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NONPROGRAMMED MULTIPLE CHANNEL PANORAMIC CCTV SYSTEM.(U)

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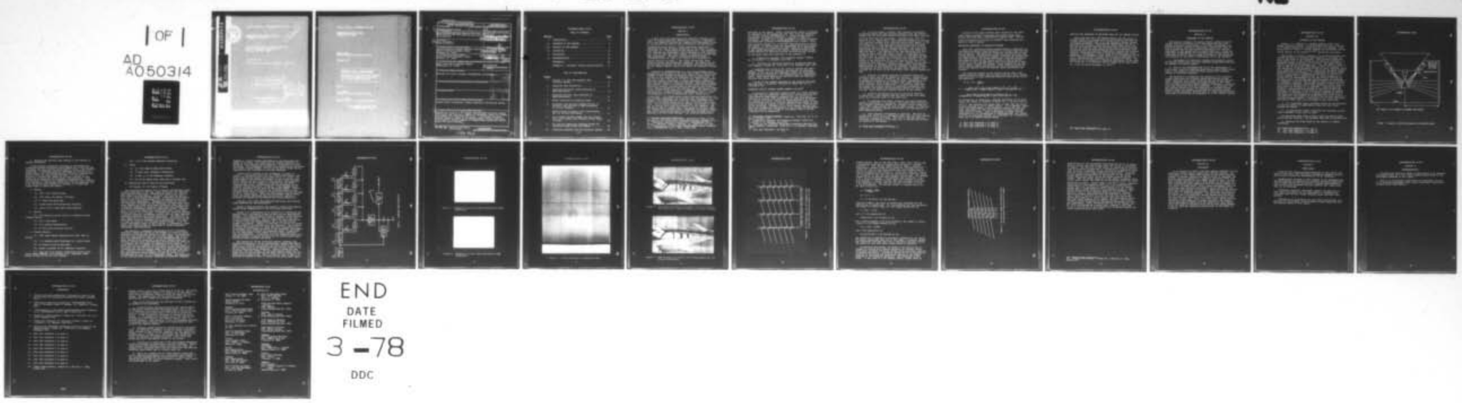

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Feasibility study of a 360 degree Nonprogrammed Multiple Channel CCTV System was made and a number of techniques useful for system development were conceived and tried. A stationary multiple channel system is shown to be feasible, under certain conditions, with insetted targets capable of translational electronic motion across the entire screen.

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SECTION I

INTRODUCTION

A need exists for wide-angle and panoramic displays in the field of visual simulation systems for training. A November 1972 joint NASA/DOD Aeronautical Research and Development Study by the Aeronautics Panel of the Astronautics and Aeronautics Coordinating Board called, "Flight Simulation Technology,"[1] indicates that the principal deficiency in the area of visual simulation is a "wide field-of-view capability," and recommends that research and development work be pursued on such displays. Much work has been done and a number of wide-angle systems have been constructed. The Naval Training Equipment Center (NAVTRAEQUIPCEN) has used a 160° system for a Shiphandling Trainer feasibility model.[2] The visual system used three fixed projectors with horizontal scanning. The system did not exhibit high brightness and the transition from one projector to its neighbor shows a splice line where the adjacent pictures met.

Interest by NAVTRAEQUIPCEN in a 360° nonprogrammed visual presentation dates back to the early 1960's when a contract was awarded to RCA's Defense Electronics Products group asking for a study of such systems and techniques for producing one. It was felt at that time and it is still true, that a high brightness 360° display could lead to visual simulation systems in such training areas as Officer-of-the-Deck, Helicopter Landing, Ship Docking, Airport or Aircraft Carrier Traffic Surveillance, Sea-Battle Problem, Aircraft/Missile Recognition and Surveillance, Terrain Recognition and possibly other applications where a wide field-of-view capability is required. The result of the RCA study was a Technical Report, NAVTRADEVCEN 1053-1, called "Investigation of 360° Nonprogrammed Visual Presentation," 5 June 1962.[3] The report gives a very detailed description of the problems associated with attempting the development of a 360° system. High brightness and very wide video bandwidths were difficult to achieve except by the use of multiple video channels. Use of multiple projectors produces the problem of overlap (or splice line) from one projector to its neighbor. The RCA study (1053-1) assumed that fixed projector multiple channel systems would always produce, "problems of boundary concealment and illumination balance," and the work excluded any consideration of such fixed systems. Two rotating designs were

1. "Flight Simulation Technology," Aeronautics Panel of the Astronautics and Aeronautics Coordinating Board, November 1972.
2. "Wide-Angle Television Projection," NAVTRADEVCEN 695-1, Louis P. Raitiere; Urban H. Santone, Jr., AD621711, Oct 1964.
3. "Investigation of 360 Degree Nonprogrammed Visual Presentation," NAVTRADEVCEN 1053-1, RCA, 5 June 1962.

described in the report. Since a significant amount of research on components of the systems was required, with low probability for success, before implementation of either system could be considered, no attempt to produce a feasibility model was attempted. Instead, work on new approaches to rotating systems was undertaken in-house at NAVTRAEQUIPCEN and a patent, "Panoramic Display System," No. 3,542,948[4] describing such a system was issued. A research task was established which would result in construction of a feasibility model based on an embodiment of the system described in the patent. Detailed study of the system resulted in obviating serious deficiencies and attempts to circumvent them were described in two patents:[5,6]

a. "Reflective Panoramic TV Projection System," Patent No. 3,740,469; J. W. Herndon; June 1973.

b. "Multiple Gun Rotatable Television Projection Head for 360° Display," Patent No. 3,758,714; J. W. Herndon; Sept. 1973.

A comprehensive review of the rotating systems was undertaken in March, 1973 to reexamine the approach to ascertain whether or not the work was proceeding toward the fulfillment of the original objective -- the construction of a feasibility model. This report details the decisions made and describes the work done since that time.

A study of the systems described in the patents indicated that the task of building a feasibility model was still a formidable one.

PANORAMIC DISPLAY SYSTEM, PATENT NUMBER 3,542,948[7]

A plurality of television cameras fixed to a first rotating drum scan through respective narrow slits, positioned with the long dimension approximately perpendicular to the plane of rotation to furnish video information to respective projectors on a second drum which rotates in synchronism with the first. The projectors scan in a direction approximately normal to their plane of rotation whereby a scene covering a 360° field-of-view may be projected. Appendix A is a brief system analysis from which the fundamental requirements of the system are determined. From the analysis and a study of the system, some of its deficiencies can be enumerated:

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4. "Panoramic Display System," Patent No. 3,542,948, Dr. H. H. Wolff, November 1970.
5. "Reflective Panoramic TV Projection System," Patent No. 3,740,469; J. W. Herndon, June 1973.
6. "Multiple Gun Rotatable Television Projection Head for 360 Degree Display," Patent No. 3,758,714; J. W. Herndon, September 1973.
7. Ibid (See reference 4 on page 4).

a. It is not clear, a priori, that rotation of multiple projectors solves the edge matching problem since the problem arises from the fact that multiple projectors are used, not from the fact that they are stationary. The RCA study, 1053-1,[8] pages 74 to 78, shows that a line interlacing system is required for rotational systems since discontinuities which appear in the same position for each scan cannot be removed from the scene. It is essential in the Panoramic Display System that uniform spacing of raster lines be attained because of the line interlace system so that banding (higher and lower line densities) does not result. The spacing is not just mechanical but electronic as well, since the raster line will be produced on a projector CRT by a driven electron beam. A reasonable system has 600 lines per projector rotating at 600 rpm producing 7200 lines (2 to 1 interlace) and a 3 minute line spacing. Since 1 minute is the resolution of the eye, spacing will have to be uniform to less than $\pm$ 1/2 minute of arc. Whether or not such a specification is adequate requires experimental verification. Repositioning of the projectors (or cameras) for more uniform line spacing would be difficult because these components are rotating and it would not be clear which ones require repositioning.

b. Rotation introduces problems of synchronization and vibration which may not be capable of solution. Vibration will be either harmonically related to the rotational speed, caused by mechanical unbalance, or random or both. Harmonically related vibration would produce banding and random vibration would produce a loss of resolution. It should be noted that the better the picture quality or resolution engineered into the system, the greater the deleterious effects of vibration will be. This limits the "quality" growth of the system.

c. Rotation introduces electrical continuity problems. In particular, video signals must be taken across slip rings which may introduce noise in the video line.

d. No technique for target insertion into the background scene is delineated in the patent. The system seems limited to CGI (computer generated images) for targets, since, except for a full 360° camera system for each 3D model target, no insertion technique is possible because of the 360° line distribution of each camera/projector.

e. Some component development is required. The most important work would be on a projector tube, with its high voltage, requiring a single line scan. The life of the tube would be shortened considerably if the same line is scanned continuously as required in the system.

8. Ibid (see reference 3 on page 3).

Because of the large rotating mass required by the Panoramic Display System,[9] techniques were sought which would produce the same result with smaller rotating mass. The Reflective Panoramic TV Projection System[10] was conceived as a result of such a search.

REFLECTIVE PANORAMIC TV PROJECTION SYSTEM

This 360° television display system employs a plurality of television projection tubes operating in a single-scan-line mode and located in fixed positions around the vertical axis of the display system. The projected single-line-scans from the tubes are mediated by a reflective assembly contoured and faceted such that when rotated, the single-line-scans, oriented vertically, are caused to move on the display screen in the horizontal direction at the televised field rate, thus generating a television raster through 360 degrees. Video signals are derived from a similar camera system with its own rotating mirror deriving the signals from a cylindrical scene surrounding the mirrors.

Six contoured facets of the rotating mirror (for a six camera/projector system) must be built with the x and y coordinates of points on said contoured facets defined by the following equations:

$$x = h - \left(k - \frac{y}{\tan x}\right)$$

$$y = \frac{\sin x \,(r^2 - 2h\, r \cos x \cos 0 + h^2 - l^2 - k^2)}{2\,[\cos x\,(h - r \cos x \cos 0) + \sin x\,(k - r \sin 0) - l]} + \frac{2K\,(r \cos x \cos 0 \cos x - h \cos x + l)}{2\,[\cos x\,(h - r \cos x \cos 0) + \sin x\,(k - r \sin 0) - l]}$$

For definition of terms and a complete derivation of the equations, the reader is referred to Patent No. 3,740,469; June 19, 1973.[11] The equations are quoted here to show that the mirror surface proposed is not a simple matter. It is apparent, therefore, that development of the projection system can come only after development of the mirror system and single-line-scan mode projection tubes. Since development of these critical components are not contemplated at NAVTRAEQUIPCEN, this system will not be considered further as a candidate for a feasibility model of a 360 degree display system.

9. Ibid (see reference 4 on page 4).
10. Ibid (see reference 5 on page 4).
11. Ibid (see reference 5 on page 4).

MULTIPLE GUN ROTATABLE TV PROJECTOR HEAD FOR 360 DEGREE DISPLAY

This technique for a 360 degree display was the result of further search into methods which would eliminate the need for a large rotating mass such as in the Panoramic Display System previously discussed. The technique contemplates the use of a new multi-gun projector tube (say six guns) which would line scan in the vertical mode and eliminate edge matching problems as well as large rotating masses by specifying desirable tube characteristics and physical dimensions to produce the required results. Development of such a multi-gun camera tube is also suggested. Development of such tubes is not contemplated by the Naval Training Equipment Center and the system described will not be considered as a candidate for a feasibility model. The reader who is interested in a detailed description of the tubes and their use in a panoramic display system should read Patent No. 3,758,714 dated September 11, 1973.[12]

12. Ibid (see reference 6 on page 4).

SECTION II

STATEMENT OF THE PROBLEM

The study of rotating 360 degree display systems using TV cameras and CRT projectors led to the conclusion that such systems entertain a high degree of risk and, furthermore, the extensive effort required to fabricate a feasibility model of such a system was not cost effective because of the limited usefulness of the system with no target insertion. It was decided that consideration of a stationary 360° system should be undertaken to see if such a system is feasible. Two technological advances in the field of television led to the decision:

a. Development of television cameras and projectors using 100 percent solid state circuitry promised exceptional stability for present television scenes.

b. Work at the NAVTRAEQUIPCEN led to the development of solid state circuitry producing beam driving control which could lead to the removal of nonlinearities required for matching scenes on contiguous channels.

The problem is to determine the feasibility of a multiple channel stationary 360° display system which would include target insertion with target motion across the entire field-of-view. Budgetary limitations precluded building a 360° model and with Naval Electronic System Command concurrence, a study of high risk technology areas was undertaken. In particular, the main efforts wouuld be to find techniques to produce picture matching where two channels interfaced and continuous target motion across contiguous channels with no target discontinuities. Techniques produced must be expandable to a 360° display system.

SECTION III

APPROACH TO THE PROBLEM

Figure 1 is a sketch of a concept showing a 360° multi-channel projector system. A pickup system could be a like set of TV cameras picking up a scene from six flat screens. Such parallelism of "input," "output" systems was postulated for the rotary systems of the patents[13,14,15] previously discussed.

The concept of figure 1 depicts a six projector system with reflective optics to increase throw distance to increase the size of the scene to be displayed. Each projector produces a scene which fills a flat screen six of which are arranged in a hexagonal format producing a 360° system. The system parameters - resolution, brightness, etc. - are the same as those of each of the six projector subsystems so that, for example, if the resolution of the projector is 600 TV lines, then the system has a resolution of 600 TV lines. Similarly, the other system parameters can be determined. To definitize the design parameters of the system, a knowledge of the state of the art of visual systems and of advanced work on visual systems is required with an understanding of all the options available so the best choice can be made when decision points are reached. For example, a decision must be made on whether to use vertical or horizontal scanning. Horizontal scanning involves solving the problem of matching 600 to 1000 television raster lines in going from one channel to its neighbors. Vertical scanning produces a simple matching problem but vertical flyback and blanking time promise a black band at each channel to channel interface. A decision to go to vertical scanning was made on the basis that the probability of matching 600 lines is very low compared to the problem of eliminating the black bands in a vertical scanning system. A decision to go to black and white television rather than color was based on the facts that:

a. If a successful black and white system can be developed, it would be useful for applications where low cost visual systems are needed.

b. An unsuccessful effort eliminates the technique regardless of whether or not color is used.

The decisions made leave us with a black and white system using vertical scanning. The problems that must be overcome are:

a. Removing the black bands at the channel to channel interfaces.

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13. Ibid (see reference 4 on page 4).
14. Ibid (see reference 5 on page 4).
15. Ibid (see reference 6 on page 4).

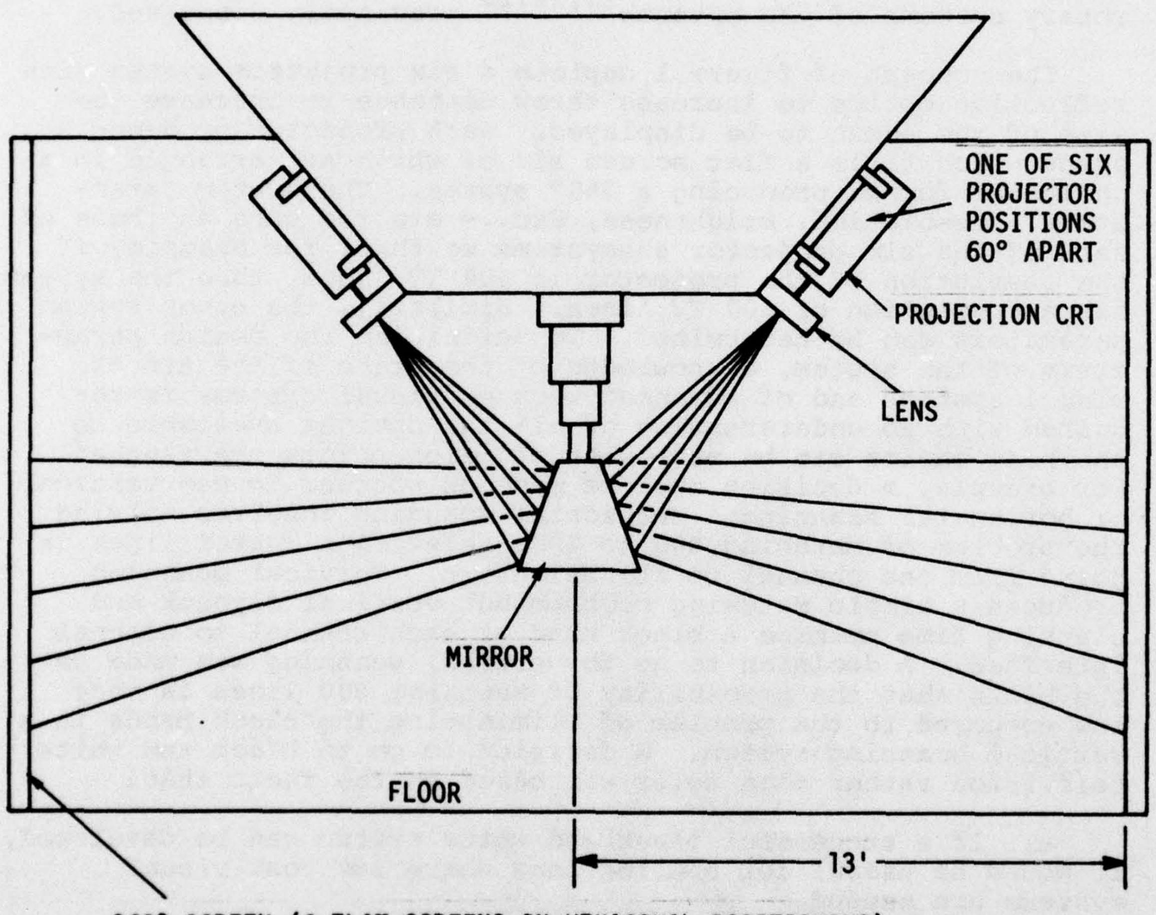

Figure 1. Concept of a 360° Multichannel CCTV PROJECTOR SYSTEM

b. Matching the vertical scan rasters at the channel to channel interfaces.

A third problem increasing the scope of the project was introduced because preliminary study showed that a solution was attainable and such solution would greatly increase the system's usefulness. A technique would be developed to include an insetted target into the background with electronic translational motion across the entire scene provided. We are now in a position to provide the capability of such a system if techniques can be developed for successful implementation. From the technical literature and commercial brochures which describe stock projectors, the system capabilities can be enumerated for a six projector system assuming a distance of 13 feet from system center to each flat screen:

a. General.

(1) 360° x 90° Field-of-View

(2) 6174 lines, 60 fields, 30 frames

(3) 7" Black and White CRT

(4) 70,000 volts CRT Accelerating Potential

(5) 120V, 60 Hz, 5 Amp Input Power Required

b. Optical.

(1) 25" spherical mirror and 22.6" corrector plates (Schmidt optics)

(2) F/0.7 lens speed

(3) 48 x nominal magnification

(4) 60 foot throw distance required

c. Picture Quality.

(1) 1200 lines center resolution and 1000 lines in corners

(2) 5 ft Lamberts peak brightness on a matte screen

(3) 10 steps of gray on EIA chart

(4) Within 2 percent of 15' dimension linearity

(5) Less than 0.15 percent registration error within circle whose diameter is 80 percent of 15' dimension (from center of each of the six flat screens).

(6) 0 to 10 db variable aperture correction

d. Video.

(1) 1.0 volt peak-to-peak input signal

(2) 75 ohms input inpedance (unbalanced)

(3) 30 Mhz, ± 1.5 db frequency response

(4) For 60 hz square wave, less than 1 percent tilt

e. Mechanical size of each of six projectors.

42" height; 26 3/4" width; 40"depth.

The specification results from a typical off-the-shelf stock projector expanded to 360° use. Many variations are available with keystone corrections, variable scan rates (e.g., 3000 to 6000 lines) and many others. In short, the state-of-the-art will give us good system performance. Projectors are available which are all solid state except for the projection CRT which insures stable performance. Equipment purchased for testing the techniques developed in the laboratory included three solid state cameras and three solid state projectors which were quite inexpensive compared to equipment which would be purchased for an advanced development model of a panoramic system. Nevertheless, a 2 1/2 hour visual test showed that after a very short warm-up period (10-15 minutes), no measurable variation resulted in picture position, brightness, picture size or other important parameters affecting the system development. The stability is very important for a stationary system since once set up at the point where effective presentation is demonstrated, the stability must be relied on for continued effectiveness. If an advanced development model of such a system is subsequently undertaken, the stability must be specified to insure acceptable performance characteristics.

The decision to reexamine the possibility of a successful stationary system was driven by development of circuitry which produced an electron beam driven by a ramp which was synthesized from five ramp segments each with variable slope. The development was undertaken on a project at the NAVTRAEQUIPCEN to improve resolution by producing a horizontal scanned scene and a vertical scanned scene simultaneously and allowing the human eye to integrate the two scenes for improved picture quality. In order that picture elements would register at the same point, it was clear that the beam driving ramp would require manipulation. A decision was made to produce ramps, both horizontal and vertical, consisting of five segments, each of which was adjustable. The ramp generators would operate at both the field (≈ 16 millisecond) and line (≈ 31 microsecond) rates. The difference in the circuits which evolved, consisted of different component elements to insure optimum performance at the particular frequency of interest. For simplicity and maximum flexibility, a series of five one-shot multivibrators is integrated into the circuitry. The arrangement provides the capability for adjusting the length of each segment (as well as the slope) which may be required for the coincidence of picture elements.

A basic block diagram of the synthesizer is shown in figure 2. The master oscillator is a solid state crystal controlled oscillator operating at either 120 hz or 33 khz. The pulse output of the master oscillator is fed to both an electronic switch and into a bank of five one-shot multivibrators. The Q outputs of the respective one-shots key the series connected AND gates, incorporating the potentiometers in the constant current generators, producing a ramp segment whose slope is dependent on the value of the potentiometer. Successive one-shots are activated by the $\overline{Q}$ output pulses of the previous stage which is timed to coincide with the trailing edge of the Q output pulse. After the five segment ramp is generated, the master oscillator keys the electronic switch to initiate the flyback by discharging the timing capacitor C.

Figures 3 and 4 show the segmented horizontal and vertical ramps generated by the synthesizer.

Figure 5 shows horizontal and vertical rasters with banding caused by the segmentation of the 60 hz ramp functions.

Figure 6 is a photograph of an aircraft on a television set showing both a vertically scanned picture and one horizontally scanned. The potentiometers are set to produce a wide deviation of the picture elements in the vertical relative to the horizontally scanned picture. Figure 7 shows the same pictures as in figure 6 with the potentiometers set to produce picture element coincidence. Clearly, a good deal of control on picture element position is achieved using the technique. The decision to review the possibility of using stationary projectors for a multichannel 360° system was based on the successful development of circuitry which produced the segmented ramps, as described, and the improvement in the design of solid state projectors with good stability. It was felt that the segmented ramps could produce channel to channel matching and the stable solid state projectors would maintain the match.

The feasibility of the stationary system, assuming that matching and stability can be accomplished, depends upon development of a technique to eliminate the black band at the end of each channel which is associated with the vertical flyback time of each camera-projector subsystem. Figure 8 shows six ramp functions (vertical ramps), one for each channel which are in phase with one another showing how black bands of video are produced during flyback time. Note in figure 8 that if ramp 2 is advanced or delayed so that it starts at the point where ramp 1

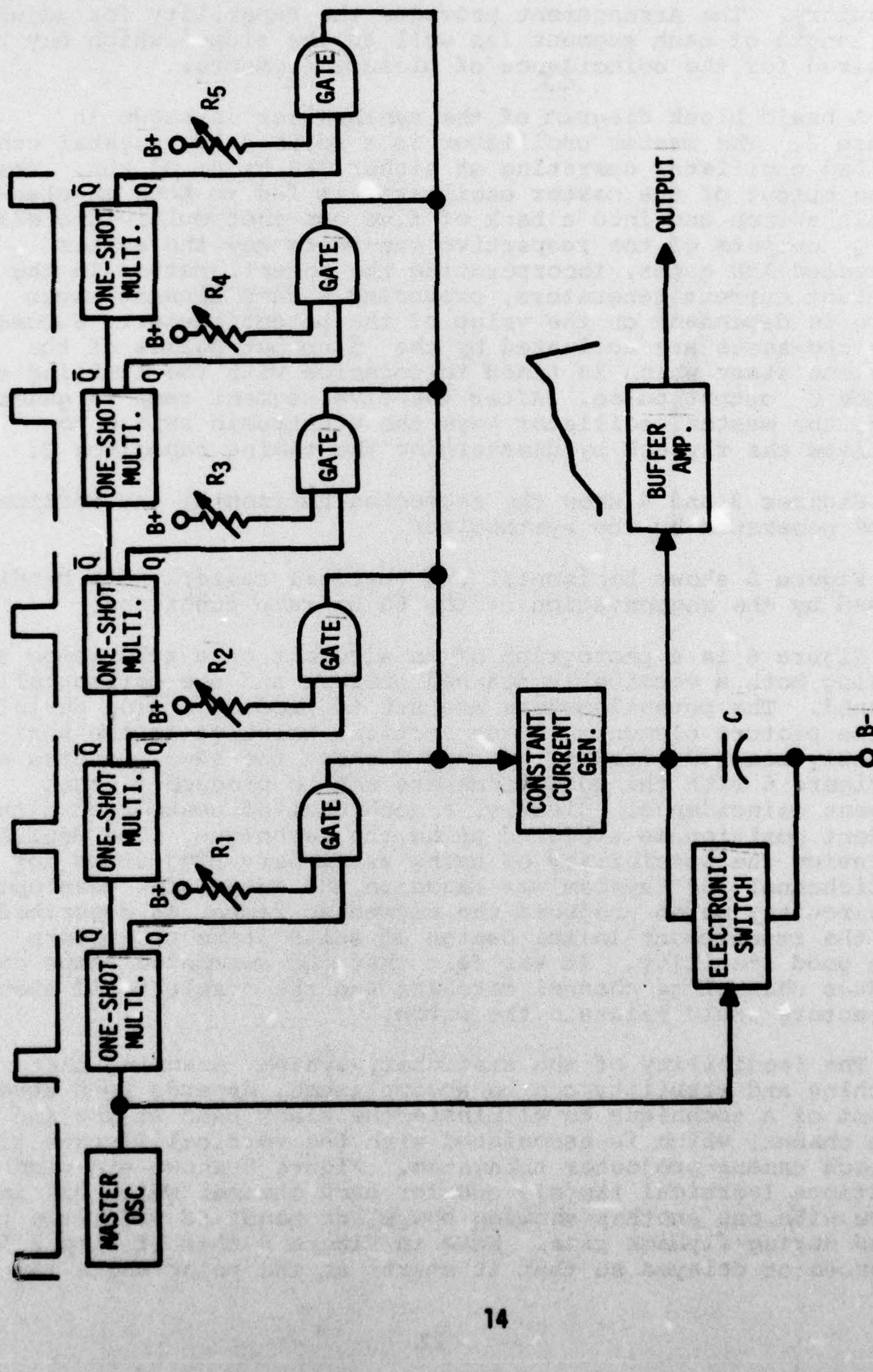

Figure 2. Segmented Ramp Synthesizer

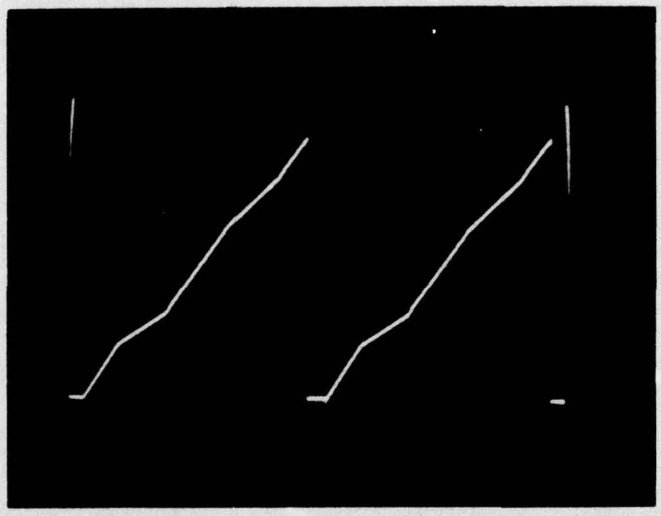

Figure 3. Segmented Horizontal Ramps Generated by Ramp Synthesizer

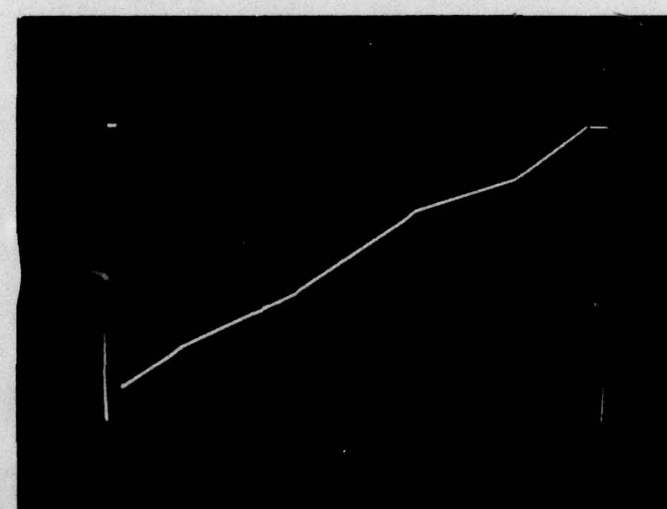

Figure 4. Segmented Vertical Ramp Generated by Ramp Synthesizer

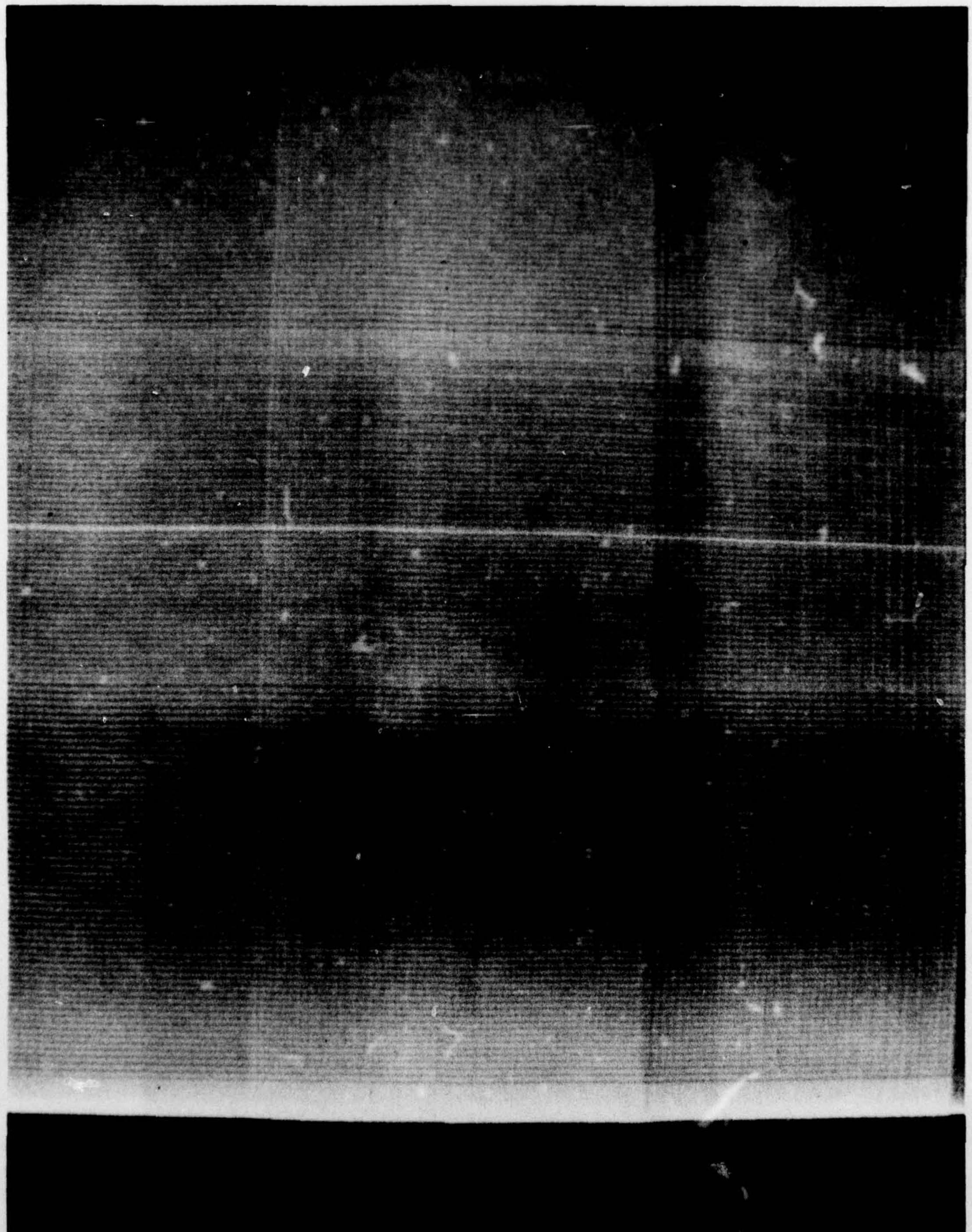

Figure 5. Raster Generated by Segmented Ramps

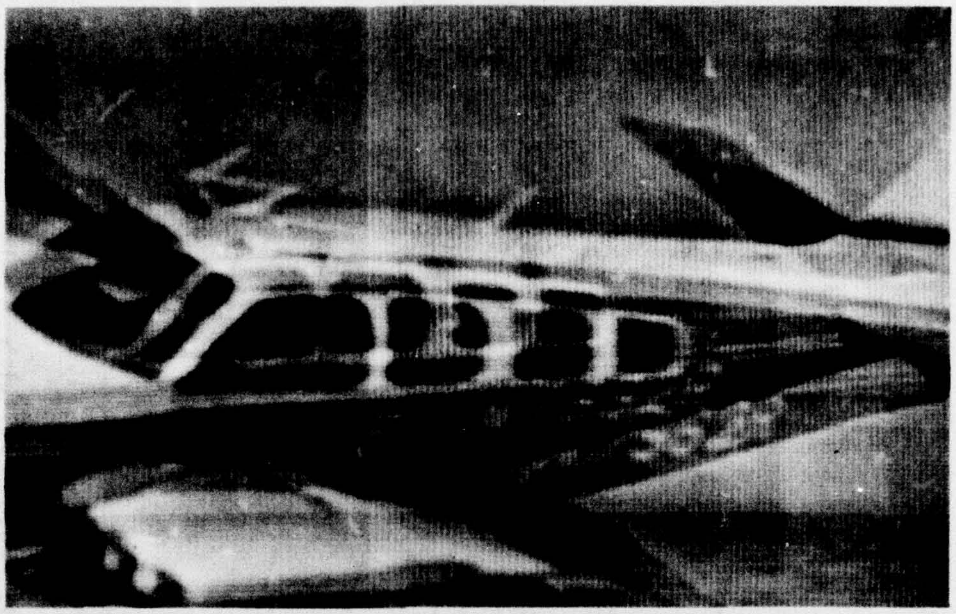

Figure 6. Horizontal and Vertical Scanned Picture of Aircraft with Pots Set to Show Divergence of Picture Elements

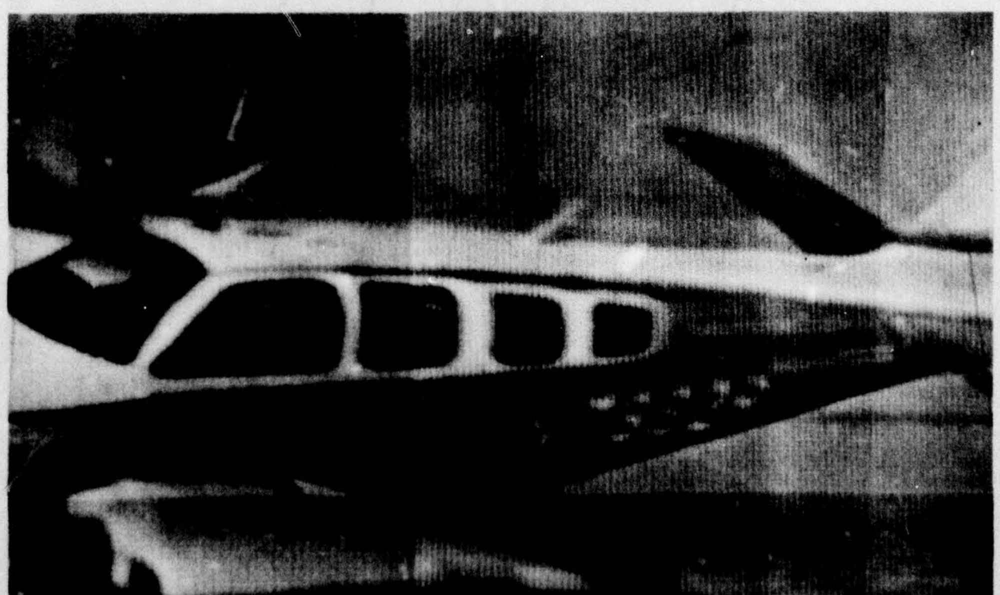

Figure 7. Same Pictures as Figure 6 but Potentiometers Set for Picture Coincidence

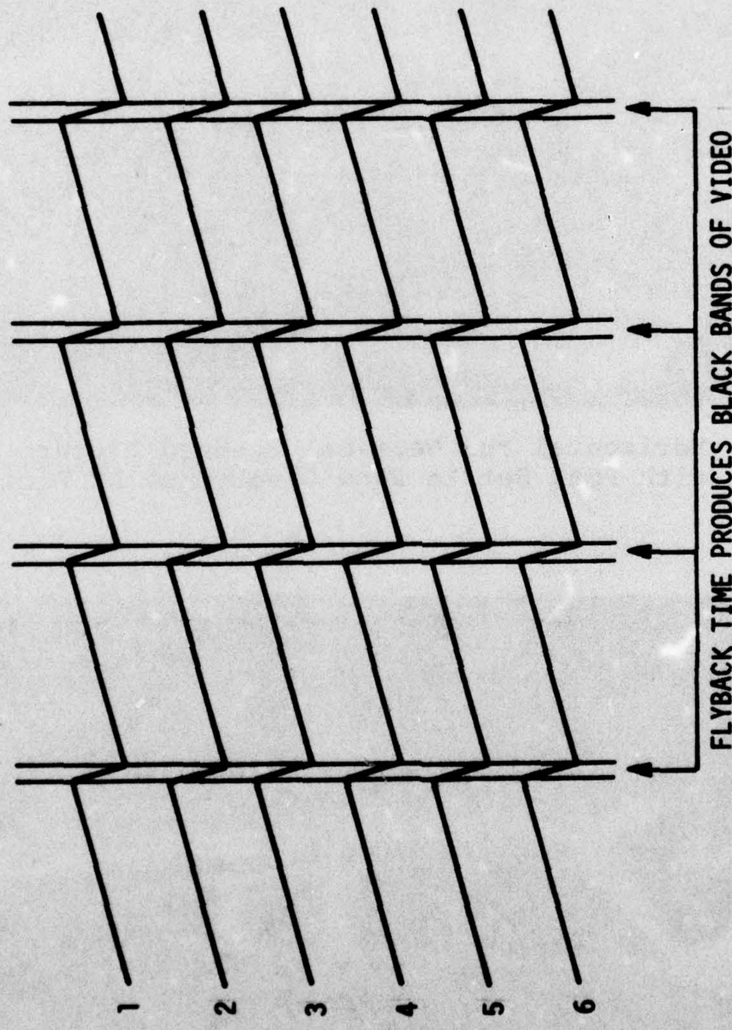

Figure 8. Six In-Phase Ramps (for Six Projectors) with Flyback Time Producing Black Bands of Video.

flyback begins, then at the time ramp 1 ends, ramp 2 begins and a continuous scene can be produced from projector 1 through projector 2. With similar phase shifts of ramps 3 through 6, a continuous 6 channel scene can be produced, provided that the "video on" time of each ramp exceeds the total flyback time of the six projectors (see figure 9). Since the "video on" time in figure 9 exceeds the total time of the blanking intervals, there is a question of just how many channels can be used. The maximum number can be determined from equipment specifications. For a 2 to 1 interlace system, a field takes 1/60 seconds or 16,666 microseconds. A typical flyback time from equipment specification regardless of line rate (525 to 1325 TV lines) is 1,250 $\pm$ 100 microseconds. The maximum number of channels which can be used is given by:

$$N = \frac{16,666 - 1250}{1250}$$

$$N = 13.3 - 1$$

$$N = 12 \text{ (Rounding off the decimal)}$$

From this number, the range of resolutions available for the systems can be determined. For a six channel 525 line projector, the number of raster lines in a 360 degree system will be

$$6 \times 525 = 3,150$$

and a TV line separation of

$$21600/3150 = 6.8 \text{ minutes of arc.}$$

For a twelve channel 1,325 line projector, the number of raster lines in a 360 degree system will be

$$12 \times 1,325 = 15900$$

and a line separation of

$$21,650/15,900 = 1.36 \text{ minutes of arc.}$$

Any resolution in between is available, depending on the choice of channel subsystems used and on the number of channels chosen. The techniques outlined show that a stationary multiple channel 360 degree or very wide angle visual system is feasible.

As mentioned previously, the scope of the project was increased to include work towards producing an insetted target which could traverse the entire screen using electronic circuits to produce the motion. Electronic target motion is produced by delaying or advancing the synchronous signals of the camera relative to its companion projector. The technique is well known. In the case of a six channel system, target video is

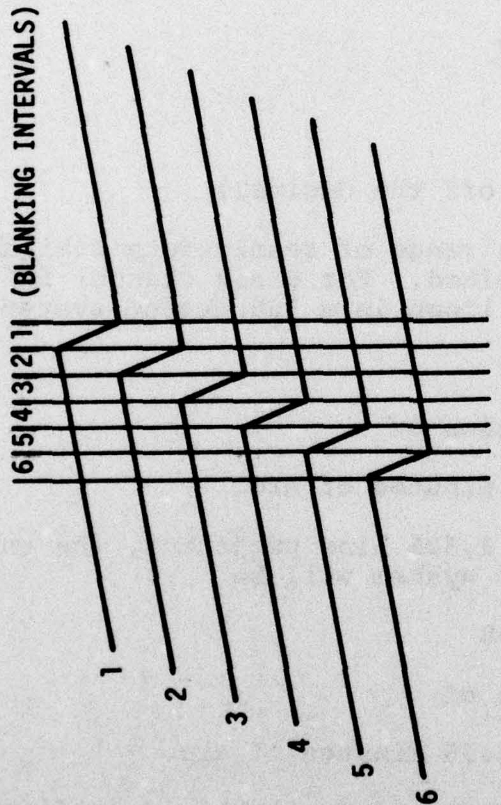

Figure 9. Six Vertical Ramps with Adjusted Phases for Continuous Video Across Six Screens

presented to all six projectors simultaneously and it is necessary to inhibit the video except where the target is programmed to appear. The position of the target is controlled by application of an analog voltage fed to a differential comparator which also receives a reference voltage arbitrarily chosen to correspond to a particular target position on the screen. Variation of the applied voltage which is proportional to the target camera synchronous delay varies the target position on the screen. Once the proper position of the target is chosen, electronic gates inhibit the video on the projectors where the target should not be shown. Patent number 3,525,804[16] gives a detailed description of the handwired logic for a one camera-monitor system which was the basis for construction of a two channel system used to experimentally verify feasibility and to demonstrate target motion across the screen of two channels. Expansion to six or more channels would be straight forward. One minor problem associated with the technique is the fact that a delay of one full line will not only move the target across the screen but a one TV raster line displacement occurs when the target appears on an adjacent channel. The problem is easily solved by physically positioning projectors for target coincidence. Then, the bottom and top of the rasters will be "off" coincidence by a raster line. Masking a few lines (6 to 12) at the top of each channel will eliminate showing any raster discontinuities that occur.

16. "Gated Video Display," Patent No. 3,525,814, J. Owen, August 1970.

SECTION IV

DISCUSSION

It is feasible to build a multiple channel panoramic or very wide angle visual display system with insetted targets. The techniques in this report show promise of providing excellent channel to channel matching and specification of equipment can provide requisite stability or adaptive techniques which will keep channels matched for the needed length of time. To make such a system much more useful, work should be undertaken on a 360° channelized probe compatible with the display system for use with a 3D model board. Such a probe development should be undertaken when definite requirements can be delineated for particular applications of interest. Model board scale factors will vary for different applications, affecting the degree of difficulty in probe development. The particular applications for which such a probe/visual display system would be useful, are low unit cost elements (e.g., relative to aircraft) such as tanks, trucks, etc. Such a low cost visual system would be useful for tank commander or gunnery trainers, for example. Cost-effectiveness studies will be required for each system, since the number of channels which can be used ranges between 6 and 12, with the resolution proportional to the number of channels.

SECTION V

CONCLUSIONS

Rotating 360° display systems described in this report have areas of very high risk and require subsystem component developments before feasibility demonstration can be attempted.

Technological progress on CCTV systems at the NAVTRAEQUIPCEN and improvements on commercially available subsystem components (solid state cameras and projectors) increases the probability that an effective stationary multiple channel 360° visual display can be developed.

Techniques conceived, developed, tested, and described in this report are useful for the development of panoramic and very wide field-of-view visual displays using television subsystems.

Delineation of requirement for particular applications are required for development of multichannel probes compatible with the display system of this report.

SECTION VI

RECOMMENDATIONS

Consideration should be given to construction of an advanced development model of a 360° visual display system based on the techniques presented in this report.

Work on a multichannel probe should be undertaken (as part of an advanced development model) with a particular application yielding probe requirements.

REFERENCES

1. "Flight Simulation Technology," Aeronautics Panel of the Astronautics and Aeronautics Coordinating Board, November 1972.

2. "Wide-Angle Television Projection," NAVTRADEVCEN 695-1, Louis P. Raitiere; Urban H. Santone, Jr., AD621711, October 1964.

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4. "Panoramic Display System," Patent No. 3,542,948, Dr. H. H. Wolff, November 1970.

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7. Ibid (see reference 4 on page 4).

8. Ibid (see reference 3 on page 3).

9. Ibid (see reference 4 on page 4).

10. Ibid (see reference 5 on page 4).

11. Ibid (see reference 5 on page 4).

12. Ibid (see reference 6 on page 4).

13. Ibid (see reference 4 on page 4).

14. Ibid (see reference 5 on page 4).

15. Ibid (see reference 6 on page 4).

16. "Gated Video Display," Patent No. 3,525,814, J. Owen, August 1970.

between raster lines) and a field rate of 60 hertz. The system requires a cylindrical scene to be picked up by the camera group and a cylindrical screen on which the scene will be displayed. The camera group and the projector group must be synchronized for a scene to be properly displayed.

Some of the deficiencies and problems of such a system can be enumerated and discussed:

a. Discontinuities between projectors and cameras cannot be removed by rotation alone (RCA study 1053-1, pp. 74-78). It is essential that they be distributed about so that the eye does not integrate and add them to the scene at particular places. A line interlacing technique is required for such a system. It is necessary to carefully set up the cameras and projectors so that uniform line density results (i.e., to prevent banding). Once rotating, it will be extremely difficult to determine which scanners need to be repositioned so that uniform line density results.

b. Rotation causes problems of synchronization and vibration. If vibration is present, it will be random or harmonically related to the rotational frequency (if any unbalance is present, e.g.) or both. It is noteworthy that the better the picture quality or resolution, the greater the deleterious effect of vibration or asynchronization. This limits the system quality or any quality growth of the system.

c. Rotation of a large mass at 600 rpm presents mechanical balancing problems and electrical continuity problems. Taking video signals from rotating cameras through slip rings, for example, will introduce noise into the video which may make the displayed scene worse than it normally would be.

d. There is no simple way to inset targets (using electronic insertion techniques) into a displayed scene because of the rotating elements and the distribution of raster lines across the entire 360° from each scanning element. This limits the usefulness of the system.

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