LB-837

TESTS OF MEANS FOR REDUCING VISIBILITY OF LINE STRUCTURE ON TELEVISION RECEIVERS

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Approved

Stuart Wm Seeley

Tests of Means for Reducing Visibility of Line Structure on Television Receivers

Introduction

This bulletin describes some tests made with the object of reducing the visibility of the line structure especially noticeable on large-screen television receivers.

If the vertical interlace on a television receiver is made accurate and steady the visibility of the scanning line structure for still pictures may be quite low and unobjectionable. However, when there is vertical motion in the picture the viewer tends to see the picture as though it were made up of paired lines, that is, as though it contained only half the normal number of lines.

By applying to the spot a fairly critical amount of vertical deflection or wobble at a frequency several times the highest video frequency the visibility of the coarse line structure may be considerably reduced whether due to motion in the picture, or poor vertical interlace. There is some loss of contrast on vertical detail, but nearly all observers liked the effect on the picture texture. Harmonics of the spot-wobble frequency are a serious source of RF interference. Spot-wobble will not be practical unless a simple solution to this problem is found.

Alternatively, the shape of the spot can be distorted into an ellipse by altering the field of the magnetic focus coil with additional magnets, or magnetic shunts. This approach does not appear to be as satisfactory as spot wobble because, while it is not difficult to make the spot sufficiently elliptical to reduce the visibility of the line structure, the vertical resolution is somewhat worse than with spot wobble, and the shape and orientation of the spot changes with deflection. If a kinescope were developed to have the appropriately-shaped spot, however, results similar to that obtained by spot wobbling should be possible.

Vertical Interlace in Present-Day Receivers

The majority of television receivers now being produced have a kinescope 14 inches or larger in diameter and upon all or most of the face of this kinescope the spot can be focused sharply enough to show well-defined scanning lines.

If there is pairing of the scanning lines each pair will be separated from the next pair by a distance greater than that which normally separates adjacent scanning lines and the result is coarse, high contrast line structure quite noticeable to a viewer near the screen. If the scanning lines are on the average properly interlaced but are fluctuating, due to noise or power-line disturbances for example, the interlace may still appear poor since the

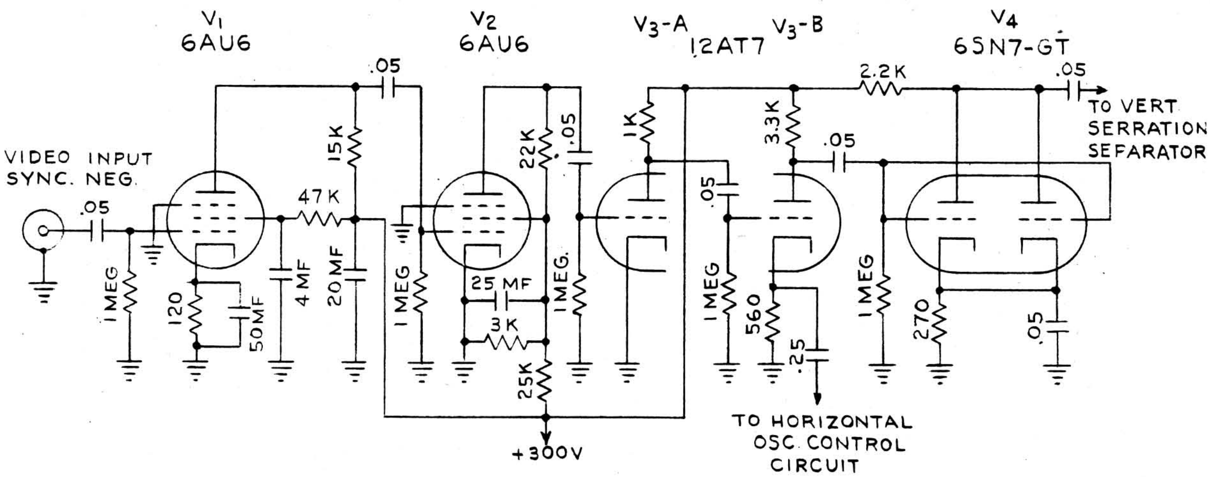

Fig. 1 – Schematic of sync separator.

eye seems to be able to detect pairing when there is only a very small fraction of a line width of inaccuracy in the vertical interlace. Good vertical interlace must therefore be very steady and very accurate.

In some commercial television receivers good interlace can be obtained only by a careful adjustment of the vertical hold control, and this adjustment must often be repeated for each station and occasionally for the same station after a period of time has elapsed. In the presence of noise the interlacing is often unsteady, resulting in a noticeable interline jitter effect. Because of these difficulties it is likely that the many viewers are not accustomed to watching well-interlaced pictures on their television receivers, and that in itself is part of the basis for the sometimes-heard complaint about the objectionable visibility of the scanning lines.

Setup for Providing Good Vertical Interlace

Most of the tests described in this bulletin were performed on an experimental 19-inch television receiver, on signals received from New York and Philadelphia. The set focused well over most of the screen. Shielding some of the leads in the vertical sync circuit resulted in some improvement in interlace, but the setting of the vertical hold control for interlace was critical and the stability of interlace in the presence of noise was poor as indicated by considerable jitter in the scanning and retrace lines.

The first experimental setup for improving the vertical interlace used a vertical a-f-c circuit. This was not completely satisfactory because in the presence of noise the phase of the vertical deflection would waver just enough to make the interlace unsteady. Furthermore, the long time-constant circuits required to improve the noise immunity reduced the pull-in range and speed of the vertical hold to the point where the setting of the vertical hold control became critical.

The next setup was more elaborate and is considered as a laboratory setup only. It consisted of (1) external sync separator circuits to provide a large, clean sync signal, (2) a circuit to separate the vertical serrations from the rest of the sync signals* (3) a circuit to provide a single pulse output occurring at the time of the first vertical serration, and (4) an adjustable means for applying this pulse to the blocking oscillator. In addition, pickup of the horizontal deflection pulse was reduced somewhat by not using the other half of the blocking oscillator double triode as a horizontal sync amplifier as is frequently done in receivers. The circuit of the sync separator used is shown in Fig. 1, and of the remainder of the circuit in Fig. 2.

With this setup and receiver the interlace timing was very steady and with the proper setting of the adjustable capacitor C_c, the

*Robert C. Moses, "Improved Vertical Synchronizing System" Vol. 24, No. 1, *Electronics*, January, 1951.

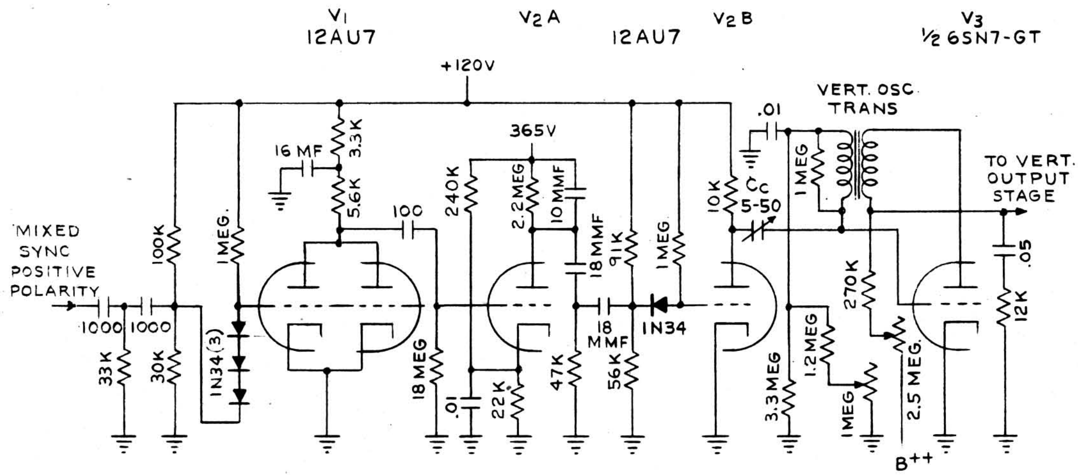

Fig. 2 – Schematic of vertical serration separator and oscillator.

interlace was very accurate and was nearly the same for all stations. The vertical hold control still affected the interlace position somewhat and was useful as a vernier interlace control.

It should be pointed out that good interlacing was both a problem of obtaining accurate timing and of obtaining exactly the same amount of return deflection after consecutive vertical scans. Whether or not the timing is accurate and steady can be checked by observing the horizontal scanning lines during vertical retrace. If the timing is right and the normal scanning lines are still paired uniformly from the top to bottom of the picture a 30-cycle modulation of the vertical deflection pulse is to be suspected. The amount of this component required to cause pairing is so small, in the order of less than one part in a thousand, that it is quite difficult to observe on an oscilloscope, but it has been observed to be, in this particular setup at least, a width modulation of the pulse portion of the blocking oscillator output wave. The frequency of this undesired modulation is one-half the vertical deflection frequency and the source of the modulation is pickup from horizontal scanning circuits. Due to the half integer relationship between the vertical and horizontal scanning frequencies the horizontal flyback is in phase with the beginning of alternate vertical fly-backs.

Line-Crawl Effects

With good vertical interlace the dark lines become thinner and double in number compared to a pairing condition and thus become much less noticeable to, say, a camera photographing the kinescope image or to a person looking at a fixed point on the face of the kinescope. If, however, the viewer looks at a point on the face of the screen which is moving up or down at the rate of approximately one-eighth of the screen height per second the scanning lines will appear to be following along at the same rate and will appear to be separated by twice the normal line spacing, even though the vertical interlace is good. Thus in scenes with slow vertical motion the effective number of lines in the picture is half the standard number of lines. This is basically an interline flicker effect and depends upon the same factors as interline flicker. It is more pronounced where the spot is bright, where the focus is sharp so that there is high contrast between the bright portion of the lines and the dark strips between lines, and where the viewing angle between lines is relatively large such as in large kinescopes. Although the effect of varying frame frequency was not checked it is probable that lowering it would result in more pronounced line crawl.

Means for Reducing Line-Crawl Effects

Defocusing a Round Spot

If the spot is merely defocused so that the adjacent scanning lines of the same field begin to overlap, the line crawling effect may be reduced to an extent depending upon the amount of defocusing. However, both vertical and horizontal resolution suffer and the resultant picture appears too soft and devoid of detail.

Elliptical Spot

If the spot is elongated in the vertical direction but remains sharp in its horizontal dimension the line crawling effect may be overcome without loss of horizontal resolution, but with some loss of vertical resolution, the amount of loss depending upon the shape and brightness distribution of the spot.

One way of accomplishing this result is to alter the magnetic field in the vicinity of the focus coil on magnetically focused kinescopes to produce an elliptical spot. A pair of alnico magnets disposed on opposite sides of the neck of the kinescope, with the forward poles of like polarity, produce a field which will make the spot elliptical. These may be located on the deflection coil side of the normal focusing magnet. Refocusing is necessary and when it is done there will be two positions of relatively sharply focused elliptical spots, the major axis of the spot being about 90 degrees different between the two settings. A pair of thin shims of magnetic material can be used for the same purpose, and can be slipped under the focus coil on opposite sides of kinescope neck. The amount and direction of distortion can be changed by the amount the shims are inserted and by their rotation around the axis of the tube.

This was done on the 19-inch receiver and the spot refocused to be elliptical with the long axis vertical, the amount of elongation being sufficient to make the spot somewhat over twice as high as it was wide. By using a picture signal consisting of a number of small dots distributed over the raster it could be seen that the spot shape, focus, and orientation changed with angle of deflection, so that only in approximately the center one-third of the screen area were the spots sharply focused and vertically oriented. The WNBT test pattern was viewed in this condition. The horizontal resolution was approximately the same as with a normal round spot, but the contrast was very poor for points on the resolution wedge corresponding to more than about 200 lines of vertical resolution. This point corresponds to the second dot from the center on the right-hand wedge in the test pattern. When the amount of spot elongation was reduced the line structure again became visible when there was vertical motion in the picture content. Therefore, it appears that spot elongation by simply stretching the spot in one direction is not entirely satisfactory because of some deterioration of vertical resolution, and with magnetically-focused kinescopes of wide deflection angle because of the variation of focus with deflection angle. Tests have not been made on electrostatically-focused kinescopes, which may be better in this latter respect.

Spot Wobble

Spot wobble - a small amount of high-frequency deflection of the spot - has been proposed in England to reduce line crawl.* If the frequency of the spot wobble is sufficiently high, say 20 Mc, the upward and downward traces due to the spot wobble will be close together compared to the diameter of the spot, and the result will be in effect a broadening of the scanning line and a change in the light distribution across the line in a vertical direction.

If the spot-wobble waveform were rectangular the effect would be essentially that of a double scanning line. By making the peak-to-peak amount of spot wobble equal to the spacing between interlaced scanning lines each field would not only have twice the normal number of lines but the position of the lines would coincide from one field to the next thus making each scanning line in the picture appear at a 60-cycle rate. The result would be the elimination of interline flicker and line crawl except on horizontal edges. From another viewpoint, it can be seen that the 262½ line component would be minimized in the vertical brightness distribution of each field.

If the waveform of the spot wobble were sinusoidal there would still be somewhat the appearance of a double scanning line since the spot would be near the extremes of its excursion more of the time than near its center. It has been shown**, that if the peak-to-peak sine wave wobble is 0.7655 of the spacing between lines in a single field (1.531 times the interlaced line spacing) the 262½ line component is mini-

*Hallows, R. W. "Television Spot Wobble" *Wireless World*, Vol. LVI, No. 3, pp. 84-86, March, 1950.
Nuttall, T. C. "More About Spot Wobble", *Wireless World*, Vol. LVI, No. 5, pp. 189-191, May, 1950.

**Nuttall, loc. cit.

mized. Sinusoidal spot wobble was applied to the 19-inch receiver and the amount experimentally adjusted to produce minimum line structure on a completely paired raster, thus minimizing the $262\frac{1}{2}$ line component. Observation of the effect of this amount of spot wobble on the previously mentioned dot field indicated that each dot appeared to be slightly greater than one line in height after spot wobble.

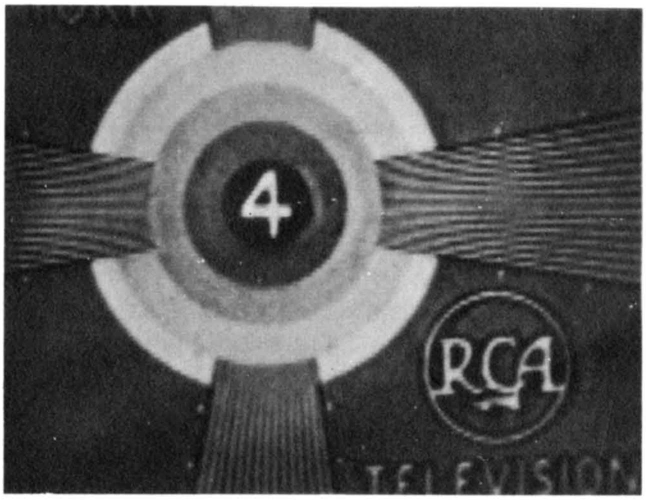

Fig. 3 - Photograph of paired scanning lines with spot wobble.

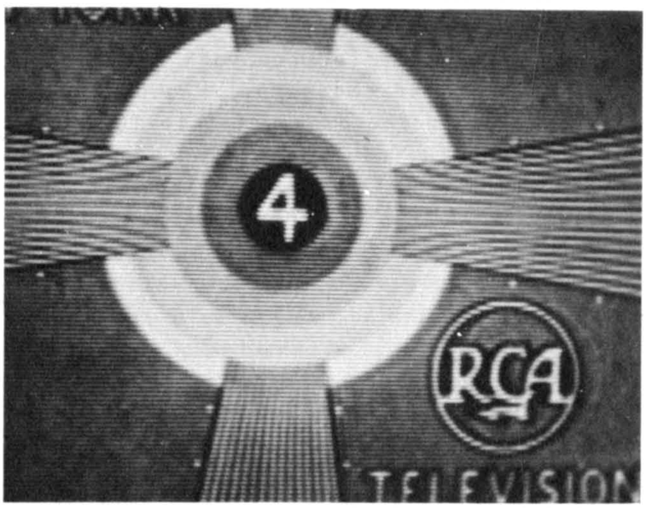

Fig. 4 - Photograph of paired scanning lines without spot wobble.

When there is vertical motion of the point of vision while watching a spot-wobbled picture there is an effect somewhat similar to that shown in Fig. 3, which is a photograph of the results of spot wobbling when the scanning lines have purposely been made to pair. Fig. 4 shows the paired condition without spot wobble. From the last two photographs it can be seen that there is a reduction in the visibility of the lines with spot wobble, but that the moiré pattern and stair-step edge effect of pairing remain.

Fig. 5 is a close-up of the center of the WNBT test pattern when the 19-inch receiver is well interlaced but not spot wobbled, while Fig. 6 shows the same portion with spot wobble applied.

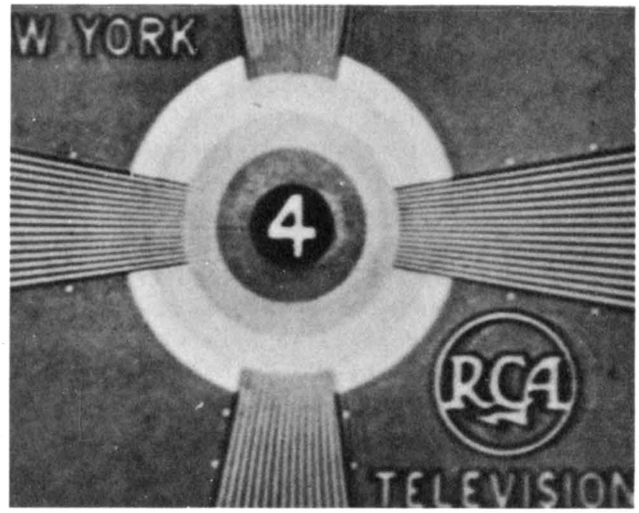

Fig. 5 - Photograph of test pattern, interlaced, without spot wobble.

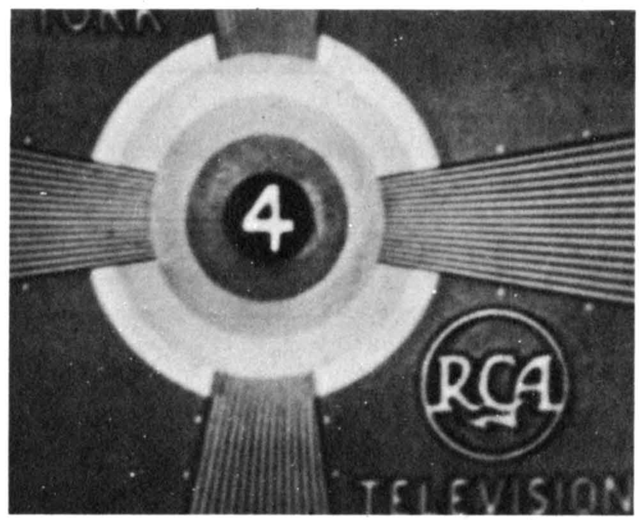

Fig. 6 - Photograph of test pattern, interlaced, with spot wobble.

The loss of vertical contrast can be estimated from the appearance of the wedges in the test patterns. These photographs, however, do not indicate the effectiveness of the spot wobble in the reduction of line crawl, since the latter effect appears only when the eye is in motion.

Observers who have seen the interlaced 19-inch picture with spot wobble applied agreed that line structure and crawl had been almost eliminated resulting in a picture texture somewhat resembling that of a considerably enlarged photograph. Even when the picture was magnified approximately 2 times by a large liquid-filled lens making the equivalent of a 30+ inch diameter tube the picture was pleasing from a relatively short viewing distance.

Shaped Spot Kinescopes

The effect of spot wobble as used to overcome line crawl is that of minimizing the 262½ line component of brightness variation from top to bottom of the raster. By developing a kinescope with the proper type of spot the results obtained now with spot wobble should be available without any additional circuitry or tubes. For example, the square-wave spot-wobble condition could be duplicated by a kinescope which had two spots oriented vertically and spaced one interlaced-line spacing between centers. Sine-wave spot wobble could be approximated by a dumbbell-shaped spot. The spot shape should not change appreciably with deflection angle or brightness.

Other Spot-Wobble Considerations

While spot wobble has a pleasing effect on the picture it has the disadvantage of being not very easy to apply to a receiver without causing interference patterns in the picture on at least some channels. Furthermore, the amount of spot wobble is somewhat critical, as variations of ±10 per cent will cause the lines to begin to reappear.

Either electrostatic or magnetic deflection could be used for spot wobbling. Only magnetic deflection was used in the tests described in this bulletin because there was an internal coating in the available kinescopes which prevented electrostatic deflection from the outside. A separate deflection yoke consisting of a few turns of wire on each side of the kinescope neck was fitted in the small space between the focus coil and the conventional horizontal and vertical deflection yoke.

The choice of the frequency to use for spot wobble was determined by three factors. First, there is a minimum frequency which must be surpassed to keep the wobble-frequency modulation itself from being visible on the screen. On the 19-inch receiver this was found to be in the order of 10 Mc.

Secondly, the power required from the spot wobble oscillator increases with frequency, and decreases with Q according to the relation: *

$$P = K\frac{\omega}{Q}$$

where K includes such factors as the size and shape of the spot wobble yoke, the amount of wobble deflection, and the stiffness of the beam. The number of turns in the yoke does not affect the power required except insofar as the Q is affected. Q will in general increase with frequency to some extent and will also be influenced by the proximity of the deflection yoke, focus coil, or spot wobble shield.

Finally, the choice of frequency should be one which will reduce as much as possible the interference caused by the spot wobble oscillator and its harmonics. However, because of the wide portion of the spectrum covered by channels 2 to 13 it is not possible to select a frequency below 72 Mc which has no harmonic in the television band. To spot wobble magnetically at 72 Mc using a deflection yoke small enough to fit between the focus coil and normal yoke would require in the order of 5 to 10 watts of oscillator plate input power for a wide-angle large diameter kinescope. Also, with such power, interference at other than r.f. would be very likely. Therefore, it was decided to use a lower spot-wobble frequency chosen for least interference in the channel 2 to 6 range and to try to reduce the magnitude of the higher harmonics to a below-interfering level for the upper channels. The frequency finally chosen was about 17.95 Mc, whose 3rd, 4th and 5th harmonics are in or near the frequencies used by channels 2 to 6 but happen to fall in adjacent channel or co-channel i-f traps.

The first spot-wobble oscillator circuit used the spot-wobble deflection yoke as the tank circuit and was unshielded. The harmonic radiation from this circuit caused strong interference on both low and high channels.

In the next spot-wobble circuit a separate oscillator tank was provided, and everything

*Appendix

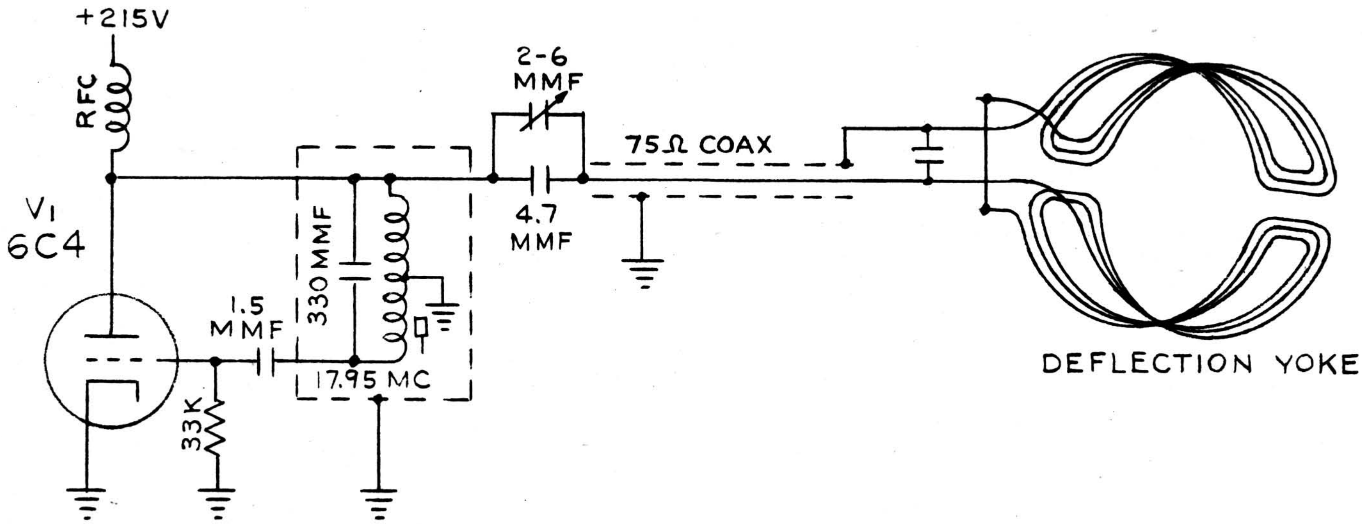

Fig. 7 - Circuit diagram of spot-wobble oscillator and deflection yoke.

was well shielded except the spot-wobble yoke itself, which was a high-Q resonant circuit loosely coupled to the oscillator tank to reduce the harmonic content. This circuit is shown in Fig. 7. By very carefully adjusting the oscillator frequency and the tuning of the yoke the interference could be reduced to being non-observable on any of the ten stations received in Princeton, N. J. This setup was used for the tests and required an oscillator plate input of about 2.8 watts on the 19-inch receiver. However, the shielding was still inadequate for a commercial application since it was necessary to readjust the tuning of the oscillator and tank circuit frequency to avoid interference in the picture.

No tests have yet been made applying spot wobble to the new electrostatically focused kinescopes but it is believed the problem would be somewhat easier due to the absence of the focus coil. With the additional length of kinescope neck available it should be possible to use a more efficiently shaped spot-wobble deflection yoke and thus be able to reduce the oscillator strength. In addition, the extra space would permit shielding of the spot wobble deflection yoke. Both of the above changes should reduce the harmonic radiation, and the resultant level may finally be acceptably low if the shielding is carefully done and the supply leads are well filtered.

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Appendix

Assume a spot-wobble yoke resonated with a lossless capacitor, and that the size and shape of the yoke remain fixed. Also assume that L, the inductance of the yoke is proportional to the square of the number of turns, i.e.,

$$L \alpha N^2$$

The power, P, supplied to the yoke is given by,

$$P = \frac{E^2}{Req}$$

where E is the r-m-s spot-wobble voltage and Req the equivalent resistance of the parallel resonant circuit.

Therefore $P = \frac{E^2}{Q \omega L}$

but $E = I \omega L$

substituting, $P = \frac{I^2 \omega L}{Q}$

but $L \alpha N^2$

therefore $P \alpha I^2 N^2 \frac{\omega}{Q}$

For a given kinescope, yoke, and amount of spot wobble, then

$$P = K \frac{\omega}{Q}$$