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DEVELOPMENT OF A STEREOFUOROSCOPY SYSTEM

FINAL REPORT

OCTOBER 1979

NAS 9-15287

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## I. Introduction

One of the major goals of the National Aeronautics and Space Administration is to be responsive to requests for application of aerospace technology to the public health sector. Johnson Space Center has been the leader in aerospace medical and communications development, two of the more obvious results of technology transfer being Telecare and STARPAHC. A newly developed technique of 3-D video imaging, developed by NASA for use on future manned missions for observation and control of remote manipulators has now been utilized by this investigator in developing and successfully testing an improved medical diagnostic fluoroscope with a stereo, real-time output. What follows in this report is a description of the history of the problem, an explanation of how this new system works, and recommendations for future work in this area.

## A. History of Stereofluoroscopy

Attempts to obtain stereo images from a fluoroscopic screen are as old as the clinical use of the screen itself (1). By the early 1960's, the advent of the image intensifier (II) screen led to renewed interest in this project due to the gross reduction in patient dose that the II allowed. Several experimental systems were proposed by Lindblom (2), Webster (3), and especially Stauffer (4,5).

Some of these systems were actually built and used in limited clinical applications. Later work by Kok (6,7) and most recently by Dummeling (8) and Kunnen (9) show that, currently, there is still research and clinical interest in such a device.

However, in all these systems there remains the critical problem of developing an adequate display capability, one which would lend itself to clinical use, especially in an operating room. Such a device should provide a stereofluoroscopic view to any number of viewers (including multiple displays), allow mobility of each of these viewers, be free from the necessity of correction for the random visual parameters of each viewer such as intraocular distance, and also allow the viewer to look away from the output device and enjoy normal sight without having to adjust or remove any necessary viewing glasses or other decoding device. It is only the PLZT viewer system which has lent itself to the solution of all of the above mentioned problems.

## B. History of the Viewing System

The NASA stereotelevision system was developed at the Johnson Space Center by William Perry, a NASA research engineer (NASA Tech Brief B74-10223). Although other stereo viewing systems have been examined in various research centers as possible solutions to stereo video imaging, including red-green color TV images and beam splitters using polarized light, all of the other systems greatly restrict the vision of the user, the resolution of the

picture, the number of people capable of viewing the output, and the mobility of the user. The NASA device overcomes all these problems.

Three-D images are built up in a normal individual's mind as a natural consequence of having each eye send a complete image of what it sees to the brain. Since there is some parallax distortion due to the offset anatomical placement of the eyes, these two views are slightly different. Once received by the brain, a single image impression is generated with depth.

NASA's 3-D TV system artificially presents the eyes with separate left and right images from a single video monitor, as shown in Fig. 1. Two synchronized television cameras are both focused on the same scene from two slightly different angles, usually with a  $6^\circ$  difference. Each camera transmits 30 separate pictures, or frames, per second. Each frame is composed of approximately 500 horizontal lines and is transmitted by first relaying the odd numbered lines (called field one), then the even lines (field two). Consequently, each camera transmits 30 images as 60 fields. The mixer combines the outputs of both cameras by throwing out the even fields from the left camera and the odd fields from the right. Therefore, the signal from the mixer to the TV monitor is composed of the odd lines from the left camera alternating with the even lines from the right. This would be perceived as a double image on the monitor which is decoded into separate images for each eye by using the decoding viewer, actually the heart of the NASA stereo-video system. Each lens of the viewer is made of lead lanthanum zirconate titanate (PLZT) ceramic, which functions as a light valve. By applying or removing a voltage across the PLZT wafers, each lens alternately passes, then blocks the impinging light in a duty cycle which is identical to that of the two cameras. Therefore, the left eye only receives light when the image from the left camera is presented, the right eye sees only the right camera's image and a real-time, dynamic stereo image is constructed.

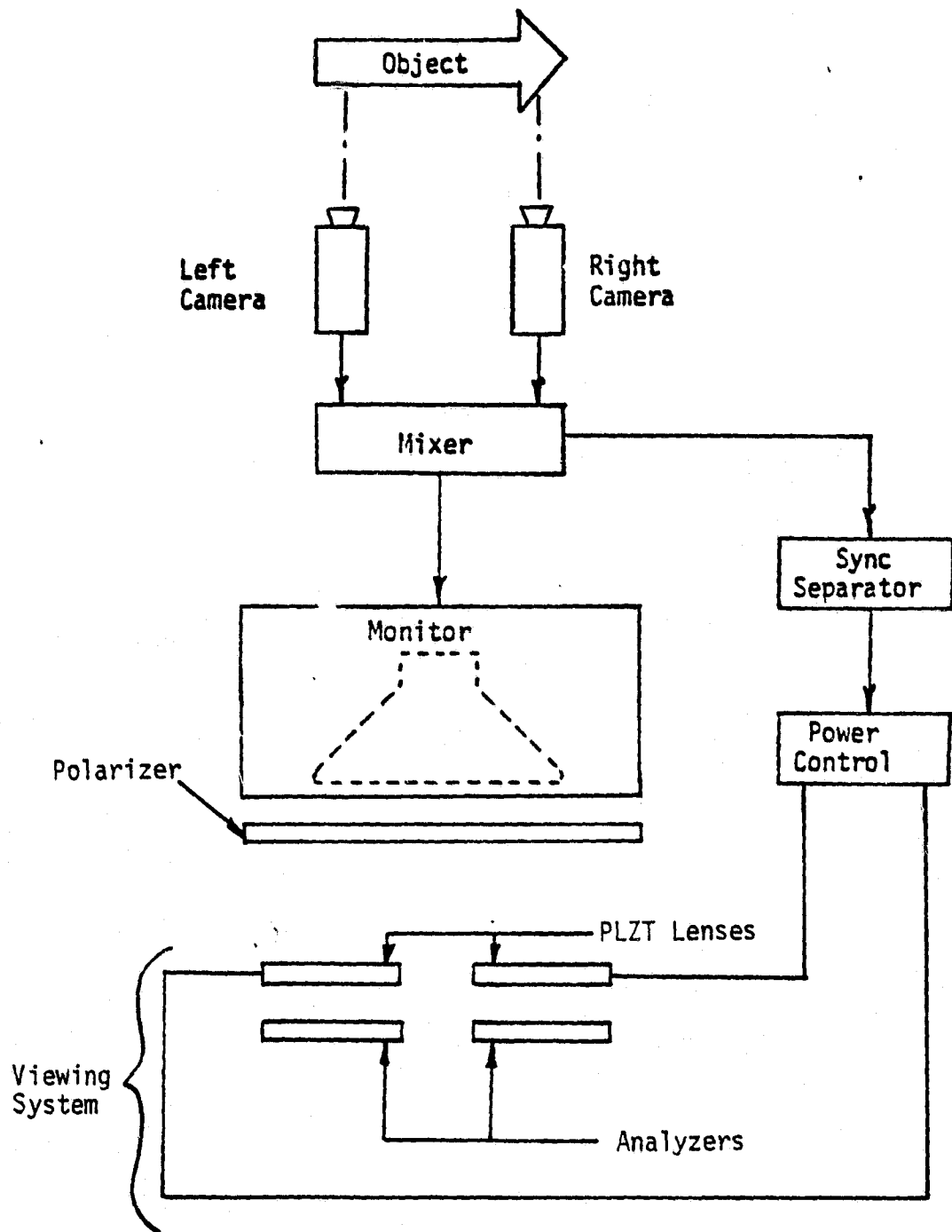


FIGURE 1. NASA STEREO VIEWING SYSTEM

It is interesting to note at this point that the NASA application of PLZT technology toward stereotelevision viewing was not a unique effort. Working on a similar system, and totally unknown to NASA, was John Roese, a research engineer at the Naval Ocean Systems Center in San Diego, California (10). Dr. Roese and the Navy were awarded the exclusive patent rights to this viewing system by the U.S. Patent Office when it ruled that Roese's claim preceded Perry's patent application. As can be seen from Fig. 2, Roese's system differs from Perry's mostly in that Perry placed the polarizer on the video screen, while Roese placed the polarizer on the front face of the PLZT viewers. The relative advantages and disadvantages of these two placement schemes were not considered for this study.

### C. Application of Stereotelevision to Fluoroscopy

Fig. 3 shows a schematic of a conventional fluoroscope, a device which has a real-time display of dynamic x-ray images. These images are created by sending a collimated beam of x-rays from a source, through a three-dimensional body, and onto a phosphor screen on the image intensifier. Denser portions of the body being viewed stop many of the x-ray photons so that these denser areas appear as darker images on the image intensifier screen. In this way, bone and other radiopaque materials in the body (both natural and artificial) are viewed easily against the relatively radiotransparent tissue. Since these shadow images are projected onto a two-dimensional screen, separate radiopaque parts of the object being viewed, which are above one another in 3-D space, appear on the 2-D screen as intersecting areas, causing one of the leading difficulties in analyzing fluoroscopic images; that is, no perception of depth is possible and only intimate knowledge of human anatomy enables the viewer to mentally rank the depth of these separate shadows shown on the fluoroscopic image. A stereofluoroscope would correct this problem.



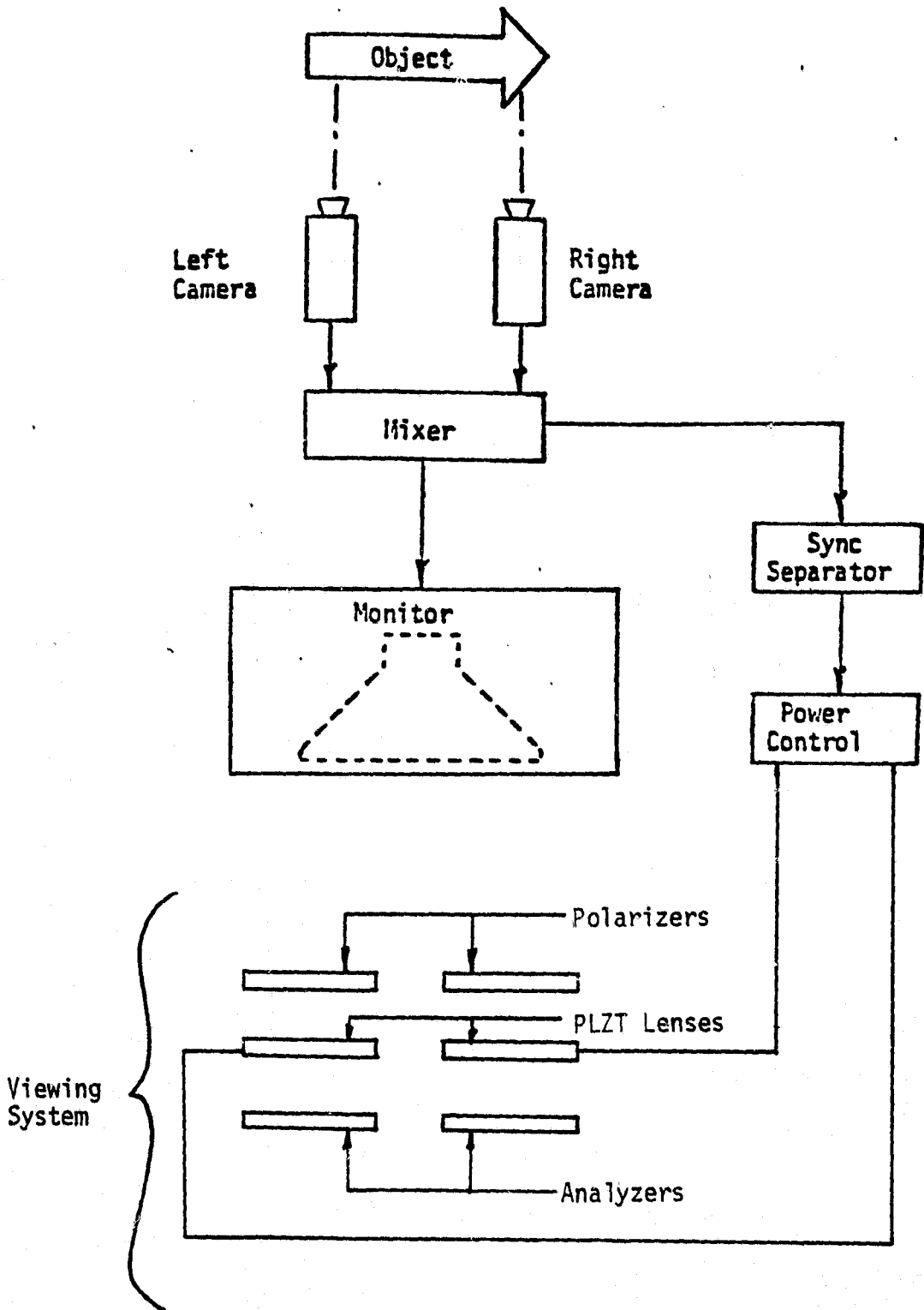


FIGURE 2. NAVY STEREO VIEWING SYSTEM

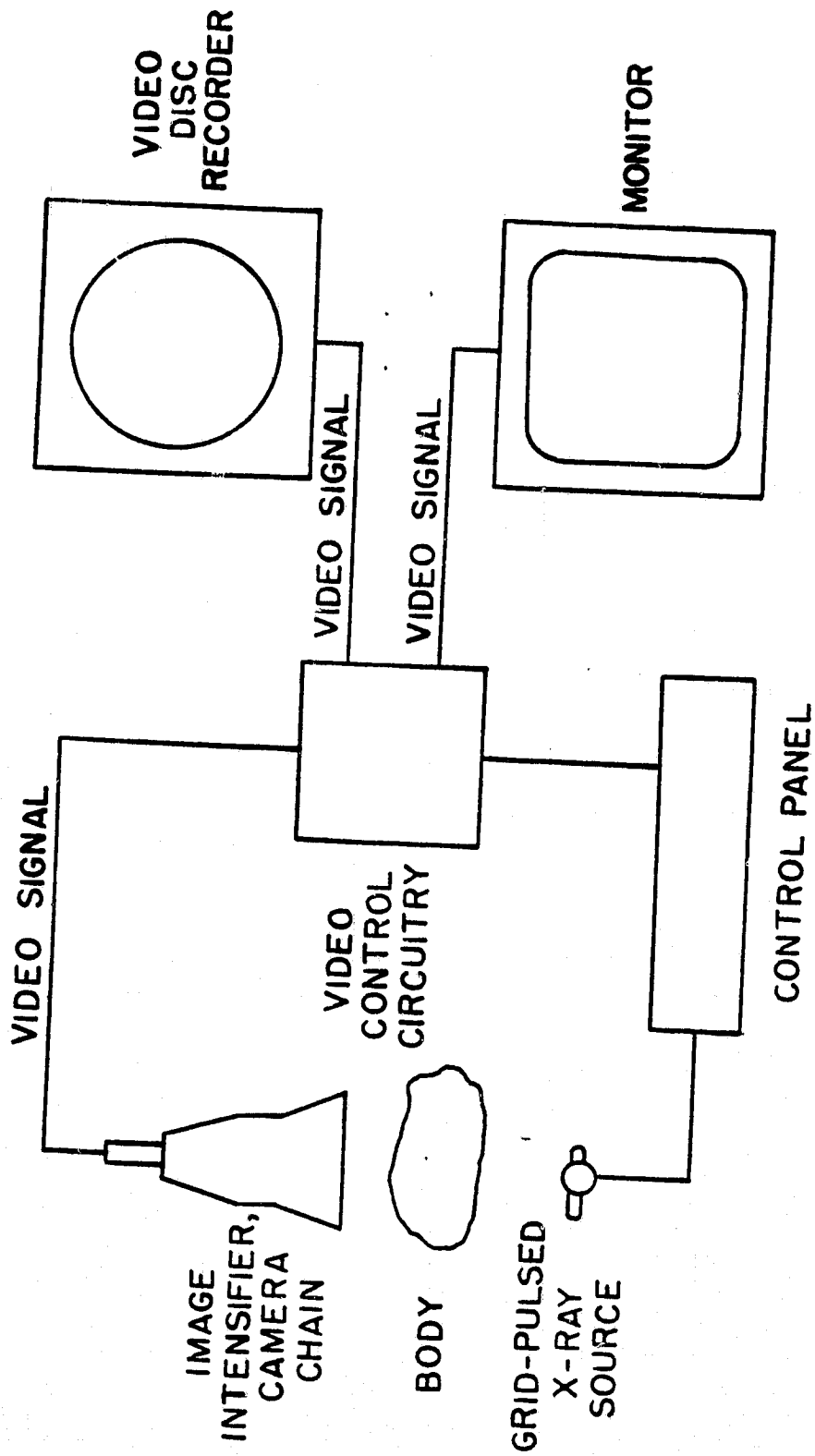


FIG. 3 2-D, PULSED FLUOROSCOPE

As can be seen in Fig. 4, the fluoroscopic application of NASA's stereo-video system differs from the original application only in terms of the input to the video signal mixer; the viewing system remains unchanged. Two x-ray tubes are alternately pulsed to provide bursts of x-ray photons which pass through the patient's body and create alternate parallax images at the image intensifier, a dose reduction device. These alternating images are synchronized with the viewer lenses so that the left eye only sees the image created by the left tube photons, while the right eye only sees the right tube image.

The next chapter describes the breadboard stereofluoroscopy system.

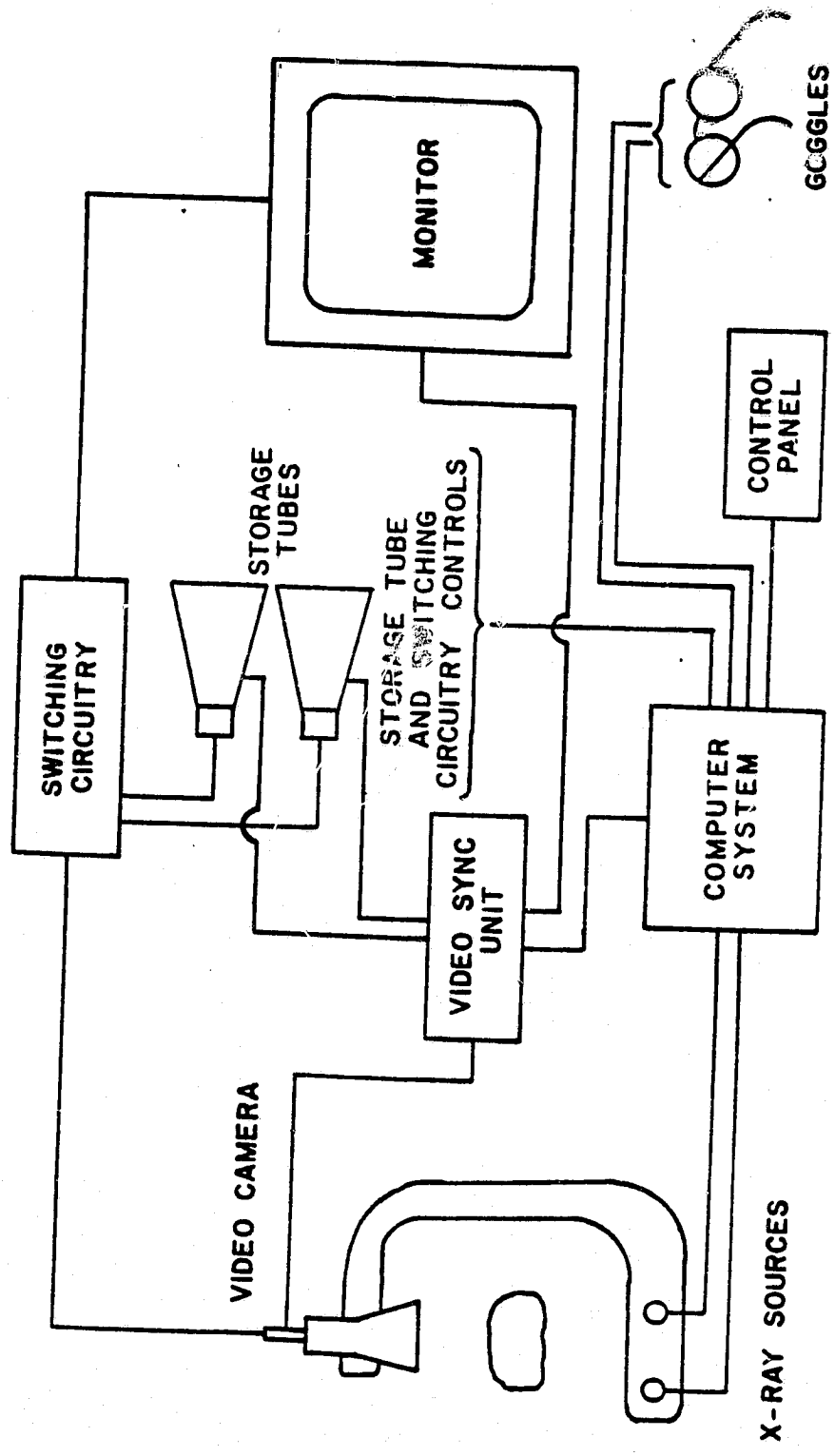


FIG. 4 TOTAL STEREOFUOROSCOPIC SYSTEM

## II. Description of the Stereofluoroscopic System

### A. Equipment

A general schematic of the breadboard stereofluoroscopic system is shown in Fig. 5. Because of the high cost of new medical-grade radiological equipment when compared with the contract funding level, it was necessary to purchase used hospital fluoroscopic equipment as components for the stereo system. These components were such that they had reached the end of their clinical life and had been replaced by various hospitals for newer and/or more technologically advanced equipment. However, these used components were carefully chosen so that they were still capable of performing the specific laboratory functions necessary to this stereo project. As can be seen in Table 1, although most of the electronic components were from hospital surplus, many required extensive modification to be compatible with a 2-tube stereofluoroscopy system. The pulse tank, controls, shielding, and structural components were entirely of our design.

### B. Laboratory

The stereofluoroscopy system was constructed in laboratory space in Randolph Hall, an engineering classroom and laboratory building on the campus of the Virginia Polytechnic Institute and State University in Blacksburg, Virginia. The only significant parameter of this particular laboratory was its sixteen foot high ceiling, which enabled the device to be mounted so the x-ray tubes were at ground level and aimed up toward the image intensifier. Above the ceiling was restricted roofing, so that there was no danger of inadvertent exposure of any personnel to the primary beam. A sixteen-foot high lead covered containment room was constructed to shield from secondary radiation. This eight-by-eight feet square "telephone booth" enabled protection within the laboratory from harmful radiation without having to lead shield the entire laboratory. Monitoring of radiation levels inside the laboratory but outside

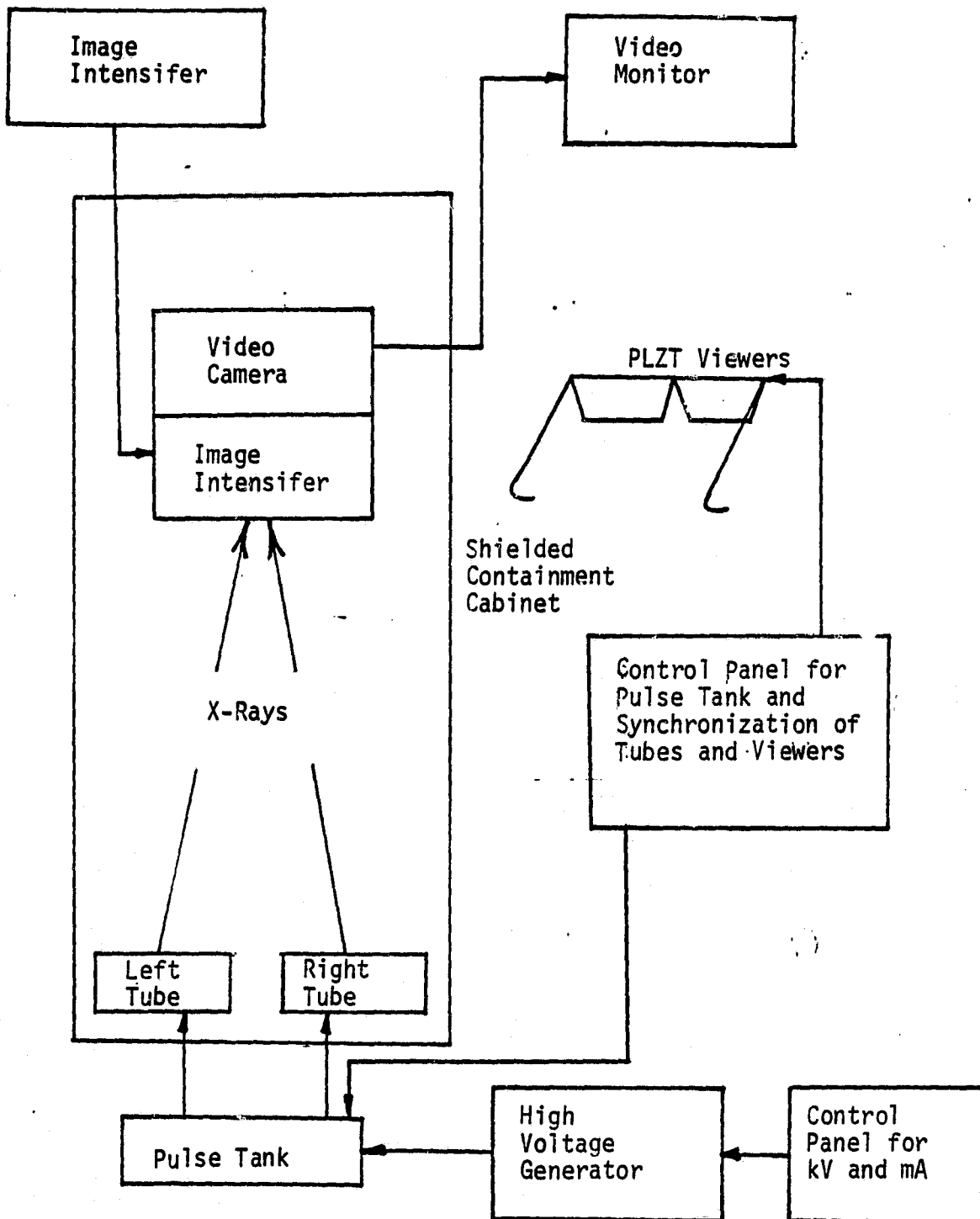


FIGURE 5. SCHEMATIC OF BREADBOARD SYSTEM

TABLE 1  
Sources of Equipment

<u>Component</u>	<u>Source</u>	<u>Remarks</u>
KV & mA control panel	M & M Equipment Co. Houston, Texas	Hospital surplus completely rebuilt to accomodate 2-tube operation
High voltage generator	"	Hospital surplus
Pulse tank	"	Breadboard system constructed by M & M Equipment Company
X-ray tubes	"	Hospital surplus
Image intensifier and power supply	"	Hospital surplus
Video camera	"	Hospital surplus
Video monitor	VPI & SU Blacksburg, Virginia	Surplus
Pulse synchronization control	"	Breadboard system constructed at VPI & SU
Shielded cabinet	"	Designed and constructed at VPI & SU
Viewer system	Megatek Corporation San Diego, Calif.	Preproduction model on loan to this project

the containment structure showed that laboratory personnel were exposed to no radiation levels above background. The x-ray tubes, target platform, image intensifier, and video camera were mounted on a rigid jig which was built on a dolly, so that the entire system could be removed from the containment structure for modification or a change of x-ray phantoms. A microswitch installed on the door of the containment room broke the control circuit to the x-ray tubes when the door was opened so there was no danger of inadvertent radiation exposure if the system was accidentally activated while the door was open.

### C. Viewing System

The key to this stereofluoroscopic system is the NASA developed PLZT viewers. It was expected that these GFE viewers would be used for decoding the double video images. However, when they were finally delivered, it was discovered that they had undergone significant degradation since the 1973 experiments. Apparently, in the subsequent years the grids which had been bonded to the PLZT crystals became unbonded in spotty sections all over both lenses. The net result of this was that they were useless for this series of viewing experiments. Discussions with the NASA-JSC group which had developed these viewers determined that these viewers were the only ones which had been constructed by NASA. An alternative set had to be found.

Further discussion with Dr. Roese indicated that none were readily available from the Naval Ocean Systems Center. However, Dr. Roese was aware of imminent commercial manufacture of his patented viewers by Megatek Corporation of San Diego, California. Megatek intended to use the viewers to produce stereo displays for graphical output computers. Dr. Ross Stone, the chief engineer of this project at Megatek, offered to loan a preproduction set of viewers so that the demonstrations of the stereofluoroscopic system could take place. Eventually a commercial pair of viewers was purchased by NASA for this



system, but at present these viewers are at JSC, not VPI & SU.

#### D. System Operation and Control

In order to produce fluoroscopic images, the x-ray tubes are alternately pulsed with an anode-to-cathode potential of 50 kV to 85 kV. This high voltage is controlled by the kV control box which also independently varies the milli-ampereage of each tube from 0 to 4.5 mA. The kV of the two x-ray tubes cannot be set independently. This control box also contains switches which allow the fluoroscopic unit to operate by pulsing a single tube, either left or right, in addition to the 2-tube stereo mode. The 208 V signal from this control station goes to the high voltage generator where it is amplified to the kV setting of the control box. This amplified voltage signal is then sent to a pulse tank which changes the d.c. amplified voltage to two pulsed square waves, one for each tube. The pulse width and repetition rate for each tube are separately controlled by TTL 5 V logic at the synchronization control station, thus giving the operator complete control over the operating characteristics and synchronization (including phase lag) of each x-ray tube.

The images which are built-up on the output screen of the image intensifier are transferred to the video camera by direct optical coupling. The video signal is then sent to a video monitor for viewing. The synchronization control station also controls the pulse width and repetition rate of the 500 V signals to each viewer lens so that the left lens transmits light to the left eye only when the image from pulsing the left tube appears on the monitor and the right eye receives only right tube information.

### III. Operating Characteristics and Limitations

The breadboard system previously described was capable of presenting the viewer with a real-time stereofluoroscopic image with both static and dynamic phantoms. It was successfully demonstrated to interested commercial corporations in early August, 1979. A more complete discussion of these demonstrations is given later in this chapter.

As successful as these demonstrations were, however, this breadboard system operated with some limitations which a final clinical device would not have. These limitations were caused by the operating characteristics of some of the components of the system. A clinical system would be constructed of state-of-the-art components which would alter the operating characteristics of the stereofluoroscope for the better. These limitations fall into basically two areas; image clarity and repetition rate.

#### A. Image Clarity

In order to produce a stereo pair of fluoroscopic images, the angle between the x-ray beams from the left and right tubes toward the center of the image intensifier target should be no more than  $6^\circ$ . Although some individuals are capable of resolving two parallax views of  $10^\circ$  or more into a mental stereo picture, the general population would not resolve more than a  $5^\circ$  to  $6^\circ$  parallax at best. This means that the distance between each focal spot (source) on the x-ray tubes and the input to the image intensifier should be approximately ten times the distance separating the left and right focal spot; the arctangent of  $6^\circ$  is approximately 0.1. Most fluoroscopes which are used clinically have no more than 36 in. separation between the focal spot on the tube and the image intensifier. However, the standard x-ray tube is a cylindrical tube approximately 9 in. in diameter. Placing these tubes side by side would necessitate locating the image intensifier 90 in. away. This problem was somewhat reduced in our breadboard system by

staggering the two tubes (see Fig. 6). In this way we were able to reduce the distance between the focal spots of each x-ray tube to 5.5 in.; thereby reducing the tube-to-image intensifier distance to 55 in. Note that the geometry of the tubes and the necessity of  $\phi_{MAX} = 6^\circ$  made it impossible to have the 55 in. dimension reduced any further. The mA setting of the lower tube was slightly higher than that of the upper tube in order to make the left and right images of approximately equal brightness on the image intensifier.

This extra 19 in. travel of the x-ray photons diminished the energy of the photons incident on the image intensifier due to the inverse square law. Consequently, a higher than normal kV setting (instead of 50 kV) was needed to create an image of sufficient brightness. The higher-than-normal photon energies caused the photons to make a harsher than normal image, thus reducing the image quality. Also, the extra travel of the photons created more opportunity for photon scatter, which caused a blurring of our image. This blurring was magnified by our removal of the beam collimators from each x-ray tube in order to move them as close together as possible. Also, no target grid was used. A grid is a series of vertically oriented thin lead plates which absorbs most photons which would strike the input screen of the image intensifier at other than a  $90^\circ$  angle. The use of a grid would have eliminated much of the scattered photon noise which was present in our images.

#### B. Repetition Rate

Ideally, this system would operate in a clinical environment with an image update rate of 30 frames/sec. (or 60 tube pulses/sec.) so as to be compatible with most available video monitoring equipment. This rate was not possible using the surplus equipment available to this project. Our image intensifier had a Zinc screen, which was the state-of-the-art output screen when the intensifier initially went into clinical service, but which is now

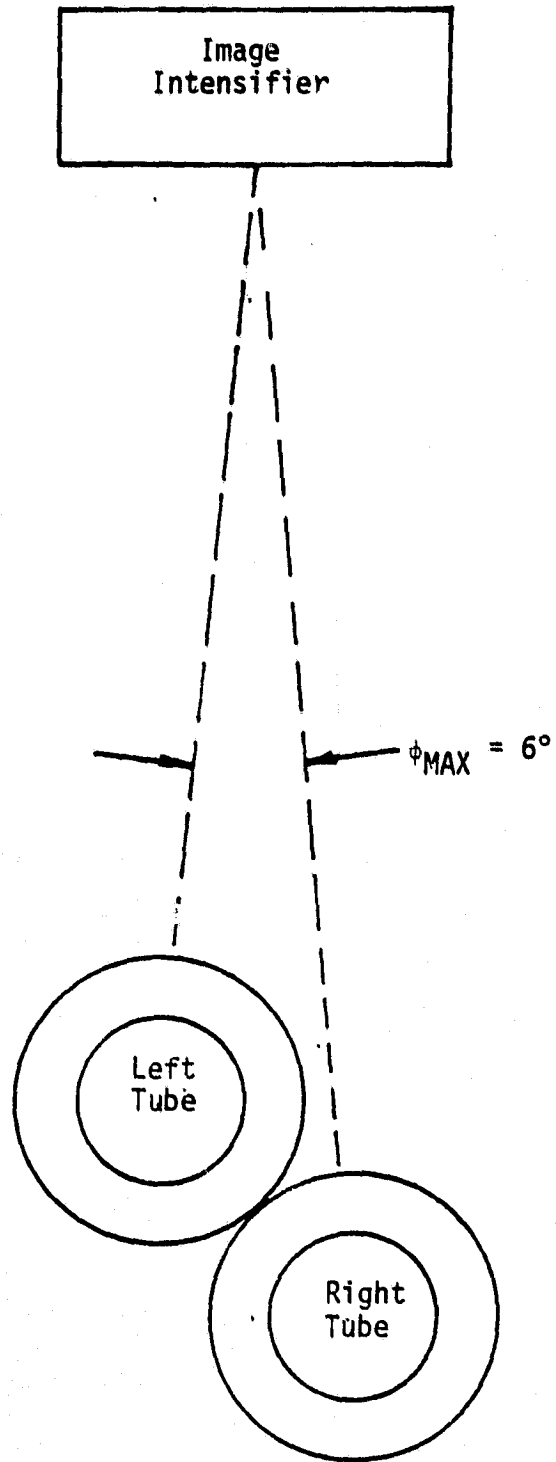


FIGURE 6. X-RAY TUBE ARRANGEMENT

considered "slow" when compared with the newer Cesium screens now available. The old Zinc screens differ from the new Cesium ones in that Zinc screens have noticeably more persistence. The stereo effect is ruined unless absolute integrity is maintained between the left and right images; that is, a stereo image cannot be made if there is bleedover between the images. Consequently, the system could not be operated at a repetition rate higher than the entire system could accommodate. Noticeable persistence occurred above 18 frames/sec. (or 36 tube pulses/sec.). It could not be determined whether this upper limit was completely caused by output persistence on the image intensifier or if it was magnified by internal persistence of the video camera optically coupled to it. In either case, the results were the same.

It is interesting to note that contrast ratio of the PLZT lenses became a problem at this low repetition rate. These lenses do not act as true light valves with off and on modes corresponding to 0% and 100% light transmittance. Instead, the lenses change their contrast ratio by at least 1000:1 when energized. Therefore, even when in the "off" mode, a small amount of light, and, consequently, a small amount of the left (right) picture, is transmitted to the left (right) eye when the right (left) eye is viewing the right (left) image. At a 60 Hz tube firing rate each lens is "on" or "off" for such a short time that the viewer perceives the lens to be a true light valve. However, at a 36 Hz tube firing rate each lens is "off" long enough to allow the "off" eye to integrate some of the light from the image being sent to the "on" eye. The viewer perceives this as image bleedover. This, of course, would not be a problem when the final clinical system operates at 60 Hz.

### C. Demonstrations

In light of the component limitations discussed in the previous chapter, it is remarkable that the final stereofluoroscopic image which we generated

was as clear as it was. However, such was the case. Dr. Burton Newmark, a radiologist at Montgomery County Hospital, Blacksburg, Virginia viewed the system on July 24, 1979. He was surprised at our good image quality, which, although faulted, was near to being of clinical quality.

This system was demonstrated to several industrial manufacturers between late July and early August 1979. Table 2 shows the parties involved, what corporations they represented, and the demonstration dates. Dr. Stone from Megatek Corporation, the ultimate supplier of the PLZT lens systems, was present at the last two demonstrations.

The demonstrations consisted of viewing phantoms composed of discrete metal objects (pennies) separated by radiotransparent rubber and arranged in several layers (See Fig. 7). All present, except Dr. Scharfman, were able to clearly observe the stereoscopic nature of the device. Dr. Scharfman's inability to correctly resolve the stereoscopic images was caused by an eye defect which precluded his having normal depth perception. Fortunately, he came to the demonstration with Dr. Mahn, who was able to resolve the images in a normal manner.

TABLE 2

Demonstration Participants

<p>Skia Corporation 460 Division Street Cambell, California 95008 (408) 374-5840</p>	<p>R. Maurice Tripp President</p>	<p>July 24, 1979</p>
<p>Seimens Corporation 186 Wood Avenue, South Iselin, New Jersey 08830 (201) 494-1000 ext. 2274</p>	<p>Bert Stadler Product Manager, x-ray</p>	<p>July 26, 1979</p>
<p>Honeywell, Inc. Honeywell Ceramics Center Defense Electronics Division 1885 Douglas Drive Minneapolis, Minnesota 55402 (612) 542-7189</p>	<p>Orlen F. Rice Program Manager</p>	<p>August 1, 1979</p>
<p>Raytheon Company Microwave and Power Tube Division Waltham, Massachusetts (617) 899-8400 ext. 4361</p>	<p>Howard Scharfman Manager Business Development</p>	<p>August 2, 1979</p>
<p>Machlett Laboratories Stanford, Connecticut (owned by Raytheon)</p>	<p>George Mahn</p>	<p>August 2, 1979</p>

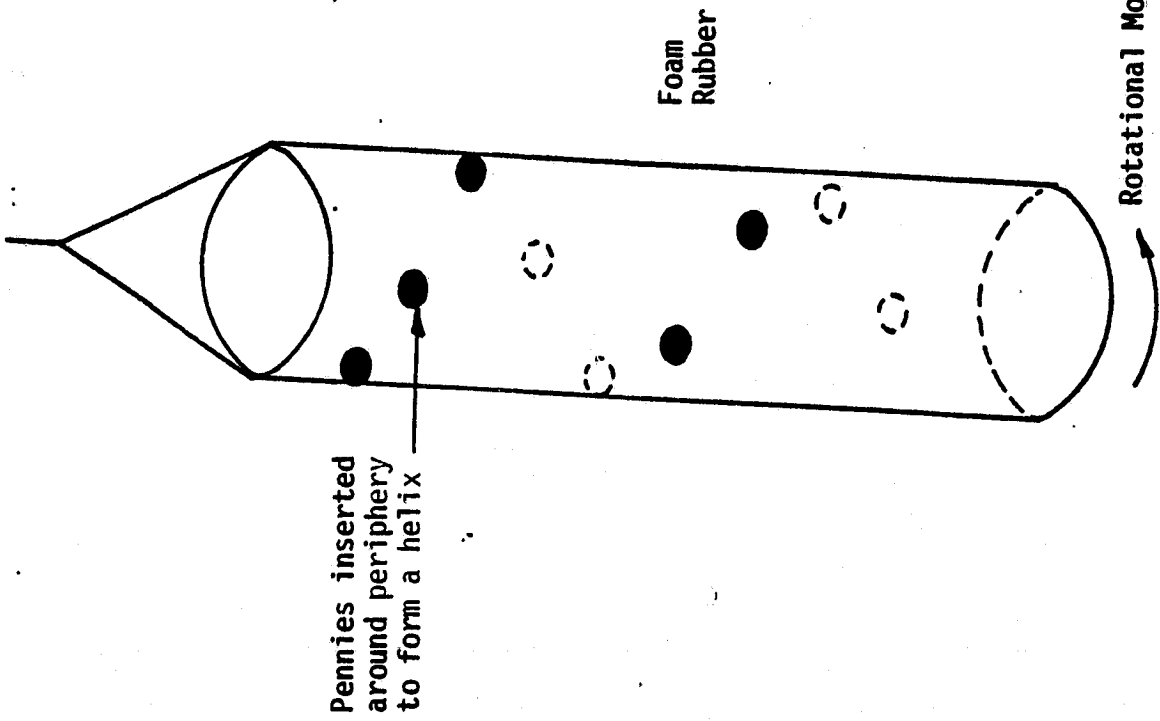


FIGURE 7B. VIEW OF DYNAMIC PHANTOM

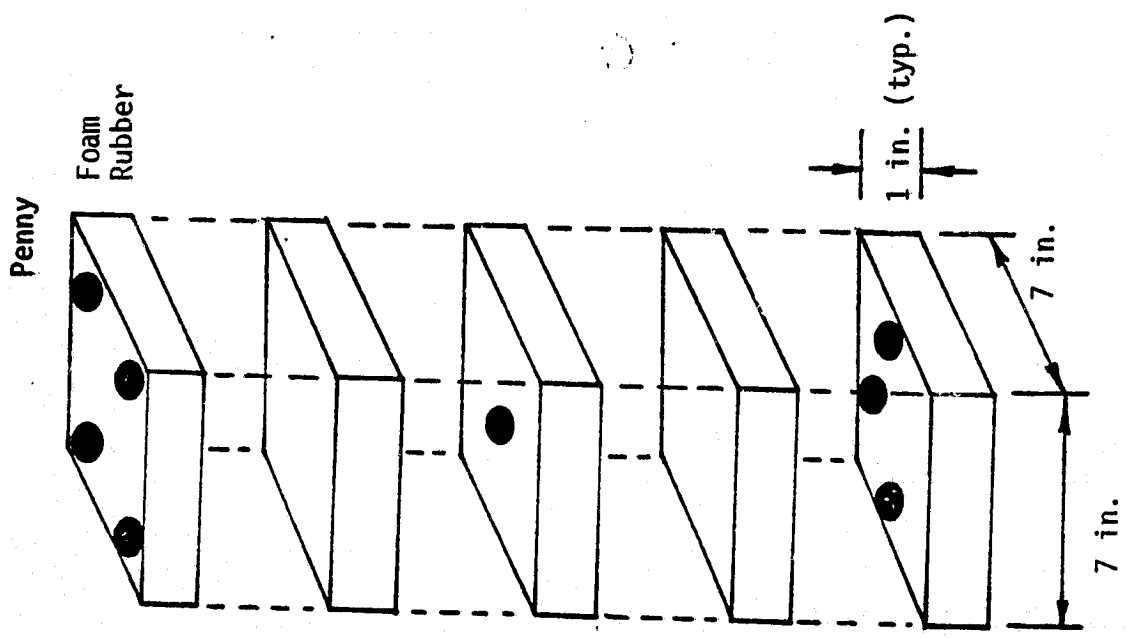


FIGURE 7A. EXPLODED VIEW OF STATIC PHANTOM

FIGURE 7. X-RAY PHANTOMS



#### IV. Conclusions and Developmental Recommendations

A breadboard fluoroscope with a dynamic, real-time video output has been successfully developed, tested, and demonstrated to several interested commercial manufacturers of medical and industrial fluoroscopes. A collection of letters from physicians in various areas of medicine testifying to the utility of such a system is found in the Appendix. These areas include cardiac catheterization, angiography, hip pinning, podiatry, arteriography, and anatomical and radiological teaching. The unit also has applications in the non-medical area of non-destructive testing. This system could not only be made into a new type of diagnostic equipment, but could also be made a part of existing clinical systems through proper retrofitting.

However, there is additional developmental work that needs to be done to this system before it is used clinically. Most of this work involves the application of newer component technology. By replacing the standard x-ray tubes with the new pencil sized radiographic enlargement tubes developed by Skia Corporation and others, the tubes could be placed close enough together so that, without staggering the tubes, a  $6^\circ$  or less parallax angle could be used without having the image intensified more than 36 in. away from the tube target. These new tubes have focal spots of 0.01 mm square as opposed to the 0.6 mm square of standard tubes. The smaller focal spot makes the x-ray source, for all practical purposes, a tube point source, so that no penumbra shading of the image edges is seen and the image appears sharper. Also, the combination of collimating the x-ray beams, lowering the focal spot-to-image intensifier distance, and using a grid at the image intensifier would significantly lower the photon scatter noise which now appears on our system.

Using a newer image intensifier with a faster screen (Cs as opposed to Zn) and an external blanking mode, combined with a faster video camera (Plumicon as opposed to Vidicon) would enable the system to operate at 60 Hz or faster

without bleedover of the left and right images.

Our system creates a higher dose rate since each frame must be formulated from two x-ray bursts through the patient, double the conventional rate. However, by inserting a video storage device into the system, this increased dosage could be considerably reduced, in fact, reduced below that of conventional fluoroscopy. This could be performed by taking advantage of the instantaneous storage and retrieval capability of a video storage device. The signal from the mixer could be sent into video storage instead of the monitor. Then the stored frames could be transmitted to the video monitor on a repeating basis, thereby using the image intensifier output only to update the storage device, not for direct video display. In this manner the x-ray tubes need not be activated to obtain a continuous fluoroscopic image on the monitor. The tubes have to have paired pulses at the frame update rate only. Since many clinical fluoroscopic procedures are views of static systems or systems which are dynamic but do not require an update rate of 30 frames per second, using a video storage device to feed the monitor would significantly reduce the patient's dose over that of continuous fluoroscopy without sacrificing the real time aspect of the viewing system. Of course, a video tape recorder could be attached to the system to provide a permanent record of the clinical test procedure in either stereo or monoptic form. The dose reduction system described above has been successfully performed experimentally using a conventional fluoroscopy setup and is readily adaptable to stereo viewing (11).

As a final remark, it must be emphasized that the direction of this work was toward the development of a medical device. The non-medical applications of this system should also be investigated, particularly in the area of non-destructive testing. Such applications of stereofluoroscopy may ultimately be even more significant than the medical ones.

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DEPARTMENT OF MEDICINE

September 2, 1976

Dale B. Rivers  
Assistant Professor  
Department of  
Mechanical Engineering  
Virginia Polytechnic Institute  
and State University  
Blacksburg, Virginia 24061

Dear Dale:

It was a pleasure to see you in Atlanta this week and catch up on your recent activities. I am intrigued by the description of the NASA stereo-fluoroscopy system contained in your technical report. This system would appear to have considerable potential for clinical application in Cardiac Catheterization Laboratories. A significant contribution might be made in the area of arteriography: e.g. in coronary arteriography where three dimensional viewing of small vessels surrounding a spherical mass (the heart) is very important. Applications also suggest themselves in the area of ventriculography where an irregular, solid geometric structure must be analyzed during changes in shape and size. Video recording systems for instant replay are used in conjunction with the fluoroscopy and cine filming equipment in most catheterization laboratories and could probably be adapted to the videodisc component in order to reduce radiation dosage to the patient. Two problem areas would seem to be: (1) integration of stereo fluoroscopy with the cine system and videodisc/videotape system-including related problems of cost and size; (2) the method of stereo viewing for the physician and/or technicians - the "goggles" are not described and the method of "stereo viewing" a monitor TV screen could be a major problem.

Keep me posted on your work in this area.

Sincerely,



Donald O. Nutter, M.D.  
Professor of Medicine (Cardiology)

DON:ch

*Journal*  
*of the*  
*American Podiatry Association*

E. DALTON McGLAMRY, D.P.M.  
Editor  
1649 Brockett Road  
Tucker, Georgia 30084

September 1, 1976

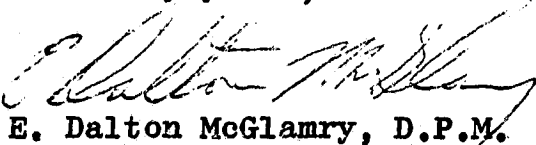
Mr. Dale B. Rivers  
Assistant Professor  
Department of Mechanical Engineering  
Virginia Polytechnic Institute  
Blacksburg, Virginia 24061

Dear Mr. Rivers:

I will be most interested in your work on three dimensional fluoroscopy. I feel that this has potentially great application in podiatry for examining biomechanical function especially in the patient with arthritis and other chronic diseases effecting the foot and ankle.

Please keep us informed as to the progress of this most interesting project.

Sincerely yours,



E. Dalton McGlamry, D.P.M.

dp

CARDIOVASCULAR DISEASES

DON W. CHAPMAN, M.D.

H. LISTON BEAZLEY, M.D.

WILLIAM L. WINTERS, JR., M.D.

WILLIAM H. SPENCER, III, M.D.

W. RICHARD CASHION, JR., M.D.

September 24, 1976

Diplomats—American Board of  
Cardiovascular Diseases

Dr. Dale Rivers  
Associate Professor of Mechanical  
Engineering, VPISU  
Blacksburg, Va. 24061

Dear Doctor Rivers:

Mike Smith at Methodist Hospital here in Houston has given me your name and address and discussed briefly with me your interest in steriofluoroscopy. My purpose in writing is to re-enforce his belief that in cardiac catheterization work steriofluoroscopy would be extremely valuable. I was first intrigued with this concept as a young Cardiologist in Philidelphia at the Temple University Medical School where Dr. Herbert Stauffer of the Radiology Dept. and several members from General Electric worked for a number of years on stereoscopic fluroscopy using colors, I believe green and red. I moved from Philidelphia and lost track of the development of their work but have always felt strongly that steriofluoroscopy would offer a great deal to the individual doing cardiac catheterization work. I am still actively involved in the catheterization laboratory at Methodist Hospital and wanted to add my endorsement for such investigation.

Sincerely yours,



William L. Winters, Jr., M.D.

WLW:mjh

GEORGETOWN UNIVERSITY HOSPITAL

3800 RESERVOIR ROAD, N.W.  
WASHINGTON, D.C. 20007

DEPARTMENT OF RADIOLOGY

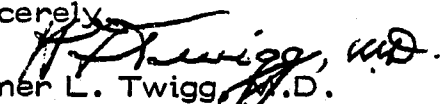
March 1, 1976

Mr. Dale Rivers  
Dept. of Mechanical Engineering  
Virginia Polytechnic Institute  
and State University  
Blacksburg, Virginia 24061

Dear Mr. Rivers:

Reference to our conversation, this morning, the concept of stereo fluoroscopy is an interesting one. Our present technology for three dimensional localization is fairly accurate. To be able to do so with a fluoroscope may have some medical applications, particularly in operative and special procedures where it is difficult to move the patient and you wish to localize a lesion, instrument, or catheter. It would be worth pursuing the clinical application of such an instrument providing, of course, the expected results would be beneficial to the patient, and the Federal Radiation Standards would be observed. I will be interested in hearing of further developments of this technology.

Sincerely,

  
Homer L. Twigg, M.D.  
Professor and Chairman

HLT/r

**United States Testing Company, Inc.**  
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March 24, 1976

Mr. Dale B. Rivers  
Assistant Professor  
Virginia Polytechnic Inst. & State Univ.  
Blacksburg, Virginia 24061

Dear Sir:

As you remember from our tel-con I believe that stereo fluoroscopy results could be very beneficial to industry.

Three dimensional information would enable industry to establish quantitative acceptance criteria. A significantly higher degree of reliability would certainly results.

Very truly yours,

UNITED STATES TESTING CO., INC.

W. C. Plumstead  
Vice President

WCP/par