APERTURE SHAPES, DIAMONDS AND CAT'S EYES

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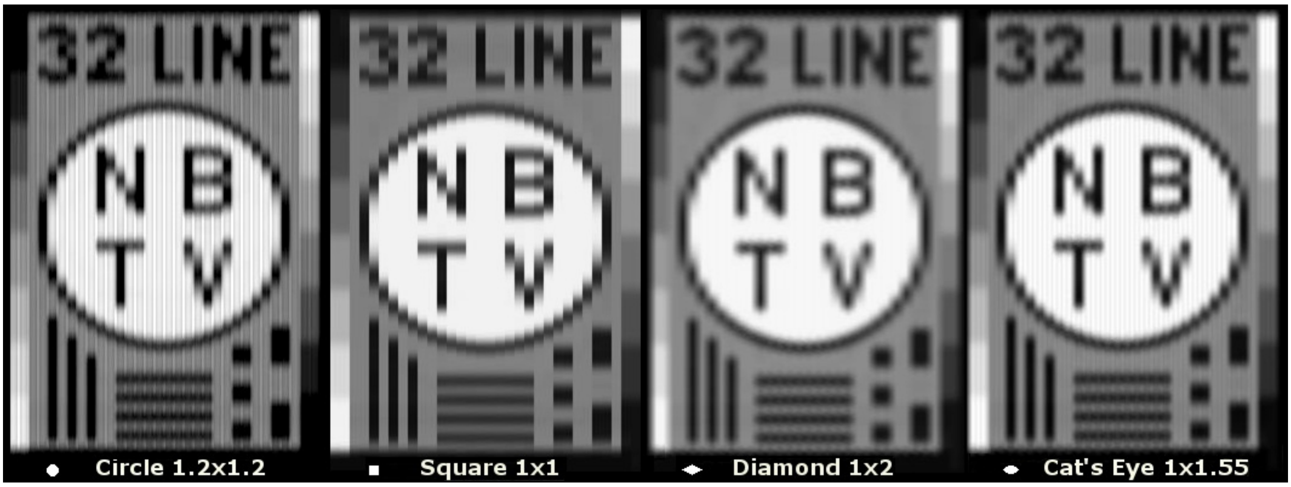
Long ago, in the beginning years of the NBTVA, the late A.O. Hopkins wrote an article in Newsletter Vol.6 No.3 under the title "TV without lines". He described in detail what happens when the aperture of a Nipkow disc scans and/or displays lines to reproduce a TV picture. He showed us how an aperture in the form of a diamond or in the form of a cat's eye eliminates the line structure which is always visible.

Nowadays computers allow us to simulate many things that would otherwise be very difficult and time consuming. Using such a simulation we can now show the effects of any conceivable aperture shape and size. Below you see the result of the well known Grant Dixon test pattern as displayed by a simple Nipkow disc monitor simulation with circular holes, square holes, diamond shaped holes and the cat's eyes. In all cases a width has been choosen to minimise the visibility of the lines. The diamond has a width of 2 lines and a height of 1. The surface of the different apertures is similar.



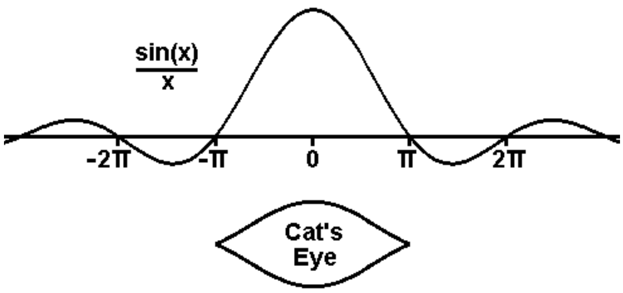
We are not jumping to conclusions: you'll need to do that for yourself. The pictures are clear enough, if needed use a magnifying glass. Observe the sharpness of horizontal and vertical lines, slanted lines, the large circle, the letters N, B and V and the digits 3 and 2.

The theory behind the cat's eye

Behind good solutions there is always a supporting theory. Although it is not clear that Mr. Hopkins didn't use it, it wasn't mentioned in the Newsletter articles.

Consider the system of scanning a picture in lines as a sampling action. In the horizontal direction (in a vertically scanned system) or in the vertical direction (in a horizontally scanned system) the variation in brightness is sampled at the positions of the lines. And when we hear the word "sampled" we know that Mr. Nyquist taught us how to reconstruct the original variations, without seeing that it ever has been sampled. The rule is: replace each sample by a wavelet "sin(x)/x", the zerocrossings at the previous and next samples (lines), and multiplied by the value of the sample. Then add all these wavelets and you have reconstructed the original continuous variation. This is what is done in a low pass reconstruction filter and if this is done in a digital way, in an oversampled FIR filter.

So the aperture in the disc should have the form of "sin(x)/x", also called "sinc". A practical problem is that the sinc-function has negative parts, the largests below -π (-180°) and above π (180°). However, we can't have negative light. Now the cat's eye aperture represents the sinc-function between -π and π . However, because the negative tails are missing we had to shrink the eye in width from 2 to 1.55 to minimise the visibility of the lines.



Interlace artifacts

When reading A.O. Hopkins' article we note that he was merely fulminating against the visibility of lines on the picture tubes of the British 405 line TV system. He must have seen the TV images made by the square apertures in the Baird system Nipkow discs, squares that were precisely aligned and showed no gaps nor overlaps between the individual lines. For the 405 line system he hoped that it might be possible to design cathode ray tubes that had a cat's eye shaped, or even better, a diamond shaped spot. However, the real problem was the interlace of the TV system, where the line width on the picture tube was balanced for frames of 405 lines, but where rasters of 202 lines were written. Of course this gave rise to a crude crawling line pattern, which can't be clouded by wider lines without spoiling the vertical definition.