Neck-Shadow Problems in Kinescopes

This Note discusses circuit and component design considerations necessary to avoid neck-shadow difficulty in kinescopes. Such difficulty, revealed by the presence of dark areas or "shadows" at corners or edges of a kinescope screen during scanning, indicates that the beam is not reaching these areas but is, instead, striking the kinescope neck. This condition, known as "Neck Shadow" or "BSN" ("Beam Strikes Neck"), usually manifests itself during initial adjustment of the deflection and picture-centering circuits. Under normal circumstances, neck shadow is merely an indication that deflecting or picture-centering components are not properly positioned on the kinescope neck, or that circuits associated with these components are out of adjustment. In some cases, however, neck shadow cannot be "adjusted out" or can be eliminated only by sacrifice of picture linearity. In such cases, the difficulty is usually the result of improper design in the deflection or picture-centering circuits and can be corrected only by a design change.

Picture-Centering Considerations

Since neck shadow is directly associated with improper picture-centering, it is desirable to review briefly the picture-centering mechanisms employed in magnetic-deflection kinescopes.

Fig. 1 shows a section through the neck and funnel of a magnetic-deflection, magnetic-focus kinescope, including the external deflecting and beam-controlling components normally used. If the yoke, focusing magnet, and ion-trap magnet are correctly positioned on the kinescope neck*, and if no extraneous fields are present, the beam emerges from the gun at the center of aperture J coincident with the kinescope axis A-B. In the absence of scanning, the beam continues along the tube axis and strikes the center of the viewing screen.

With linear scanning, the raster will be symmetrical and will also be centered in the kinescope screen. The picture, however, *will not be centered* because unequal areas at the edges of the raster will be darkened by the blanking components of the video signal. Consequently, in order to obtain a full-size centered picture it is necessary to overscan the screen and to decenter the raster. Under ideal conditions, the amount of overscanning required is 17.5 per cent horizontally and 7.5 per cent

* See appendix on page 6.

vertically. Under practical conditions, however, somewhat greater ranges are usually necessary to permit compensation for deviations in raster position or picture phasing caused by normal differences in tubes, components, and circuit voltages.

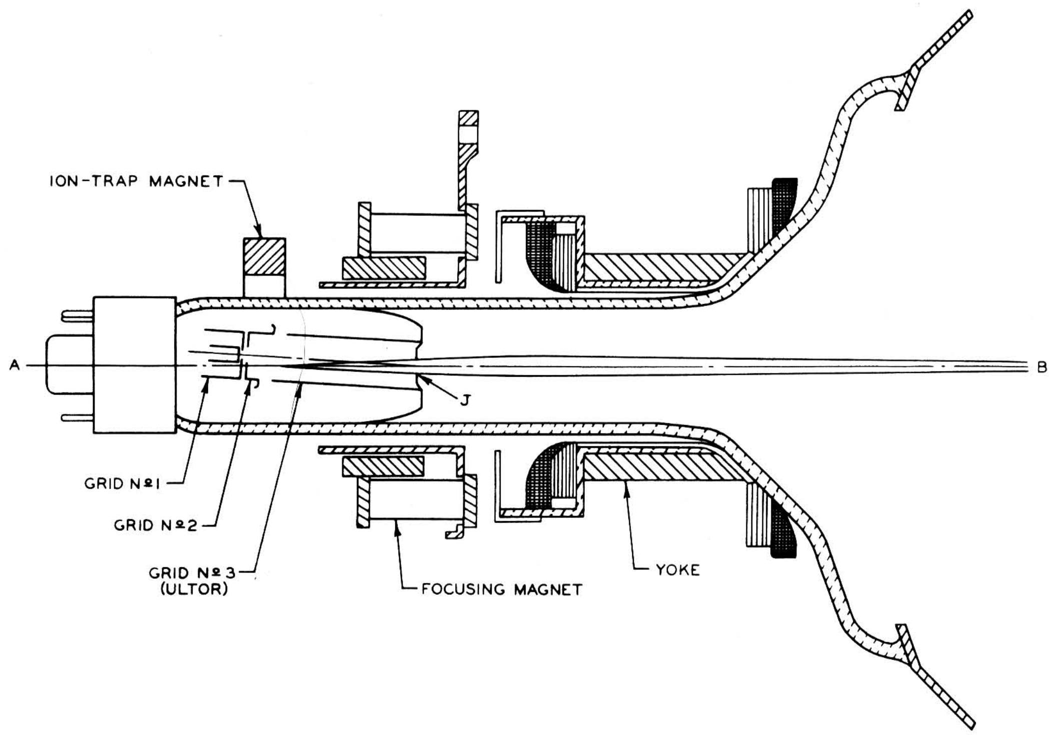

Fig. 1 - Section through neck and funnel of magnetic-deflection, magnetic-focus kinescope showing normal positions of external components and ideal path of undeflected beam.

In order to maintain good deflection symmetry, picture centering (raster decentering) should be accomplished after scanning, and preferably at a point as close as possible to the screen. It is impractical, however, to install a centering device between the yoke and the screen. Consequently, centering is usually accomplished either by the use of dc bias currents in the yoke windings (electrical centering), or by the use of adjustable permanent magnets between the focusing field and the yoke.

Electrical centering permits very precise picture positioning, and can easily be given sufficient range to compensate for large deviations in raster position. This method, however, requires the use of additional circuit components and controls. It also increases the dissipation requirements of the yoke as well as the power consumption of the equipment. Consequently, it has largely been supplanted in home television receiver design by non-electrical centering devices. These devices may be adjustable pole pieces or shunts for the focusing magnets, or mounting arrangements which permit tilting of the focusing magnet with respect to the kinescope axis. For electrostatic-focus kinescopes, they are usually small adjustable magnets installed on the kinescope neck. Under normal conditions these devices make it possible to obtain a full-size picture free from shadow centered in the viewing screen.

Specific Difficulties

When neck shadow cannot be eliminated with the aid of the centering devices described above or of the other adjustments provided in the equipment, the following possibilities should be considered.

(1) *Improper yoke for the kinescope type used.* If the yoke selected is longer than the one recommended by the kinescope manufacturer, the radius of curvature of deflection will be greater than the optimum, and the beam may strike the neck before reaching the corners of the screen, as shown at X in Fig. 2.

A yoke having an improper funnel contour may also make it difficult or even impossible to obtain a full-sized, centered picture free from neck shadow, since such a yoke cannot be properly seated on the kinescope neck. The yoke contour must exactly match the funnel contour of the particular kinescope for which it is designed and care must be exercised in handling and positioning the yoke to assure that its contour is not distorted.

(2) *Improper mechanical arrangements for positioning the yoke on the kinescope neck.* Yoke positioning arrangements should permit the yoke to be seated firmly against the kinescope neck funnel, and to be rotated

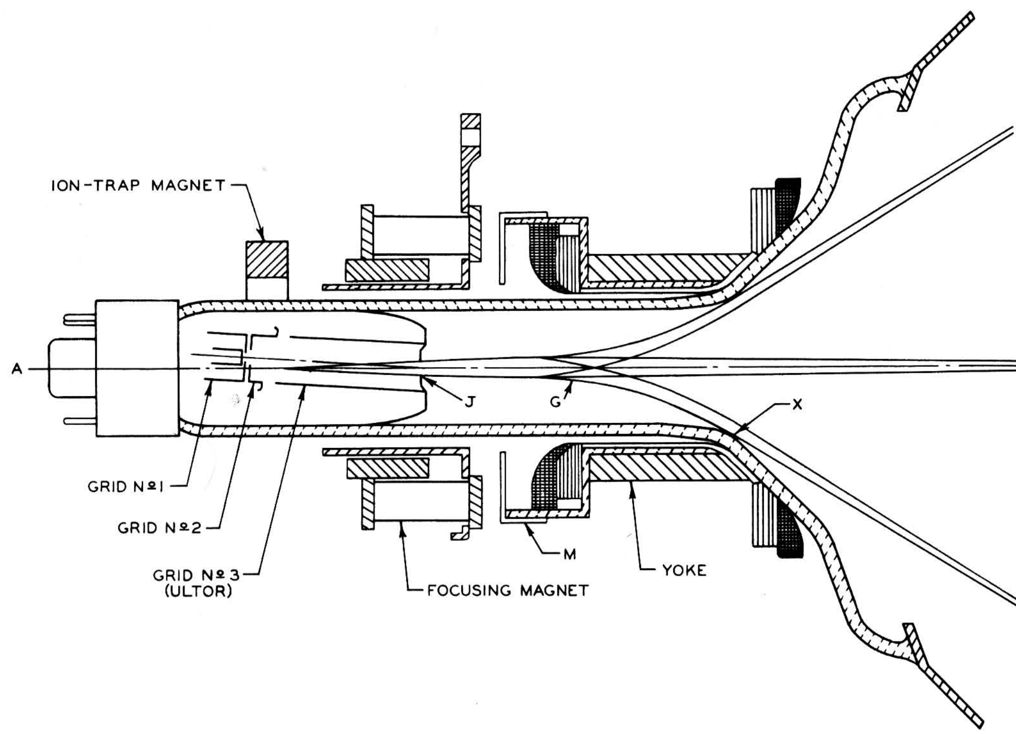

Fig. 2 - Section through kinescope neck and funnel showing beam striking neck because of excessive yoke length.

about its axis approximately 15 degrees in either direction when in this seated position. These arrangements must also be so designed that positioning operations will not result in deformation of the yoke contour or in excessive pressure on any part of the kinescope.

(3) *Improper mechanical arrangements for positioning the focusing magnet with respect to the yoke.* The proper position for the focusing magnet with respect to the yoke depends on the particular beam characteristic desired. To minimize the likelihood of neck shadow, the focusing magnet should be as close as possible to the yoke windings. However, contact or very close proximity between the focusing magnet and the yoke winding should be avoided, because the resulting interaction between focusing and scanning fields may distort the beam; furthermore, the metal of the focusing magnet changes the yoke loading and affects the amplitude and linearity of the scanning waveform. In most cases, such contact is prevented by the non-metallic covers used to protect neutralizing and damping components wired across yoke terminals. In general, the mounting arrangement should permit positioning of the focusing magnet at any distance from 1/8 inch to 3/4 inch behind the yoke cover, the minimum distance representing the optimum position from the neck-shadow standpoint.

(4) *The use of an ion-trap magnet of improper strength for the conditions under which the kinescope is operated.* The point in the gun aperture J (Fig. 1) at which the beam emerges and the direction of the beam at this point are determined by the design of the internal ion-trap lens, the ultor voltage, and the effective strength of the external ion-trap magnet in the lens area. The proper position for the ion-trap magnet has already been discussed. The field strength B required for this magnet is determined by the ultor voltage, E_u, and is given by the expression $B = 33\sqrt{E_u/16}$, where B is in gausses and E_u is in kilovolts.

The specific ion-trap magnet strength recommended in technical data for an RCA kinescope is based on the highest ultor voltage permissible within the tube ratings. Consequently, the use of an ultor voltage lower than the maximum must be accompanied by a corresponding reduction in effective ion-trap magnet strength to minimize beam decentering and attendant neck-shadow difficulties.

In some cases where the ultor voltage employed is smaller than the maximum, the required reduction in the effective strength of the ion-trap magnet can be achieved by moving the magnet from its proper position to one nearer the tube base. Although a certain amount of latitude in positioning is generally permissible, consideration must be given to the fact that a relatively small change in ion-trap magnet position may result in damaging bombardment of the aperture edges as well as in a large change in raster position. Consequently, it is extremely important to select an ion-trap magnet having the proper strength.

(5) *Extraneous Magnetic Fields.* The presence of even moderately strong extraneous fields in the vicinity of a kinescope can cause serious neck-shadow difficulties. Consequently, considerable care should be used in the selection and placement of such components as transformers and loudspeakers to minimize the decentering effects of their external fields. Test equipment near the kinescope may also contribute magnetic fields causing neck shadow. For the same reason, it is usually necessary that metal parts (particularly those in the vicinity of the yoke) not be magnetized. Controlled magnetization of the yoke frame may be used to correct beam deviations caused by other factors such as scanning nonlinearity.

(6) *Ultor-supply regulation.* Changes in brightness which occur normally in the transmitted picture vary the load on the ultor supply

and cause variations in ultor voltage. The resulting variations in ultor voltage affect the position of the beam and, if excessive, may cause intermittent neck-shadow. Consequently, the regulation of the ultor supply must be good enough to assure that the ultor voltage does not vary appreciably over the normal brightness range.

(7) *Scanning Nonlinearity.* Any nonlinearity in scanning causes an apparent decentering of the raster and therefore may be responsible for neck-shadow when an attempt is made to center the picture. If the nonlinearity causes a substantial difference in raster dimensions on opposite sides of the zero-deflection point, it may be necessary to shift the beam so far off axis for picture centering that neck shadow cannot be avoided. The linearity of the scanning system must therefore be taken into consideration in the design of the picture-positioning mechanism.

In some cases apparent decentering due to scanning nonlinearity can be compensated by the use of a yoke frame permanently magnetized in the direction and to the degree necessary.

Improper phasing between the scanning waveform and blanking pulses may also contribute to neck-shadow problems by offsetting the picture excessively in the raster. Since modern deflection systems seldom include phasing adjustments, it is important that proper phasing characteristics be incorporated in the design.

(8) *Normal variations in individual kinescopes.* The principal kinescope factors affecting beam position are the angles formed by the internal ion trap and the tilt of the gun assembly with respect to the tube axis. Because manufacturing standards permit some variation in these angles, deviations in initial position can normally be expected in individual tubes. In order to avoid neck-shadow difficulties, the range of these deviations must be considered in the design of the positioning mechanism.

Appendix

Positioning procedures for yokes, focusing magnets, and ion-trap magnets, and picture-centering procedures are described in RCA Application Note AN-153--"Adjustment Procedure for Ion-Trap Magnets." In the case of either a magnetic-focus or electrostatic-focus kinescope, the yoke is positioned as far forward as possible on the kinescope neck and seated firmly against the neck funnel. The minimum separation of 1/2 inch between focusing magnet and yoke specified in AN-153 was based on optimum focus considerations. However, smaller spacing may provide better inherent beam centering and is permissible. To minimize the possibility of neck shadow in magnetic-focus tubes, it is desirable that the field of the focusing magnet be symmetrical with respect to the tube axis, and that picture centering be accomplished either in the yoke or by the use of auxiliary magnets, rather than by tilting the focusing magnet itself.