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Beam Index Display

The Answer to Modern Helicopter Cockpit Design

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Abstract

The basic requirements for modern helicopter cockpits are not new, but are increasingly harder to fulfil.

Manufacturers of displays for helicopter or aircraft application have found a solution regarding the display of data on a monochrome display which is sufficiently bright enough and ruggedized to be read under all environmental conditions.

This solution had just been found when the high density of data which could be supplied to the crew by modern avionic systems required a colour presentation.

Because of availability penetration and shadow mask CRTs were selected. Of these types only the shadow mask CRT can give a full colour presentation with the well-known, inherent shortcomings in brightness and colour stability under vibration.

One possible solution to the shortcomings is the Beam Index CRT. But a complete new development was necessary to produce a CRT with full colour capability using a single gun and no shadow mask.

In addition the development of new electronic circuitry had to be coincident.

The development has now reached a stage at which it can be presented to the public.

The advantages that a Beam Index Display has over current avionic displays will be given during the lecture.

The superior performance over conventional displays under the adverse environmental conditions will be one of the focal points.

The principles and details of Beam Index Displays will be shown. The improved standard of key display parameters will be substantiated by test results.

Introduction

When engineers first thought about colour presentation on a CRT it was not a shadow mask CRT they tried to develop but a Beam Index CRT. However, they did not call it a Beam Index CRT at the time which was in the middle of the 1930-s.

The difficulties at that time were the very high regulating speed and accuracy which are necessary to achieve good colour saturation together with high linearity and good stability of the deflection system.

Therefore the invention of the shadow mask CRT was only a means of overcoming the technical problems the engineers could not solve at that time.

As an introduction a brief description of the shadow mask principle will serve to explain the colour information presentation.

In the high resolution CRTs used for aircraft application a phosphor dot arrangement exists on the rear side of the front glass (see Fig.1). The shadow mask which is mounted between the three guns and the front glass is geometrically arranged in such a way which guarantees that electrons from the "red" gun, which are destined to stimulate the red phosphor only hit the area with the red phosphor. The same obviously must apply to green and blue. Each colour, which can be mixed out of the three basic colours, is generated by variation of the electron beam, sent to each phosphor dot. The generation of the colour is actually done via the human eye in the brain.

The presented figure is misleading as not all the electrons leaving the gun hit the phosphor. As the beam has a diameter much larger than the diameter of the hole in the shadow mask. A loss of 70-80% of the electrons occurs.

Only the rest hits the phosphor and the energy from them can then be converted into light emission.

The high percentage hitting the mask heats it up and leads to temperature problems in the system.

But the questions someone may ask, may still be, why deviate from this proven system or why is the need for an alternative?

There are mainly two reasons why AEG is certain that the shadow mask CRT would not do the job in helicopter or fighter cockpits under the severe environmental conditions.

1. Required Luminance
2. Vibration Resistance

These two parameters are vital for a coloured display which can be read under all circumstances. The Luminance must be high enough so that the pilot can read it at all especially under high brightness conditions in an aircraft or helicopter cockpit. The vibration level can be extremely high. The relative movement of the 3 guns with respect to each other, the shadow mask and also the faceplate results in a deterioration in colour definition of information on the display which is unacceptable under all flight conditions.

The Beam Index Principle

The principle of a beam index display makes the shadow mask and two guns redundant. As only one gun system is necessary the basic CRT resembles a monochrome CRT.

By processes which are well known from normal television crts a phosphor structure is formed on the faceplate having a black matrix between two adjacent phosphor stripes (see Fig.2 and 3).

An aluminium layer covers the phosphor structure which as in normal crts serves as the anode.

Into this layer a comb structure is etched. When now an electron beam sweeps over the screen it passes over this structure and like a capacitor the individual elements of the comb structure are charged by electrons. The signal derived from this charging process can be decoupled from the EHT via a transformer and the resulting signal is fed into an amplifier and pulse shaper.

This signal forms the basis for the control of the whole display. It is used primarily for the following purposes.

1. to trigger the video amplifier
2. to synchronize and correct the speed and linearity of the deflection amplifier

Each point where the signal which resembles a sinusoidal waveform passes through zero can be taken as a new reference point for the beam and an internal counter can therefore determine for every point in time where the beam is.

This obviously means that for the time the beam is scanning over the screen a minimal beam current is necessary even in the case when no information is displayed on the screen.

In AEG-s design this current is less than 1 uA and

therefore no visible light output from the screen occurs even in a totally dark environment.

A second beam index principle should be mentioned briefly, although this method has not been adopted by AEG (see Fig.4).

With this system the faceplate is covered with additional stripes on top of the black matrix stripe after each triplet with a material which emits UV-light when the electron beam passes over it. A UV-light detector at the rear side of the CRT cone senses the emitted UV-light. In this way the system produces a Beam Index Signal and is able to determine the present position of the beam.

Colour Generation

To generate a colour dot the video information is fed in the right order to the electron gun and due to a very short rise and fall time of the video amplifier the electron beam is only switched on during the short period of time during which the beam is passing over the respective phosphor, e.g. if a red dot should be generated only the red phosphor will be hit by the electron beam.

To generate any mixed colour the adjacent phosphors out of a triplet are stimulated such that the correct intensity of each of the basic colours is reached. This results in the human eye having the impression of the mixed colour originally intended.

Deflection System

The deflection system consists of an extremely linear deflection amplifier which together with the correction network for the pin cushion distortion, maintains an overall accuracy of some o/oo.

Furthermore minor corrections are possible by the regulating network triggered by the beam index signal. This is particularly important in the case that any adverse effect from outside the display occurs whether it is from an electromagnetic source or a mechanical source, i.e. vibration or shock.

Video Amplifier

The video amplifier is also synchronized by the beam index signal. To reach the maximum achievable output in luminance the beam should have its maximum intensity over the full phosphor stripe width. Therefore a video amplifier with a bandwidth of more than 100 MHz was designed.

The black matrix stripe between two phosphor

stripes guarantees that the adjacent phosphor stripes are not hit by electrons even if there is a small non linearity in the deflection system.

Focus

Looking at the phosphor layout of one of AEG-s prototype CRTs shows that a phosphor stripe is 0,115 mm wide (see Fig. 5).

This means that a gun system which is used must have a focus better than this at maximum beam current to reach the colour purity needed.

In the prototypes currently under test a gun with 0,075 mm spot diameter is used. As vertically there are less constraints the spot is electromagnetically formed into an ellipse with a ratio between the small and large axis of about 1:3.

This avoids driving the phosphor into saturation under max. beam current and improve the average luminance of the display.

Block Diagram of a Beam Index Display

Comparing the block diagram of a beam index display with that of a common high quality CRT display there is really not much difference (see Fig.6).

The only new module is the Index Signal Module. As no problems with convergence occur the necessary circuits for its correction are no longer required. The remaining modules are very similar to the ones used in common displays although the requirements with regard to linearity, accuracy and bandwidth are a little bit higher.

These characteristics can be easily fulfilled with modern transistor technology.

Even the power supplies (LVPS and EHT) not shown on the diagram can also be taken from common aircraft displays and do not represent any problem to the design.

Video Presentation

A point still to be mentioned is that for a colour presentation on the beam index CRT a certain regularity in the deflection of the beam is necessary, i.e. a raster presentation is required. But this is no disadvantage at all because raster presentation of the display is especially advantageous when the complete avionic system of a helicopter is considered.

In modern avionic systems a display will be used not only for presentation of alphanumerical data but especially to display information from numerous sensors, e.g. Flir-, LLTV-, Radar images and a moving map from a digital map generator. Furthermore display recorders form an essential part of avionic systems, e.g. for post mission analysis.

Therefore the use of a common raster standard makes the display compatible with other equipment and avoiding the use of scan-converters. Thus the disadvantage of extra space, additional weight and power consumption are avoided.

Another important fact is that shadow mask CRTs use the stroke writing mode to reach a brightness which is marginally acceptable under moderate external brightness conditions. When a complete sensor image has to be displayed it cannot be avoided that the raster mode has to be used. The resulting brightness of the image is then even lower than that produced by the stroke mode.

As already mentioned in the order of 80% of the

beam energy hits the mask and is not converted into light. This figure increases the higher the beam current and the better the resolution of the CRT is.

Comparison between Shadow Mask and Beam Index CRT

A comparison of the two displays can be summarized as follows (see Fig.7).

- Resistance of the Beam Index Display against shock and vibration is better because of the much simpler construction of the CRT, i.e. no shadow mask, single gun.
Furthermore there is a possibility of the correction in the deflection system in case of any external influence with the Beam Index CRT.
- This leads to a much better colour stability.
- There is no difference in the capability of presenting the three basic colours and secondary colours.
The weight of each type is comparable.
- The resolution for a shadow mask CRT is very much dependent on the displayed luminance, i.e. the brighter the display, the wider the spot diameter.
The figures for the shadow mask CRT for resolution and luminance are taken out of a leaflet from a CRT manufacturer and are substantiated by AEG-s tube division.

The resolution of the Beam Index CRT is dependent upon the geometrical arrangement of the phosphor stripes, i.e. with the current prototype the resolution is horizontally comparable but vertically much better than the shadow mask.

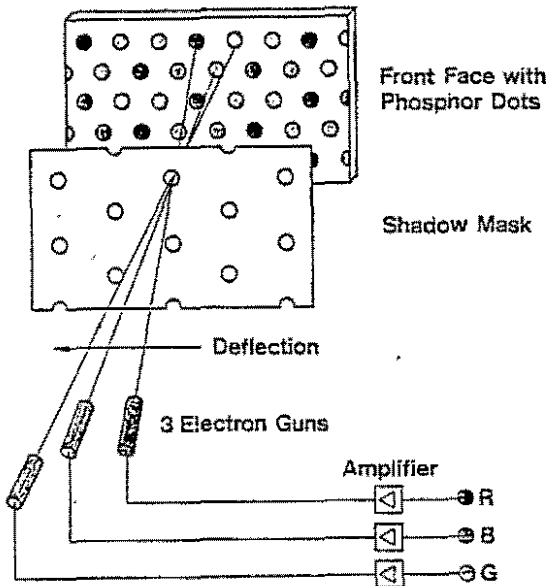
The most improved parameter for the Beam Index Display is the brightness.

Every user is always concerned about the brightness. With a beam index display writing in raster mode a brightness can be obtained which is three times that of a shadow mask display using stroke mode.

The values which can be read from the table are measured values from one of AEG-s prototypes.

Conclusion

As there will be no real alternative to the use of a colour CRT-display, at least for the next generation of helicopters or aircraft, the beam index display is the development which overcomes the major shortcomings of the shadow-mask display currently used for such application.



Shadow Mask

Fig. 1

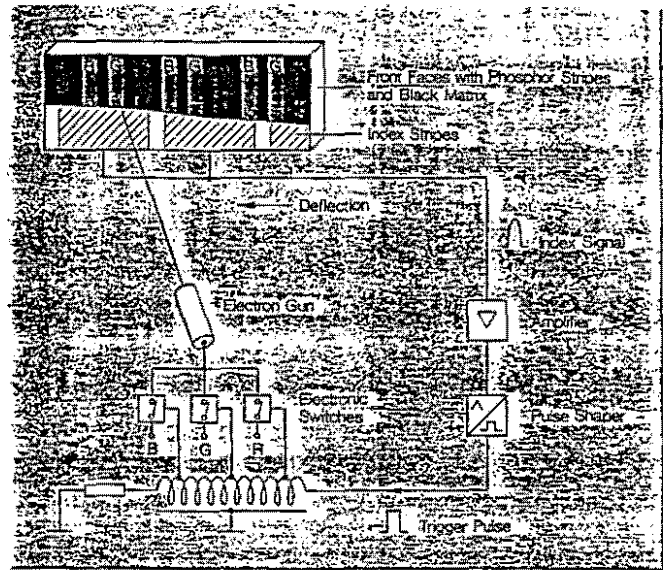
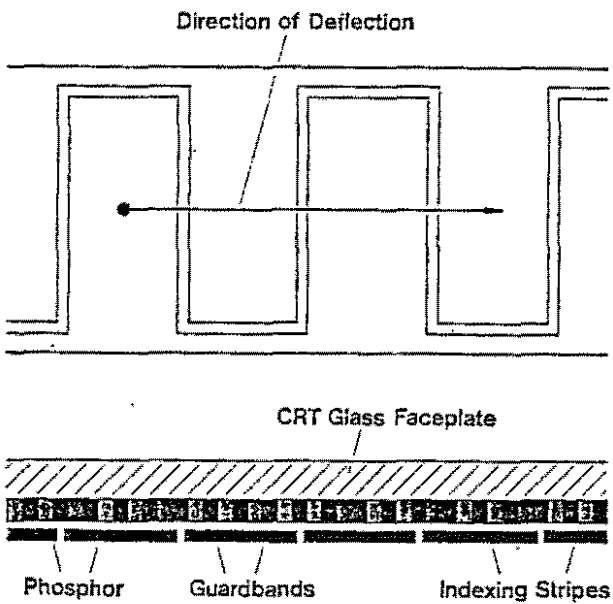


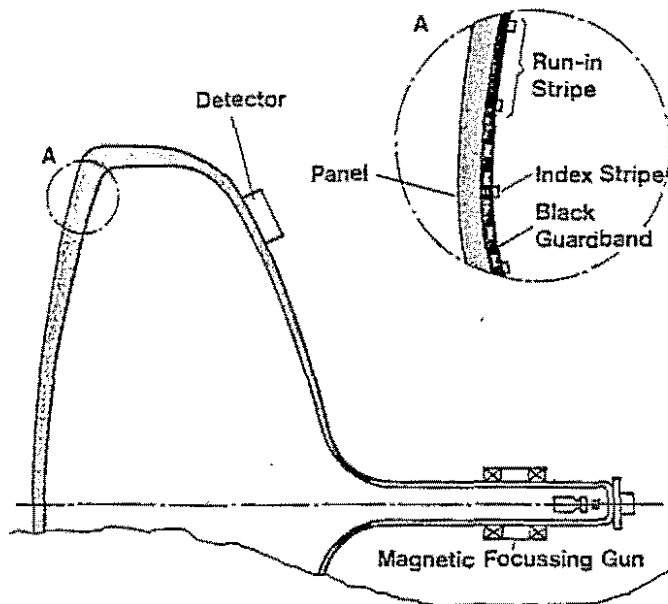
Diagram of Beam Index Principle

Fig. 2



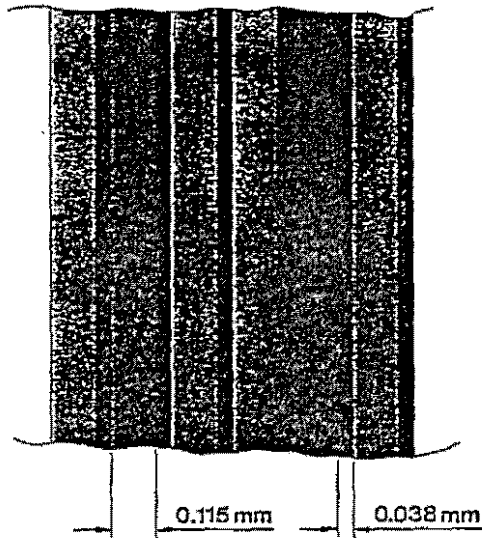
Phosphor and Aluminum Structure on CRT Frontplate

Fig. 3



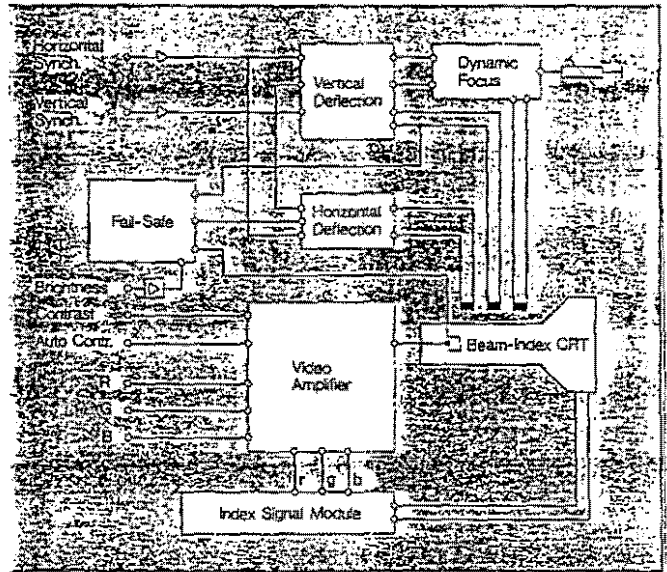
Principle Beam Index with UV Light Detector

Fig. 4



Prototype Phosphor Layout

Fig. 5



Block Diagram of Beam Index Display Unit

Fig. 6

	Shadow Mask CRT	Beam Index CRT
Resistance against Shock and Vibration	Not sufficient with CRT's currently available	No problem as per monochrome CRT
Colours	red, green, blue and secondary colours	red, green, blue and secondary colours
Stability of colours	not guaranteed under all temperature, vibration and shock conditions	very good
Weight	as Beam Index CRT	as Shadow Mask CRT
Efficiency	In the order of 20%	In the order of 80%
Resolution	Screen center: 0.41 mm at 500 μ A at 50% amplitude	over the entire screen: horizontally: 0.42 mm vertically: 0.15 mm at max. brightness
Luminance	red 120 ftl green 230 ftl blue 145 ftl with 600 μ A	red 245 ftl green 140 ftl blue 200 ftl with raster scan writing speed

Comparison between Shadow-Mask and Beam-Index-CRT Performance

Fig. 7