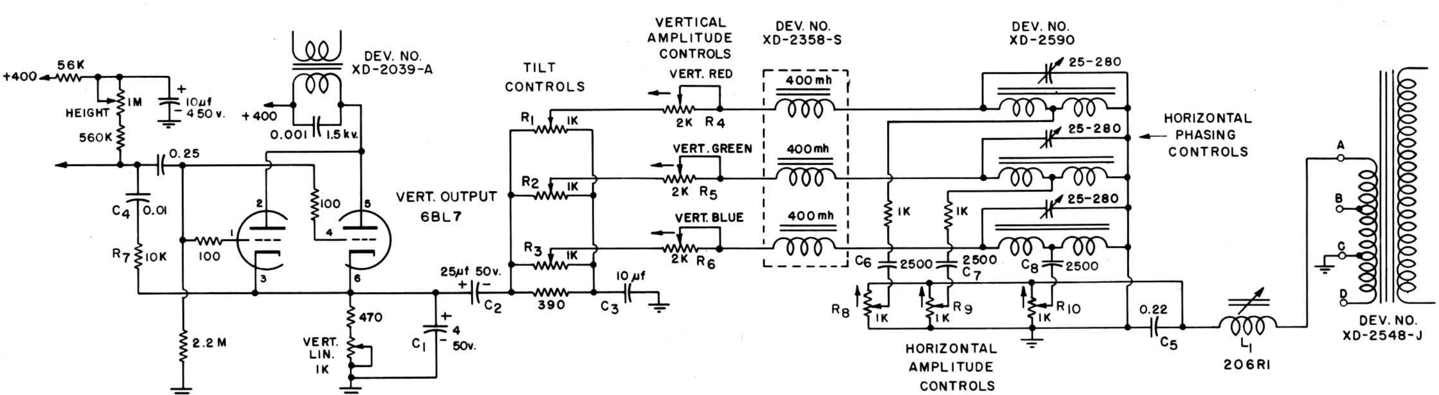

Fig. 8 - Dynamic convergence circuit.

through each of the convergence coils is individually adjustable in amplitude and phase. The phase is adjusted by the 25-to-280-μμf variable trimmer capacitors used to resonate each coil at line frequency. Shifting the phase of the sine wave provides an effect which is similar to the tilt obtained by the addition of a sawtooth to a parabola.

The vertical portion of the circuit is more conventional using the readily available parabolic and sawtooth wave forms.

The converging-coil and magnet assembly used in the convergence circuit of Fig. 8 is the RCA Dev. No. XD-2590, shown in Fig. 9. It is of the type shown in Figs. 1 and 2 and is designed for use with the developmental 21-inch color kinescope, C-73685-D. Two windings, one of 800 turns and one of 1200 turns, are used in the dual coils for each horseshoe core. These coils are connected series aiding. In addition, a dynamic convergence inductor pack, RCA Dev. No. XD-2358-S, consisting of three ferrite-cored chokes each of about 400 millihenries inductance, is used. One choke of this unit is connected in series with the two converging coils for each gun.

A vertical frequency parabola voltage obtained from the cathode of the vertical output tube is fed via the blocking capacitor C_2 and the three vertical tilt controls R_1, R_2, and R_3, to capacitor C_3. The voltage across C_3 is a parabola delayed and tilted differently than the voltage across C_1. The tilt controls permit the voltage applied to each coil to have adjustable tilt. The current in each coil is limited by the vertical amplitude controls (R_4, R_5 and R_6). Resistors R_4, R_5 and R_6 constitute the dominant impedance offered to the voltage, so the current will be similarly parabolic in wave shape. The vertical tilt adjustment shifts the minimum point of the parabola toward the start or finish of each cycle. In order to permit the vertical output tube to operate normally the sawtooth charging capacitor C_4 and peaking resistor R_7 are not returned to ground as is usually done, but are returned to the cathode of the output triodes.

The horizontal-frequency component of voltage originates as a negative pulse of about 200 volts amplitude at point A in the horizontal output transformer. The current flowing

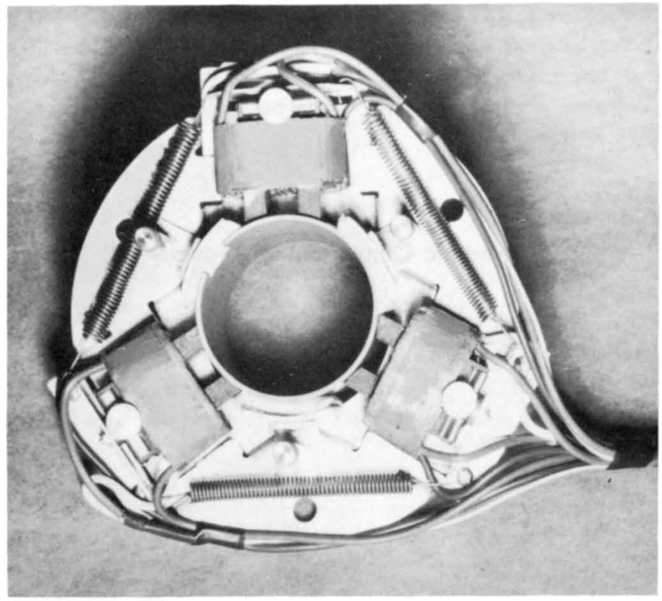

Fig. 9 - Photograph of the converging-coil and magnet assembly, RCA Dev. No. XD-2590.

through L_1 which is sawtooth in wave shape produces a horizontal-frequency parabola across C_5 which is supplied to three horizontal amplitude controls R_8, R_9 and R_{10}. An adjustable amplitude of this signal is applied to the 800-turn coil via a 2500-μμf capacitor. This capacitor, the 800-turn coil, the 1200-turn coil, the 400-millihenry choke and the associated horizontal phasing capacitors, C_6, C_7 or C_8, form a series-parallel resonant circuit. The total inductance of the series aiding coils is effectively in shunt with the 400-millihenry choke, not in series, as it is for the vertical component. C_6, C_7 and C_8 help to resonate the parallel combinations. The voltage developed at the junction of the two coils is stepped up by autotransformer action in the pole piece core at the upper end of the coils. The 2500-μμf capacitor is series resonant with the net inductive reactance seen at the junction causing the current flow to be in phase with the input parabola. By adjusting the trimmer capacitors the phase of the current may be shifted as desired. This phasing moves the minimum current point toward the left or right in the picture.

Because this arrangement permits very low power drain from the voltage sources the loading effect observed on the vertical or horizontal output circuits is small. By series connecting the coils of the converging-coil and magnet assembly the magnetic fields aid each other and thus the current required from the vertical frequency voltage source is reduced.

Dynamic Convergence Alignment

The following procedure may be used as a method of adjusting the convergence of the developmental 21-inch color tube. The final convergence adjustment must follow the color purity correction sequence. A preliminary static convergence setting should precede this sequence for best purity. Similarly, the vertical and horizontal output circuit should be adjusted for amplitude, linearity, high voltage level and focus, before aligning the convergence circuits. The external pole pieces of the converging-coil and magnet assembly should be aligned carefully with the internal pole pieces in the kinescope neck. Also the blue-positioning magnet should be mounted over the blue-positioning pole pieces of the kinescope.

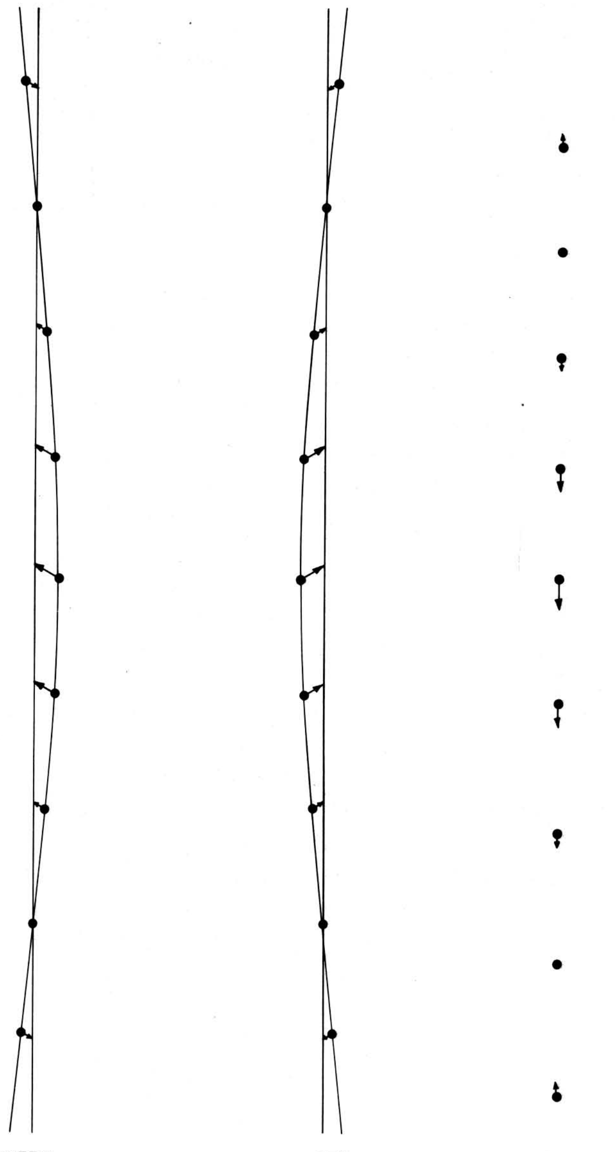

Fig. 10 - Movements of dots effected by vertical dynamic convergence currents.

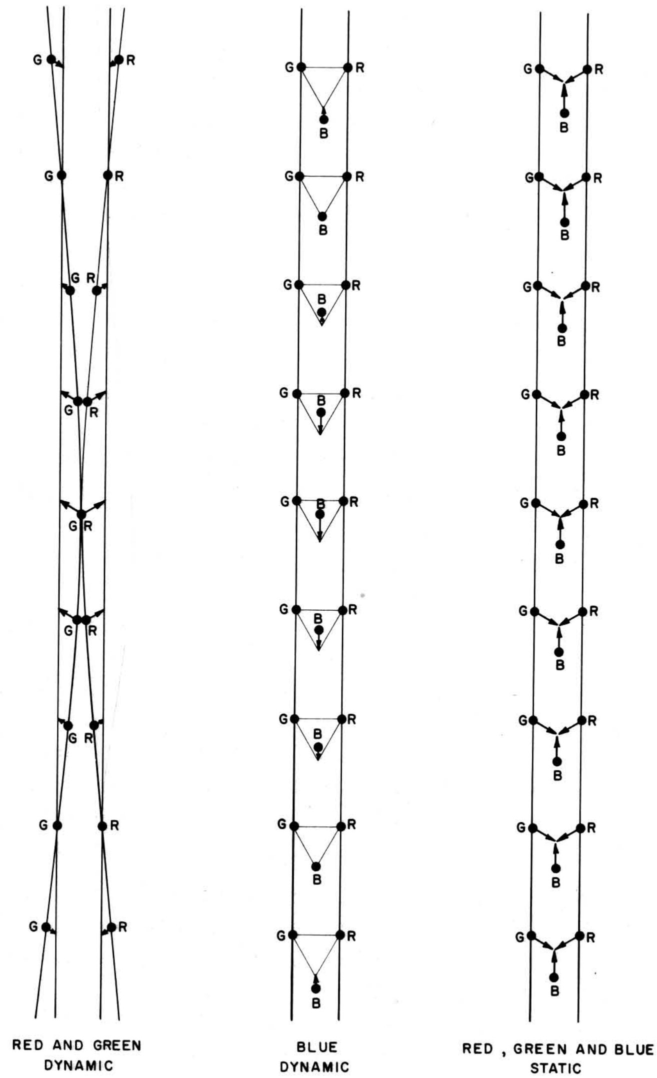

Fig. 11 - Motion of dots due to applied vertical converging fields.

With a dot-pattern generator, such as the RCA WR-36A Dot-Bar Generator, supplying the three electron guns simultaneous signals, adjust the vertical and horizontal dynamic amplitude controls to minimum current (counter-clockwise) position. Adjust the magnets of the converging-coil and magnet assembly and the blue-positioning magnet as described in the preceding section (Static Convergence Adjustment), so as to converge the red, green and blue dots in the center of the screen. The red, green and blue dots other than in the center will appear as shown in Fig. 5.

Some knowledge of the movements effected by the magnetic (static or dynamic) fields will be helpful. Figs. 3 and 5 show the angular direction of movement effected by these fields. All dots of one color are moved an equal amount in the same direction by the static field applied to that gun. There is very little interaction on dots of the other colors. The movements effected by the dynamic convergence currents are given below.

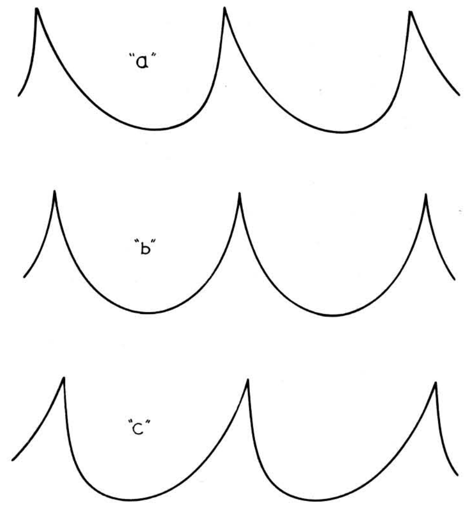

Fig. 12 - Effect of tilt on vertical parabola.

If the row of tricolor dots running vertically through the center of the screen is considered, an imaginary line connecting the green dots and a line connecting the red dots will be found to be bowed toward each other, and touching at the center. As the vertical parabola amplitude controls for red and green are advanced clockwise, the bowing of each line is reduced and may even be reversed. The movements of the red and green dots are in opposite directions, each being parallel to the direction between the respective guns and the axis of the tube; see Fig. 10. Since the dynamic components of current applied are a.c., the movement of

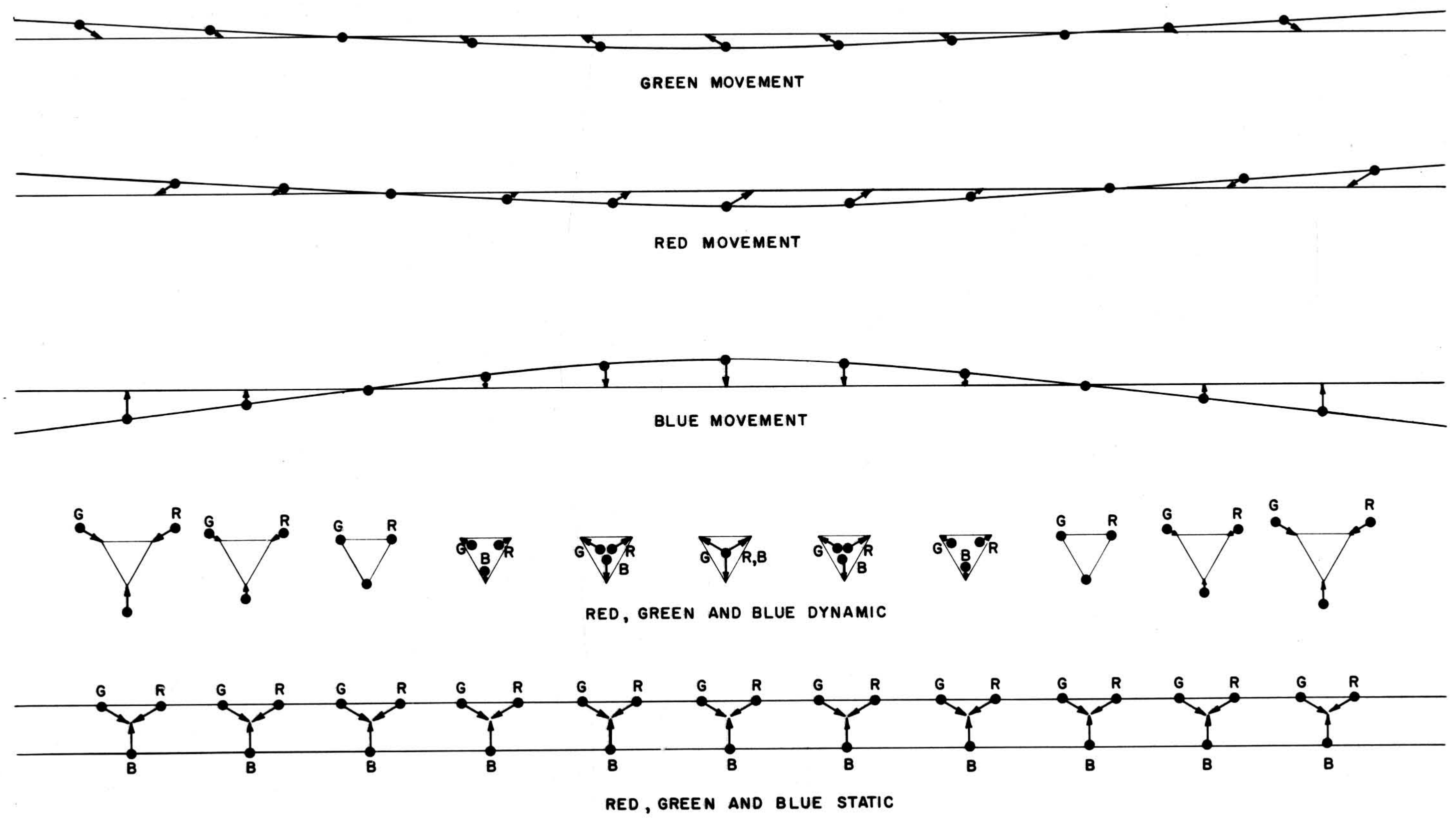

Fig. 13 - Motion of dots due to applied horizontal converging fields.

the dots in the top and bottom quarters of the line for each color is different from the middle portion. The middle portion which has been converged at the center actually deconverges, while the top and bottom portions move closer to each other, as shown in Fig. 11. The object is to achieve uniform spacing from top to bottom, with red and green dots side by side at the same level. If the spacing between dots is not symmetrical about the center, the tilt controls are adjusted to cause the maximum movement to be shifted above or below the center, so as to compensate for this lack of symmetry. See Fig. 12.

When the vertical parabola control for blue is advanced clockwise the movement it produces is vertical. Similarly the dots in the top and bottom quarter move upward, whereas the dots in the middle portion move downward. The object now is to form equilateral triangles with the green and red dots that are equal in size from top to bottom.

The static convergence is now readjusted. The red, green and blue dots in the middle vertical row should now converge simultaneously. A slight readjustment of the vertical controls at this time will permit more accurate convergence, because it is easier to discern slight errors in adjustment.

The action of the horizontal controls is similar to that of the vertical. The phasing capacitors act similarly to the tilt controls. The movement produced by the horizontal amplitude control adjustment for red, green and blue is shown in Fig. 13. The object now is similarly to achieve equal-size equilateral triangles for red, green and blue dots on the center horizontal row of dots. The static convergence is again readjusted. The dots over the entire screen are now converged simultaneously.

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