 

# CRT Competitive Strategies Towards Flat Panel Displays

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### Abstract

CRTs can survive in the long run for TV applications, because of their realistic reproduction of live images. CRT technology development has to be directed towards form factor, but also attention has to be paid to the form design of sets. The CRT is the only technology allowing a doubly curved screen surface.


## 1. Introduction

LCD technology is making significant inroads into the desktop market. We want to see to what extend this will happen in the TV market and what CRT makers should do to limit this inroad. The reason for the inroad into the desktop market is based on the advantageous form factor of the LCD display and the excellent performance for displaying text-based images. For displaying TV images, other requirements play an important role. This paper will discuss some of these TV-specific requirements to determine the position of the CRT. Furthermore, proposals for improvement of the form factor of CRT based TV, and thus the CRTs themselves, will be given.

## 2. The TV Specific Image Requirements

The image requirements for TV pictures differ from the typical desktop PC images in the following aspects.

### 2.1 High ratio peak / average luminance.

In a text-editing application, the peak luminance is very close to the average luminance. For TV applications, however, this is different. An investigation within Philips in 1958 revealed for TV images a ratio that is much higher: typically a factor of 5. This investigation was repeated in 1990 with the advent of HDTV. It turned out that for studio quality images this ratio was even higher, between 10:1 and 7:1. Once the images are compressed for the purpose of transmission, the ratio is reduced to about 6:1, still a considerable ratio. This is important because, like all emissive displays, the CRT only requires power when luminance is required (apart from scanning).

The fact that the size of the spot of an electron beam grows with the beam current is not so much of a problem because the need for high luminance and high resolution requirements rarely occur simultaneously in real-life images. This is illustrated in the Joint probability distribution of fig. 1 [T. Doyle and T. Lammers of Philips Research, personal communication]. The Joint probability distribution indicates on how many lines a luminance jump with certain amplitude occurs, as a function of the luminance value of a pixel.

As an example, suppose we look at all pixels with a luminance value of 0.8 times the maximum value. Then the luminance jump towards the next pixel can be between +0.2 and –0.8 times the maximum value. These borders are indicated by the contour lines "1" in fig. 1. The number of lines, however, on which the luminance jumps down by more than –0.2 the maximum luminance

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is less than 78 (of the 1152 active video lines).

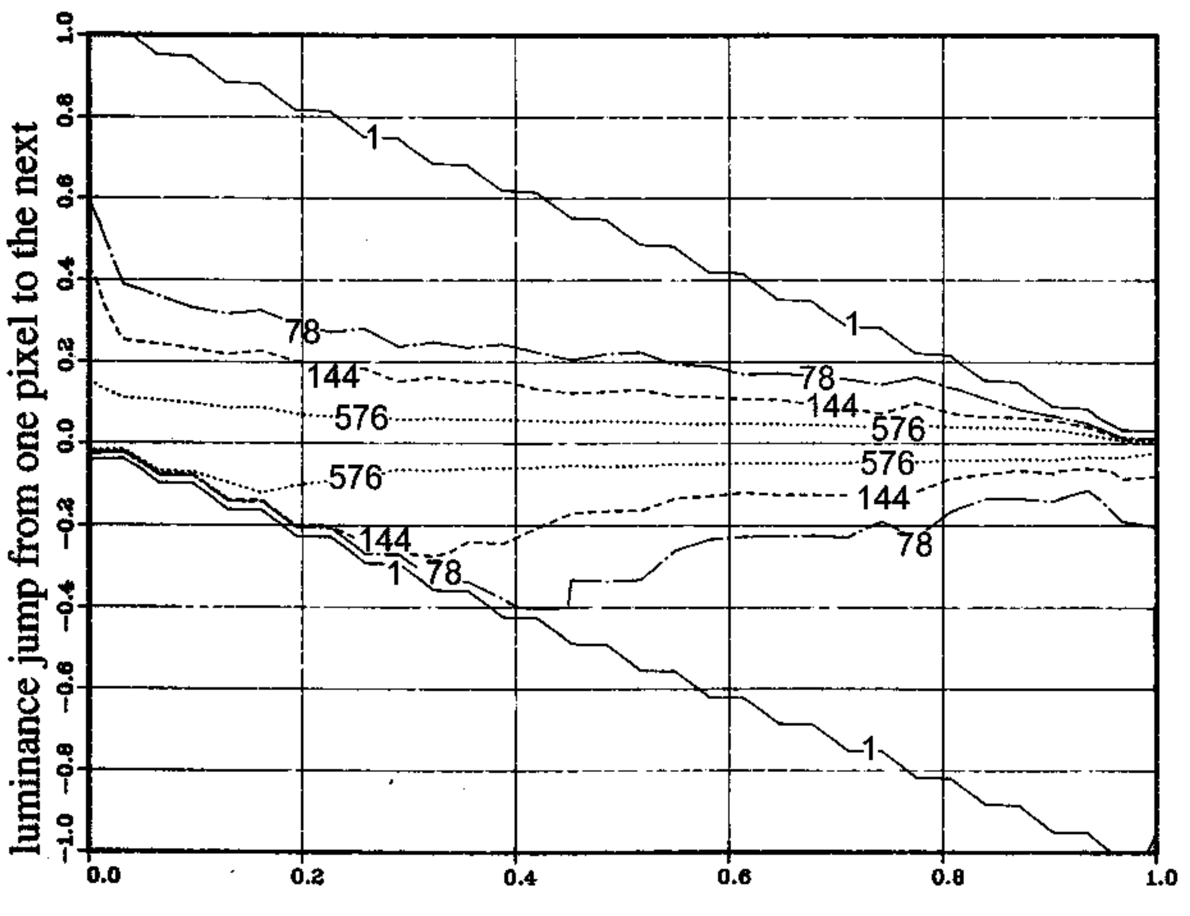


**Fig. 1.** The Joint probability distribution of an HDTV image. The number in the graph indicates on how many (of 1152) lines a luminance jump from one pixel to the next pixel occurs, with a certain value (vertical axis) from a given value (horizontal axis). Each line has 1440 active pixels.

Fig. 1 is the result of an evaluation of 17 real-life HDTV images. Specific test images are not included in fig. 1.

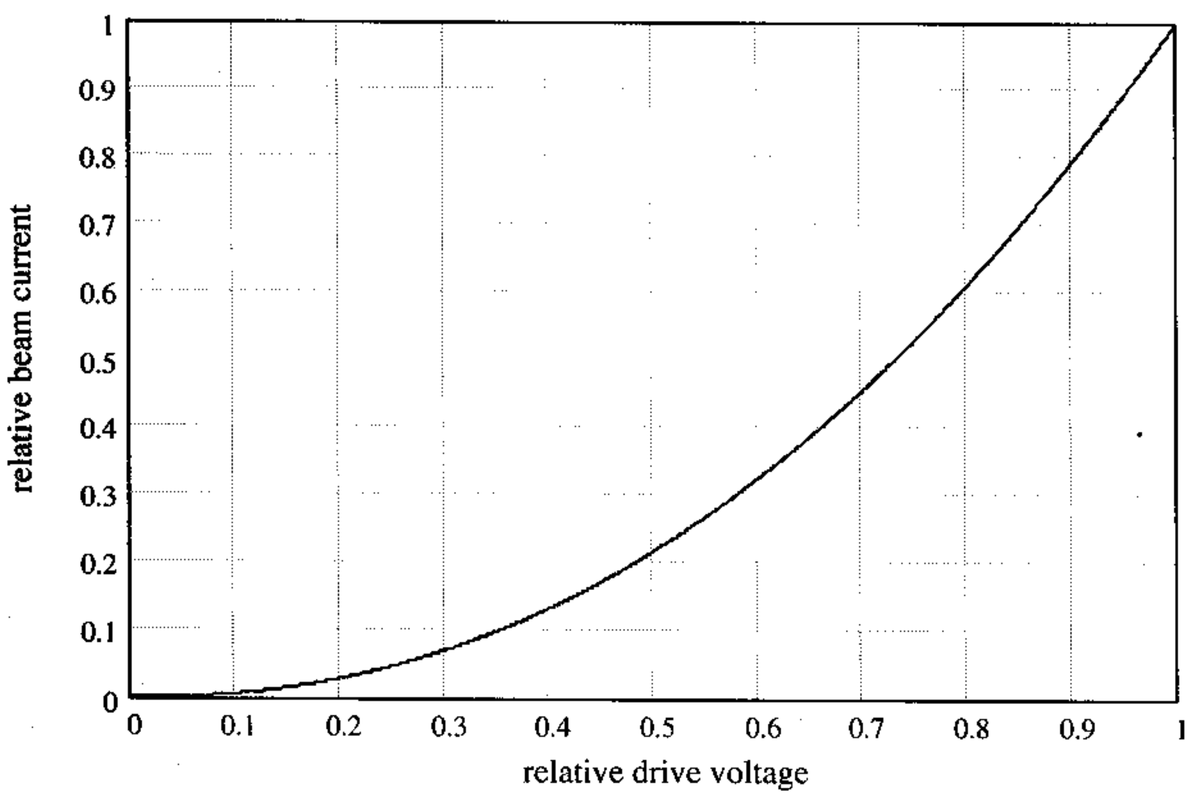


**Fig. 2.** The γ characteristic of a CRT gives for equidistant drive voltage levels, luminance levels that are dense at low luminance values and sparse at high luminance levels.

## 2.2 High number of grey levels

For good reproduction of grey levels it is important to understand that in human vision, grey level steps have to be small in dark areas but can be large in high brightness areas

In this respect, the so-called γ characteristic of the CRT helps. For equidistant drive voltage levels, the luminance levels are dense at low luminance levels and sparse at high luminance levels. For display types that do not have this characteristic, it has to be introduced per colour for each pixel. When the γ characteristic is not reproduced correctly, the displayed images may become very sensitive to noise of the video signal.

## 2.3 Motion representation

The representation of motion is determined by two factors:

1) the time needed to switch from one image to another.
2) the hold time of an image (the time that an image is maintained exactly as it is).

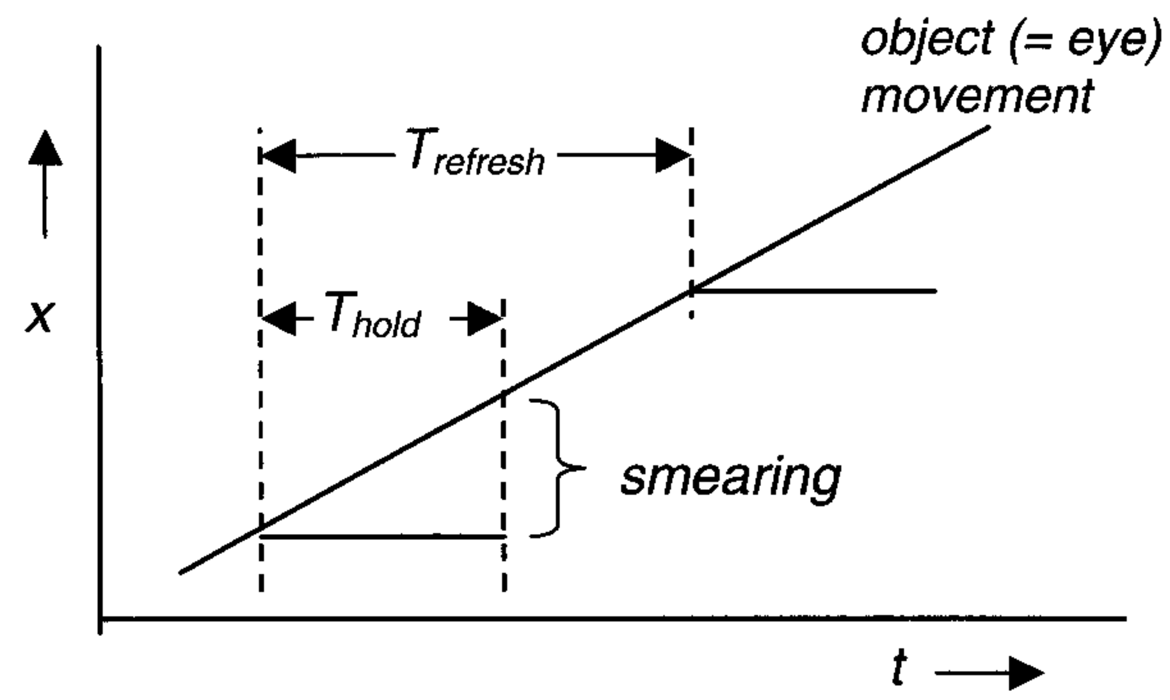


**Fig. 3.** The occurrence of smearing of a moving object as a function of speed and hold time.

The factor of image switching time is a subject requiring improvement effort of LCD panel suppliers, and at this point progress is being made. However, the latter effect will remain, even when a display has an infinitely short switching time [1]. The mechanism is as follows: when a sequence of images is supposed to represent motion, the eyes will follow the motion. However, if each individual image is maintained unchanged for a time, called the hold time, smearing of the image will occur on the retina of the eye. The amount of smearing, also called motion blur, is proportional to the hold time and the speed of the object on the screen. The mechanism is illustrated in fig. 3.

Numerically, the smearing or motion blur is given by

$$\text{smearing} = T_{hold}\, {}^{dx}\!/_{dt}, \qquad \text{Eq. 1}$$

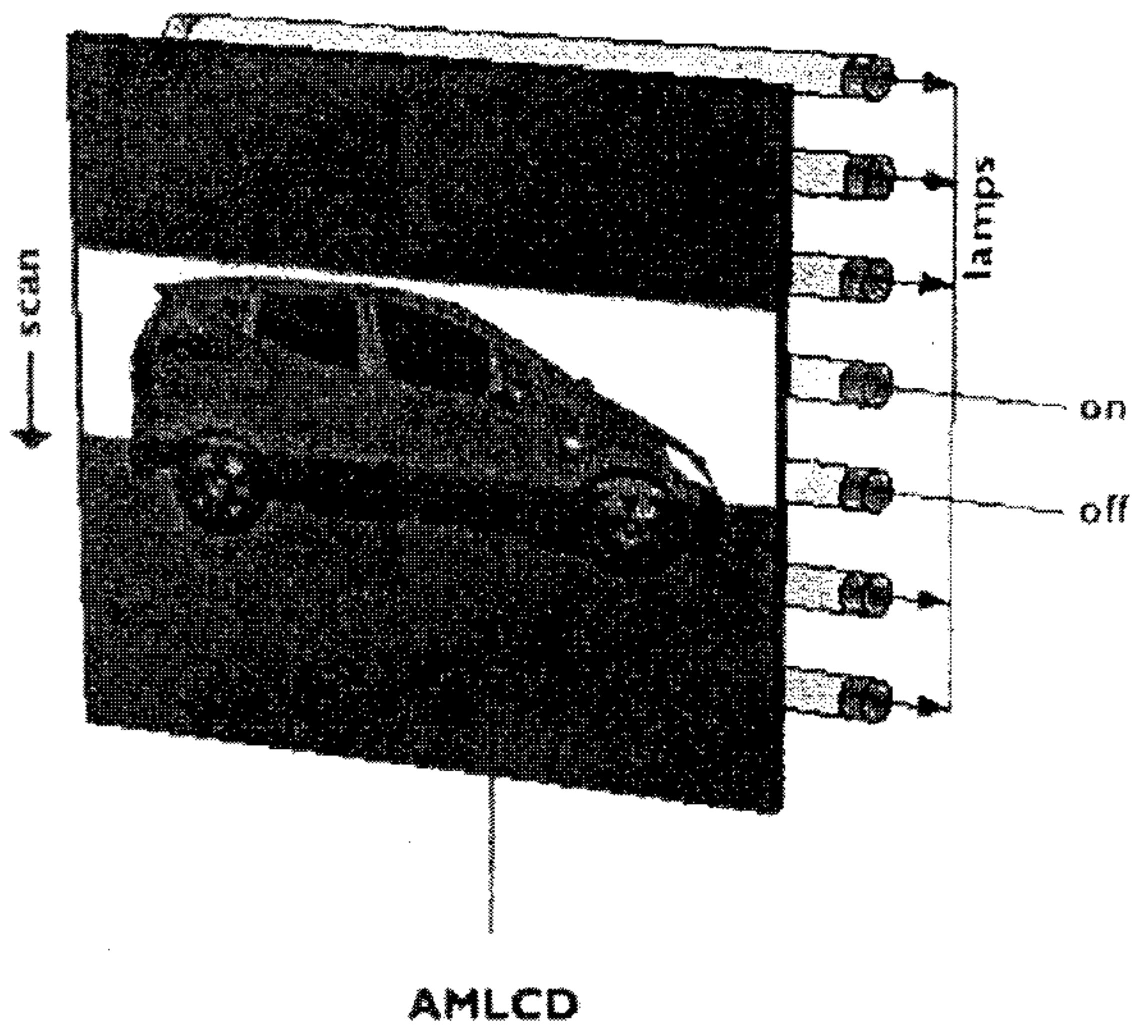


**Fig. 4.** The scrolling back-light principle [4] needed to get good motion representation in an LCD display.

where dx/dt is the speed of motion on the screen of an object. To give an example: a text is moving over a 66 cm wide screen from right to left in 2 seconds. The hold time is assumed to be equal to 1 frame time of a 60 Hz (interlaced) image: 17 ms. Then the smearing would be 5.6 mm!

This smearing is there regardless of the so-called "switching time". The only way to solve this issue in an LCD (and to avoid the introduction of unnecessary image flicker) is to apply a so-called scrolling back-light [2], as shown in fig. 4.

A point of worry for any backlight is the short-distance non-uniformity of the produced light, in particular when the backlight ages. Non-uniformity of the backlight is most clearly noticeable when displayed objects move over the screen, because the non-uniformities do not move with the object and can therefore no longer be regarded as belonging to the object.

So, from an image quality point of view, significant improvements in LCD technology will be needed before the picture quality of the CRT TV can be achieved. These innovations will add to the already significant cost difference between LCD and CRT displays for TV applications.

In this respect, for monitor applications in the home, where photo editing and gaming are allowed, the CRT monitor also has a chance as long as the potential customer is made aware of this.

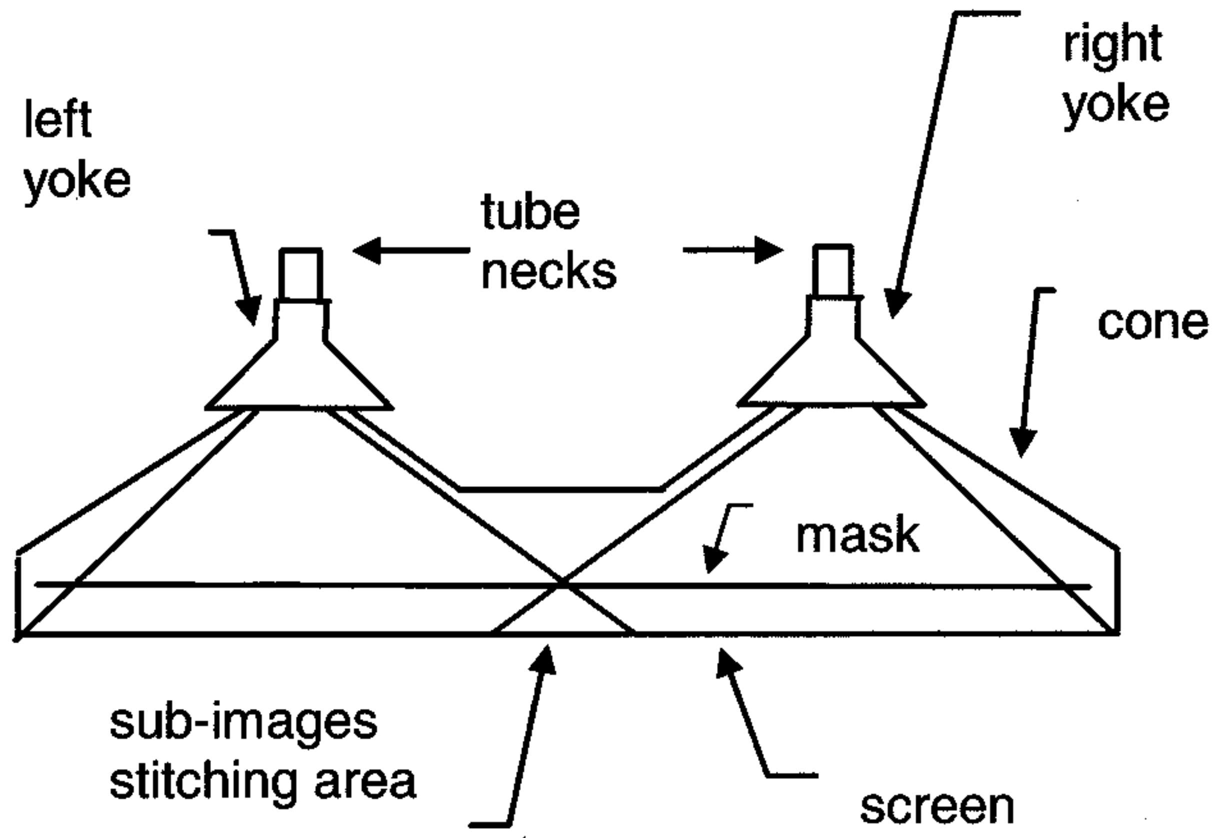


**Fig. 5.** Drawing of top view of a Camel CRT. The image is made up of two sub-images, thus saving display depth for a given display size and deflection angle.

**Fig. 6.** Image on a camel tube. Only at the bottom the cross-over from the left to the right sub image is (made) visible.

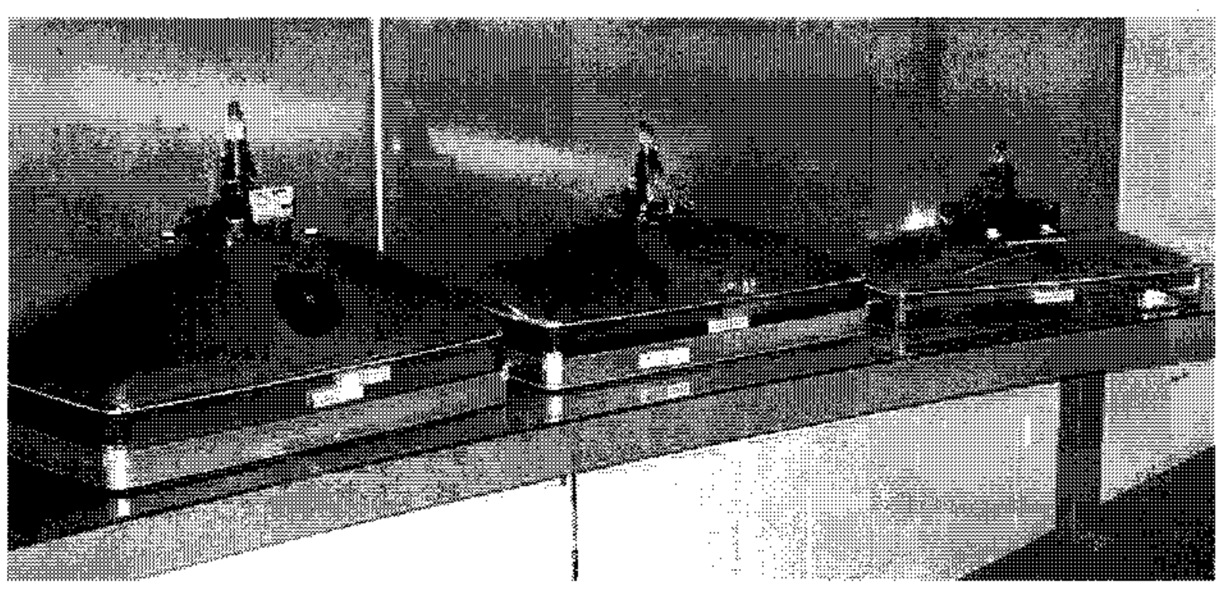

**Fig. 7.** three 32WSRF CRTs with deflection angles of 105, 120 and 135 degrees.

## 3. The Form Factor

Even though an LCD TV still does not achieve the picture quality of a CRT TV, the form factor might nevertheless be a reason to buy it. Although a CRT display can never be made as thin as an LCD, there are still a number of ways to improve the form factor of a CRT-based TV set. Notice that in practice, Flat TVs are often sold with a stand, in which one can house the VCR, DVD player etc. Such stands typically have a depth of 40 to 45 cm.

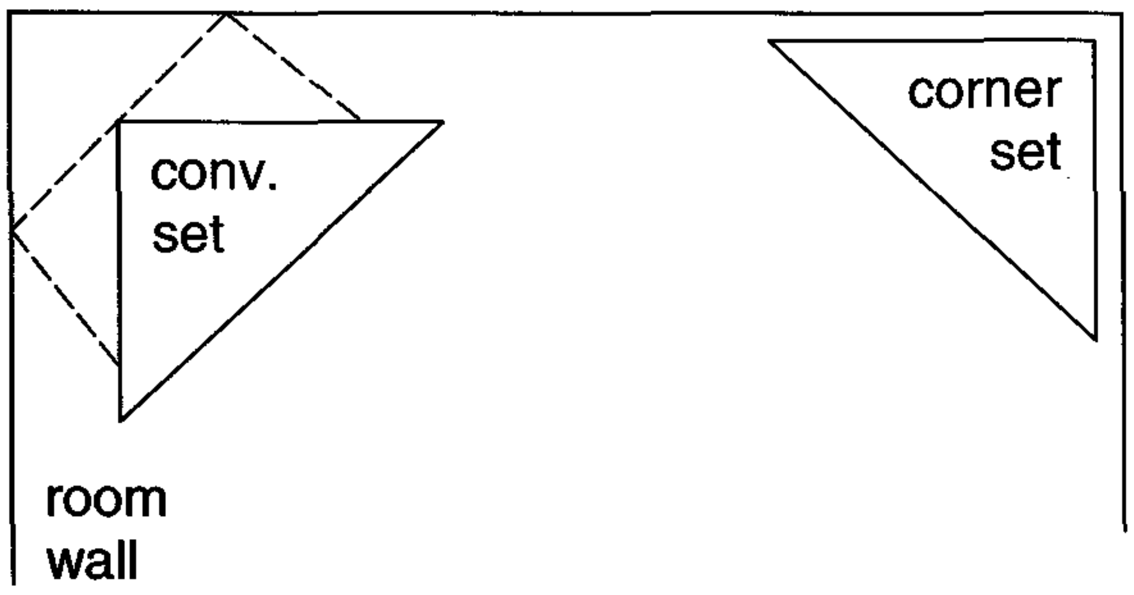


**Fig. 8.** By designing a set as a "corner set", the set can be pushed much further into the corner.

Four approaches for improving the form factor of CRT based TV sets will be given next.

### 3.1 The camel CRT

An interesting example is the development of so-called Camel CRTs, as reported by Philips [3] and the HDTV institute in Shanghai [4]. In a Camel CRT, an image is divided into two sub-images, which are then merged into one image. The top view of such a tube is shown in fig. 5. The challenge in such a design is to make a seamless fit of the two sub-images. Having achieved that, a Camel tube is an effective way of creating a large CRT with a limited depth

This has been shown to work, but at the cost of driving simplicity of the CRT, one of the CRT's strengths. Therefore, other approaches are needed that require less effort in their application.

### 3.2 Large deflection angle

Other options are to increase the deflection angle, thus maintaining the simplicity in signal processing of the normal CRT [5-7]. Unfortunately, driving the deflection system often introduces additional complexities, like north/south pincushion correction. So the challenge is to make a CRT with an enlarged deflection angle, in which the driving of deflection is as simple as it is in normal deflection angle CRTs. Increasing the deflection angle to 135 degrees will be the subject of another paper during this conference.

### 3.3 Corner set

Another approach to save space in the room of a TV viewer is to design a "corner set". Such a set design makes full use of the fact that a set is often placed in the corner of the room, as shown in fig. 8.

As an example, the reduction of the width of a set by 60 cm makes it possible to push the set 30 cm further into the corner of a room. This does not require a significant technological effort. A similar approach can even be used for computer monitors that can be made to fit optimally in the corner of a desk or in a cubical.

### 3.4 Screen curvature

As we know from cars and furniture, a lot of value can be added by giving products the right shape. At present, TV sets often resemble shoeboxes that display an image. We expect that in the near future set-makers will devote more attention to the shape of the TV set. An interesting option is to use CRTs with curved screens, after all the CRT is the only technology that can supply double curved screens. Difficulty in exploiting the form factor for CRT manufacturers is that they very much depend on set-makers, who also want to promote LCD or Plasma TV sets.

## 4. Conclusions

The CRT can maintain a dominant position in displaying TV images based on picture performance and cost. The CRT's bulkiness can be reduced to such an extend that even large displays will fit on stands comparable to those presently used for LCD and Plasma TV sets. Furthermore, the form factor of the TV can be exploited, by means of corner sets and or sets with curved screens. The latter cannot be followed by other display technologies.

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