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THE PRESENT STATE OF HIGH DEFINITION TELEVISION

by

Advanced Television System Research Group

1. INTRODUCTION

The ultimate goal for the future television system may be stereoscopic television. However, the present state of technology is not sufficiently developed for realization of this. It may be natural, therefore, to assume that a large screen high definition television is the target in the next step of development in television and that the development of high definition television may bring about the standardization of television systems which is common throughout the world.

2. SIZE OF SCREEN AND SHARPNESS

Generally, a large screen television gives viewers realistic and stereoscopic vision compared to conventional television. It has been reported that the most preferable screen height is about 0.5 to 1.0 meter, and the desirable aspect ratio is in the range of 5/3 and 2/1 as the results of subjective tests made by us.(1)

As for sharpness, it has been reported(2) that in the 525-line receiver, picture sharpness is evaluated as fair (grade 3) at a viewing distance of 5H (H: picture height) in terms of the six comment scale, while it is evaluated as poor (grade 2) at a shorter distance of 2.5H. On the other hand, picture sharpness of a 1,000-line system is evaluated as very good (grade 5) at a viewing distance of 2.5H.

According to another report[3], of an experiment using photographs, a modulation transfer function (MTF) of 50% at 1,500∿1,800 TV lines is required to get better picture quality.

In an experiment using a color television system having 1125 scan lines and a screen size of 0.5 m by 1.0 m, overall picture quality was evaluated as grade 5 or 4 in terms of the seven comment scale. With a black-and-white system having 2125 scan lines, sufficient sharpness was obtained at a short viewing distance of 2H[6].

From these facts, it appears that the desirable number of scan lines for high definition television may be between 1,000 and 2,000.

The desirable line-interlace ratio has been reported as 2:1[4]. On the other hand, the possibility of further reduction of bandwidth with psedudo-random dot-interlace has been pointed out[2]

3. STUDIES OF PICTURE QUALITY USING SIMULATED PICTURES

A new high resolution picture simulator which can analyze a still picture into electric signals by aperture-scanning and reconstruct them on a colour transparency after processing has been developed. It can be operated with up to 235 lines/cm of scan-line density and with maximum picture size of 20 cm by 25 cm. The signal may be processed in either analogue or digital form. Fig.1 shows a block diagram of the simulator. The colour transparencies made by the simulator are projected on to a rear projection screen for picture quality evaluation.

A subjective test was performed on the effect of the number of scan lines and screen size on picture quality. Test conditions were as follows:

number of scan lines	540, 675, 850, 1055, 1320 and 1650
screen size	0.2, 0.4, 0.8, and 1.6 m^2
aspect ratio	3:5
viewing distance	2.5 m
contents of picture	a town landscape, full-length figures of a family, fruit on a table

Since the number of scan lines of the transparency is not equal to that of a television picture, provided the quality of the two pictures is judged the same, it should be noticed that each number of scan lines mentioned above is not the actual number on the transparency. It is the number for the simulated television picture. And it is valid only for the simulation of a 2:1 interlaced television picture.

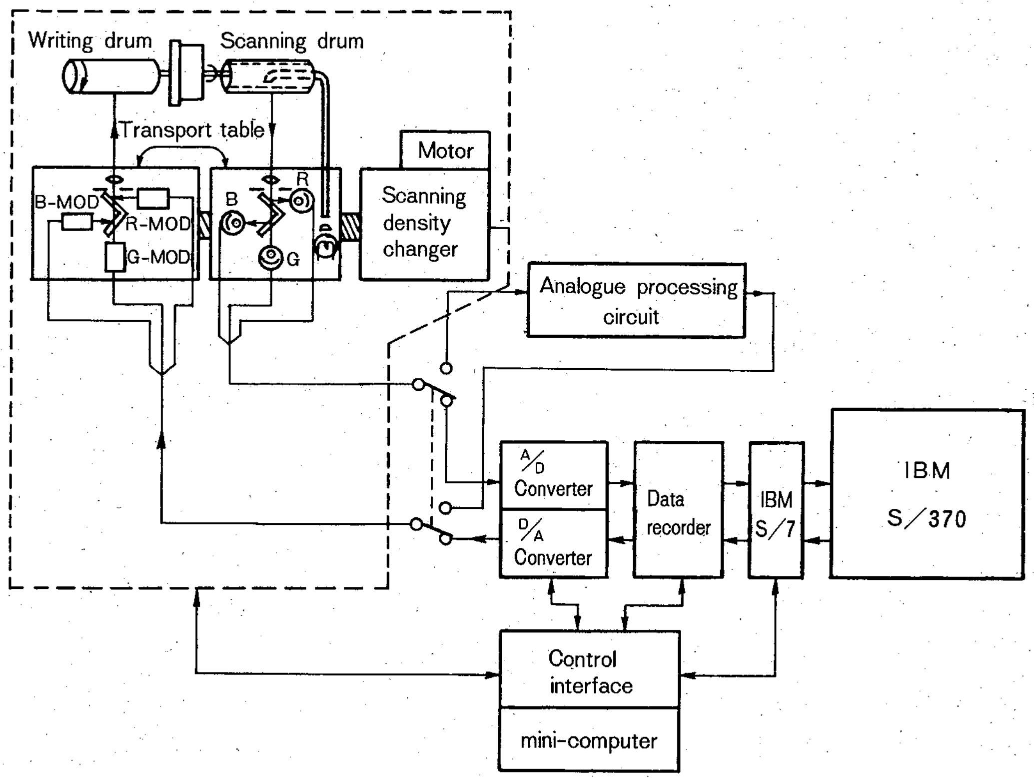

Fig. 1 A block diagram of the simulator.

The results showed that: (1) in the case of a small screen, such as that of the conventional 25" CRT, an increase of the number of scan lines resulted in a rather small improvement of picture quality; (2) while in the case of 500 scan lines, enlargement of the screen over about $0.4m^2$ was not advantageous for the improvement of picture quality; (3) for a picture having over 1,000 scan lines, however, enlargement of the screen was quite useful for the improvement of picture quality. For instance, when the screen size was doubled, the subjective value of the picture quality was improved by almost one grade in terms of the seven comment scale.

It can be said that the improvement of picture quality by enalrging the screen should be fully utilized and the number of scan lines should be minimized as far as possible, bearing in mind transmission economy. More advanced investigation including evaluation of the effect of screen brightness is now being carried out.

4. DEVELOPMENT OF HIGH DEFINITION TELEVISION EQUIPMENT

High definition CRTs of 22" and 26" of which the shadow-mask pitch was 310 μm and 440 μm respectively, were developed, and thus it became easy to fabricate a display of about 1,000 scan lines.(4)(6)

A wide screen television display, 0.5 m in screen height and 1.0 m in width, was developed using three 26" colour CRTs, the screens of which were connected optically, and was operated on a 1125-line system. Fig.2 shows an external view of the wide screen display.

A new pickup tube, the Return Beam SATICON (RBS), was used for both 1125- and 2125-line cameras. The RBS is superior in resolution and S/N ratio, with reasonable lag, to other existing tubes. It is playing an important role in the studies of high definition television. Fig.3 illustrates a cut view of the RBS tube and its coil assembly.

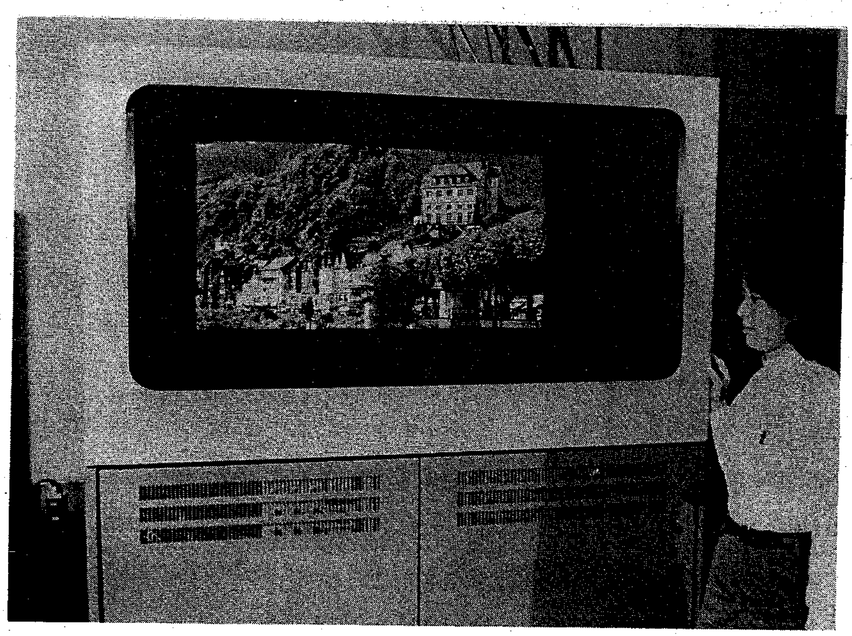

Fig. 2 An external view of the wide screen display.

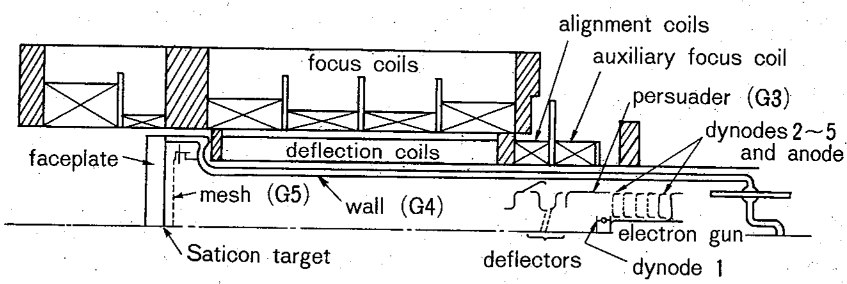

Fig. 3 A cut view of an RBS tube and coil assembly.

For the 1125-line system, the picture presented by a combination of the wide screen display and a 3RBS colour camera, was recognised as effective for an increase in the reality of the scene. A moving picture generated by high definition tele-cine equipment, which was composed of a three 1.5" vidicon camera and a 70 mm film projector on the wide screen display accompanied by stereophonic sound, was seen by viewers as if they were actually in the scene.

Subjectively, optimum viewing distance for a 2125-line black-and-white picture displayed on a 27" high definition CRT was examined and was found to be 2H (H: picture height). Factors which limit shortening the distance from the screen were neither the exposure of the line structure nor provision of no additional detail, but some mental discomfort caused by the wide viewing angle. The picture gave the viewer the impression of looking at a photograph.

The following values will give some idea of the picture quality.

2125-line black-and-white 27" CRT	5.5
1125-line wide screen display	4.8
(525-line 22" colour CRT	3.0)

These values were evaluated with the seven comment scale for high definition television.

Recently, home-use video projectors appear to have found acceptance in the United States. But it seems that the resolution of this type of display is not, nor will it be, good enough for high resolution display systems.

As for the panel display, which is expected to be an ideal kind for the large screen display, researches on colour gas-discharge panels are now in progress. For example, an experimental panel of 7" size having 160 by 127 discharge cells with 1.0 mm pitch was fabricated at our laboratories. The cells contain the phosphors of the three primary colours so that the spacing of the triad is 2.0 mm. White luminance of about 5 ft-L and a contrast ratio of 30:1 were obtained. At the present, research is being directed toward increasing luminance and luminous efficiency by using, for instance, the positive column as an ultra-violet source, and achieving a large sized high definition panel.

5. TRANSMISSION

The bandwidth of chrominance signal required for the 1125-line large screen system was examined. In the experiment, the colour difference signals, R-Y and B-Y, were selected as transmission primaries, and the bandwidth of the luminance signal was 20 MHz. It was confirmed that the bandwidths of colour difference signals to keep the picture quality of more than acceptable limit for any picture having much detail were 7 MHz for R-Y and 5 MHz for B-Y.

Several types of composite colour signal of high definition television, including the NTSC, PAL and FDM systems without frequency interleaving, have been conceived. Tests related to an efficient use of the frequency band and the relation between picture quality and transmission parameters are now in progress.

As for the method of modulation, an AM-VSB with composite colour signal generally seems to be desirable for economy of frequency utilization. In the future, however, satellite broadcasting will be one of the powerful ways of transmitting high definition television signals. And, for FM transmission of the composite signal which is usually used in satellite transmission, larger power will be required so as to keep a high S/N ratio for chrominance signals, because the chrominance signal stands in the higher frequency region of the composite signal.

In order to reduce power requirement, the Y/C separate transmission, in which the luminance signal and line-sequential chrominance signal are transmitted through individual FM channels, is being experimented with. In this system, the amplitude peak after pre-emphasis is suppressed in order to take the large frequency deviation. Thus, a higher S/N ratio with smaller transmitting power can be achieved at the cost of acceptable distortion. This technique is called the Non-Linear Emphasis[5]. Table 1 shows an example of theoretical parameters for the Y/C separate transmission and composite signal transmission systems.

Table 1 Theoretical parameters for the Y/C separate transmission and composite signal transmission systems.

Parameters	Composite colour signal transmission	Y/C separate transmission	
		Y	C
Video bandwidth	30 MHz	20 MHz	7 MHz
Type of modulation	FM	FM	FM
Radio frequency bandwidth	100 MHz	70 MHz	30 MHz
Frequency deviation for low frequency component	40 MHz (no emphasis)	17.5 MHz	7.5 MHz
Required signal to noise ratio (unweighted)	36 dB	35 dB	40 dB
Corresponding carrier to noise ratio	26 dB	13.6 dB	19.6 dB
Required transmitting power (relative value)	1.0	0.04	0.07
	1.0	0.11	

REFERENCES

(1) C.C.I.R. Doc. 11/31, 1970~1974, Japan.

(2) Wilmotte, R.M., Technological Boundaries of Television, FCC OCE Report, CE 74-01, December, 1974.

(3) Rudolph, J., Über die Möglichkeiten zur Kennzeichnung der Bildschärfe fotografischer Aufnahmen (II), Bild und Ton, Heft 12, Jahrgang 22, 1969

(4) C.C.I.R. Doc. 11/296 (CMTT/191), 1970~1974, Japan.

(5) C.C.I.R. Doc. CMTT/59 (4/219), 1963~1966, Japan.

(6) C.C.I.R. Doc. 11/J-8 (CMTT/J-6), 1974~1978, Japan, to be submitted.