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BIOMEDICAL APPLICATIONS OF NASA SCIENCE AND TECHNOLOGY

Contract No. NSR-34-004-035
RTI No. EU-279

Quarterly Progress Report 3
15 December 1966 to 14 March 1967

Prepared for

National Aeronautics and Space Administration
Technology Utilization Division
Washington, D. C. 20546

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

BIOMEDICAL APPLICATIONS

OF

NASA SCIENCE AND TECHNOLOGY

J. N. Brown, Jr.

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ABSTRACT

This third quarterly report covers the activities of the Research Triangle Institute's Biomedical Applications Team during the period from December 1966 to 14 March 1967. The work is being supported by NASA contract NSR-34-004-035. This report was prepared by Dr. J. N. Brown, director of the applications team. Other team members contributing to this program are Dr. E. A. Johnson, Professor of Cardiac Pharmacology, Duke University Medical Center, Durham, North Carolina; Dr. F. L. Thurstone, Professor and Director, Department of Biomedical Engineering, Bowman-Gray School of Medicine, Wake Forest College, Winston-Salem, North Carolina; Dr. M. K. Berkut, Associate Professor, UNC Medical School, Chapel Hill, North Carolina; and RTI staff members Mr. Ernest Harrison, Jr., Engineer; Mr. J. W. Murrell, Physicist; and Dr. H. G. Richter, Chemist. Additionally, the following individuals act as liaison between the applications team and the staff of other medical institutions: for the Dental Research Center, School of Dentistry, University of North Carolina, Chapel Hill, North Carolina, Dr. A. D. Dixon, Assistant Dean; for Rockefeller University, Monte Fiore Hospital and the Albert Einstein Institute, New York, Dr. Lawrence Eisenberg; and for the Hospital for Special Surgery, New York, Dr. William Cooper, Director of Rehabilitation Medicine.

1.0 Introduction

This report summarizes the activities of the Research Triangle Institute's Biomedical Applications Team during the period from 15 December 1966 to 14 March 1967. During this reporting period, the activities of the applications team have been directed primarily toward the following:

(1) Completing a number of technology transfers.

(2) Increasing the general capabilities of the team.

(3) Analyzing and changing the operation of the team to make it more effective.

(4) Analyzing the applications team's consultants roles.

(5) Studying the preparation of problem abstracts and the method of performing information searches in an attempt to improve these information channels.

(6) Expanding the team's contacts to the Veteran's Administration Hospital in Durham, North Carolina, the Hospital for Special Surgery in New York and the Albert Einstein Institute in New York.

Before discussing the results of this work, the overall program objectives are reviewed and discussed in the following section.

2.0 Program Objectives

The Technology Utilization Division of the National Aeronautics and Space Administration is making very significant efforts to transfer the scientific and technological results of aerospace activities in general to industry and educational institutions. There are many instances of success in this technology utilization program. One of the most important areas to which technology can be transferred is the field of medicine. There are, however, some rather unique problems associated with the transfer of technology to problems existing in the biomedical field. Many of these problems are related to the differences in both language and methodology used in the physical and life sciences.

In order to facilitate the transfer of scientific information to clinicians and biomedical researchers, NASA is presently supporting three multidisciplinary teams working in this area. The primary objectives of these "biomedical applications teams" are:

(1) To identify existing problems in the field of biomedicine which appear to be "solvable" by the application of aerospace science and technology.

(2) To identify technology or concepts leading to solutions of these problems.

In achieving these objectives, members of the applications team discuss specific problems which are being encountered in both medical research and practice with researchers and clinicians at participating medical institutions. These meetings are coordinated by consultants, or contacts, at these institutions. Members of the team attempt to understand fully the nature of the problem and how it is affecting progress of research or hindering patient treatment and care. Biomedical problem abstracts defining these problems clearly and in the terminology of engineers and physical scientists are then prepared. These are sent to NASA centers, as well as other organizations, in an attempt to uncover any information which may lead to a solution. At the same time, the team takes advantage of the NASA information retrieval services, such as those offered by the Science and Technology Research Center located in the Research Triangle Park, in an attempt to uncover any information related to these medical problems. All information obtained, resulting from problem abstracts or information searches is then evaluated. This evaluation is aided by the university consultants, as well as the researchers and clinicians who originated the problems. Finally, the team both encourages and aids the application of any suggestions, information or technology which results from these activities.

The following sections contain discussions of completed and potential transfers of aerospace technology to a number of these problems.

3.0 Technology Transfers

During the preceding quarter, five transfers of technology have been achieved. It is perhaps significant that each of these involved a different channel by which information can be transferred to the medical field. These five transfers are discussed in the following paragraphs.

3.1 Correction for Latency in Vidicons

This particular problem was describedin Biomedical Problem Abstract DU-6 and was submitted to NASA in December 1966. A description of the problem taken from DU-6 follows:

Needed

A method of correcting for the lag or image retention in vidicons used in viewing the rapid movements of muscle tissue.

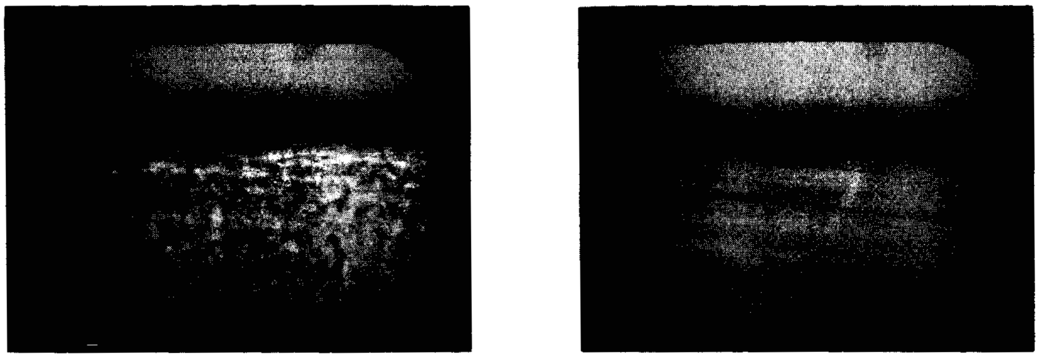
Background

Precise and quantitative measurements of the length of single muscle cells as a function of time during both contraction and relaxation can lead to a better understanding of the fundamental process of muscle contraction. For example, this information may be helpful in identifying the chemical reactions and ionic movements which are most significant in the mechanisms of muscle contraction.

At present, these rapid muscle movements are recorded using a television camera and a video tape recorder. The image is magnified by a factor of ≈1000 by using an optical microscope between the muscle and television camera. Further magnification by a factor of 1 - 5 is attained by the television system itself. This video recording allows one to repeatedly study and observe the movements of a single muscle cell. However, the image appears quite blurred during the times that the muscle cell is contracting or relaxing. This blurred motion results from latency or memory in the vidicon used in the television camera. As observed on the television monitor, the movement of the muscle cell can amount to approximately 1/4 of the width of the picture within 50 milliseconds. The vidicon used at present in the television camera is an English Electric Valve Co. Ltd., JEDEC Designation 8626. A copy of its published lag characteristics is attached.

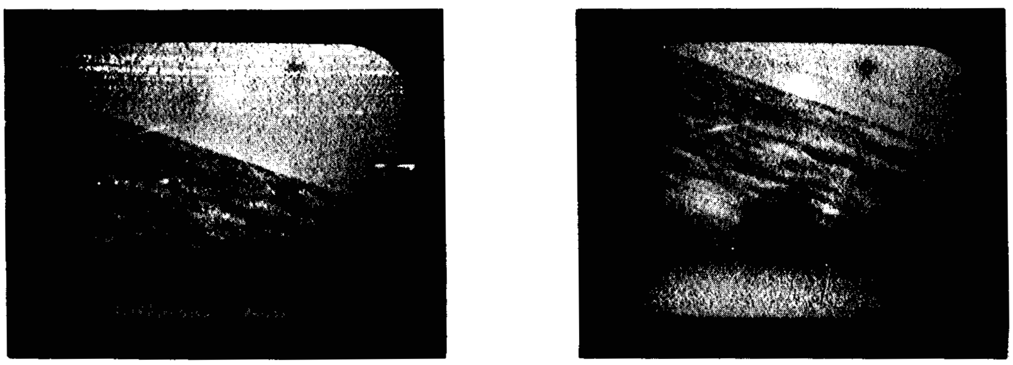
A method of correcting for these latency effects by image processing techniques or by some other method would be a great help in this program. Analog image processing techniques would be preferable to digital processing because at present there is no facility at Duke for digitizing the video data. Also, any information related to the possibility of obtaining vidicons which have been selected for low photometric constants would be the easiest solution to this problem.

A solution to this problem came from Donald Buchele at Lewis Research Center. The solution involved using a stroboscopic light source synchronized with the 60 per second framing rate of the closed circuit TV system. Initial experiments with the stroboscopic light source indicate that latency problems have been reduced to an acceptable level. Figures 1(a)-(d) are television images of cardiac muscle tissue both with and without stroboscopic lighting. Muscle tissue as viewed with continuous lighting and when not in motion is illustrated in (a). When this tissue is moving as a result of contraction, the image appears as in (b). Note the extreme blurring of the image which makes it totally impossible to obtain useful information related to the



(a) (b)

Continuous Lighting



(c) (d)

Stroboscopic Lighting

Fig. 1. Television Images of Cardiac Muscle Tissue

process of muscle contraction. An image of muscle tissue not in motion when stroboscopic lighting is employed is shown in (c). During the time in which the tissue is moving, the image appears as in (d). Note that although image retention is still apparent, the structure of the tissue and its position can easily be determined. This is actually an extreme case of image retention when stroboscopic lighting is employed. The xenon flash tube used in obtaining images (c) and (d) in the figure had relatively low intensity. With a more intense light source, it is expected that image retention will be further reduced and the quality of the picture further enhanced. We have supplied Dr. Johnson with sufficient information on commercially available flash tubes to allow him to order a more appropriate light source.

An additional problem with the system has also been eliminated by the use of synchronized lighting. Since muscle tissue moves a discernible distance during the time required to scan one frame in the TV system, the image of the muscle tissue in (b) if it could be seen would appear skewed. Since illumination from the xenon flash tube lasts only a few microseconds, this geometric distortion of the image is eliminated in (d) in the figure.

As a result of the great improvement in quality of the pictures obtained with the closed circuit TV system, stroboscopic lighting is being permanently installed. The improved operation has allowed additional experiments to be initiated which had not been considered previously.

3.2 Spherical Aberration in Ultrasonic Holograms

Research efforts are presently being directed toward generating three-dimensional visual images of optically opaque objects. This research involves the formation of optical holograms from the intensity and phase information contained in reflected or scattered ultrasonic energy. Upon realization, this technique may greatly enhance diagnosis and investigations of the internal structure of the human body. Advantages of the techniques as compared to conventional radiographic studies are:

(1) ultrasound at the energy levels normally employed are not dangerous to the body, and

(2) the internal structure of the body can be viewed in three dimensions.

Ultrasonic holograms are constructed using coherent ultrasonic energy in a manner similar to that employed for constructing optical holograms. With ultrasonic holography, however, the reference wave is added to the scattered wave electronically instead of in a film emulsion as is the case with optical holograms. Illuminating the resulting ultrasonic hologram with laser light results in reconstruction of optical wave fronts which form three-dimensional real and virtual images of the object of the hologram. The fact that the hologram is constructed with ultasonic energy having a wavelength of approximately 0.3 millimeter and the optical images are reconstructed using light having a wavelength approximately three orders of magnitude smaller results in significant spherical aberration in the reconstructed images. To correct for this spherical aberration, the hologram must be geometrically scaled nonlinearly with respect to distance from the optical (or ultrasonic) axis of the hologram. Dr. Thurstone who is conducting this research program at the Bowman-Gray School of Medicine has determined that this nonlinear scaling should be made according to the following equation:

$$r_2 = \sqrt{2}\, f \sqrt{\frac{\sqrt{r_1^2 + f^2}}{f} - 1}\ .$$

Where r_1 is distance from the optical axis, f is the object distance used in forming the hologram and r_2 is distance from the optical axis in the corrected hologram. This equation assumes that the ultrasonic wavelength is orders of magnitude greater than the optical wavelength employed.

Corrections for spherical aberration in an ultrasonic hologram have been made by Mr. Robert Selzer of NASA's Jet Propulsion Laboratory. These corrections were made using the image processing facility and techniques which have been developed by JPL for enhancing photographs obtained from Mars and Lunar space probes. Figure 2 illustrates a corrected ultrasonic holograph obtained very recently from JPL. Initial evaluations of these processed holograms indicate the following:

(1) Holograms which have been quantized, processed by a digital computer and then reconstructed by a flying-spot scanner do reconstruct three-dimensional optical images; and,

(2) the effects of spherical aberration have been significantly reduced by geometrical correction of the hologram.

A complete evaluation of spherical aberration correction by digital image processing is not complete. Considerable additional work with the corrected holograms will be necessary. Two problems were encountered

Fig. 2. Ultrasonic Hologram After Digital Image Processing

with the processed and reconstructed holograms. First, the interference patterns were the inverse of what is needed for obtaining a high quality three-dimensional image. Additionally, the density range in the reconstructed hologram is not appropriate for obtaining high quality reconstruction. These problems are not inherent in image processing nor are they the result of changes introduced at the Jet Propulsion Laboratory.

The correction for spherical aberration did not result directly from the dissemination of a problem abstract nor did it result from an information search. Rather, a response obtained from the Jet Propulsion Laboratory to an entirely different problem (Problem Abstract DU-1) was seen by Dr. Thurstone to represent a solution to his problem of spherical aberration. Dr. Robert Nathan and Mr. Robert Selzer at Jet Propulsion Laboratory were subsequently contacted. They offered their assistance in demonstrating that spherical aberration can be corrected by digital image processing. Drs. Thurstone and Brown visited JPL during February 1967 to discuss in general ultrasonic holography. Dr. Nathan had several suggestions which appear to be useful,in addition to the spherical aberration considerations. These suggestions were related to corrections for source and sensor apertures, gamma corrections, spatial filtering, the calculation of Fourier or similar transforms of the holograms to obtain directly specific views of the holographic image and the suggestion that recording of the hologram on video tape instead of on film would allow phase to be recorded directly so that more sophisticated image processing could be accomplished. As a result of our association with Dr. Nathan and Mr. Selzer as well as other individuals at JPL, it is felt that image processing can be very significant in advancing the state-of-the-art of ultrasonic holography.

3.3 Low Temperature Lubricant for Microtomes

Obtaining good tissue samples from some parts of the body requires that the part be frozen very rapidly to reduce damage caused by crystallization of water. Rapid freezing generally requires that very low temperatures be used for freezing. It is also highly desirable that sections obtained using a microtome be taken from samples which are maintained at these low temperatures. According to Dr. William Waddell of the UNC Center for Research in Pharmacology and Toxicology, there is great difficulty in lubricating microtomes at even -20°C. Further, Dr. Waddell actually wanted to operate his microtome to as low as -80°C and even at temperatures of liquid nitrogen. At these temperatures, ordinary lubricants such as oils, greases and graphite are completely unsatisfactory. NASA document SP-5059, Solid Lubricants, discusses the properties of solid lubricants and led the team to recommend some commercially available materials which would be appropriate. Dr. Waddell tried both a molybdenum disulfide preparation and a teflon dispersion and found the latter to be perfect for this purpose. This teflon dispersion is being used routinely as a lubricant for microtomes at low temperatures.

Again in this instance, no biomedical problem abstract or information search was involved. The transfer resulted from the building up of a library of NASA survey-type reports.

3.4 Aberrations in Holography

During the preceding quarter, an information search was initiated at the Science and Technology Research Center related to ultrasonic imaging techniques. The search was directed rather specifically toward methods of presenting ultrasonic scan data and toward any technology which may be related to ultrasonic holography. One citation resulting from this search has turned out to be of signicant importance in Dr. Thurstone's work with ultrasonic holography.* This particular article contains an analysis of high order aberrations of different types occurring in holograms. Derivations of these aberrations are in general very complex and time consuming. The article is saving Dr. Thurstone considerable time and is advancing his research project.

3.5 Analysis of Electrophoresed Samples

Dr. J. J. Van Wyk, Professor of Pediatrics and Endocrinology at the University of North Carolina is presently investigating the effects of growth hormones on midget infants by a radio-immunoassay technique. Each experiment results in approximately 150 electrophoresed samples which are taped end-to-end and passed through a radioactivity strip counter. The resulting radioactivity scan must be examined by Dr. Van Wyk and the activity peaks identified and separated. The areas under these peaks which are representative of quantities of different materials in the samples are then determined with a planimeter. This manual determination of areas which is performed by student-wives, which is time-consuming and not infallable, is the weak link in the entire process. At present several months of data are waiting for analysis.

Several alternative techniques were suggested. In view of the fact that Dr. Van Wyk wants to continue to perform the initial inspection of the radioactivity scans, only one of these approaches appears applicable.

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* Reinhard W. Meier, "Magnification and Third-Order Aberrations in Holography," J. Optical Society of America, Vol. 55, No. 8, August 1965, pp. 987-992.

This involves cutting the original electrophoresed samples at points indicated by the visual inspection of the radioactivity scans. The areas, or quantities of materials, are obtained by a determination of total activities of these sample sections using a counter with an automatic sample changer. The resulting digital data obtained in this manner are convenient for recording and are obtained more rapidly.

This particular transfer was a result of the experience and familiarity of one of the members of the applications team with radioisotope techniques and instrumentation.

4.0 Potential Transfers of Technology

The applications team is continuing to work on a number of problems which have been identified. The following paragraphs contain brief discussions of activities which are felt will ultimately result in technology transfers. Some of the topics of discussion are related to activities which can result in opportunities for working closely with medical investigators in programs that are now in the planning stage.

4.1 Calculation of Left Ventricular Volume from Cineradiographs

The significance of and the problems associated with the calculation of left ventricular volume from biplane cineradiographs have been described in Biomedical Problem Abstract DU-1. The possibility of using digital image processing techniques developed at the Jet Propulsion

Laboratory was discussed briefly in Quarterly Report No. 2.* Dr. Robert Nathan of JPL continues to be optimistic concerning this approach to calculation of ventricular volume but work assignments at JPL have not allowed Dr. Nathan or any of his associates to actively explore this possibility.

4.2 Oxygen Measurements in Gas Mixtures

The need for a highly reliable method of measuring oxygen partial pressure and flow rate in anesthetic gas mixtures is described in Problem Abstract UNC-1. Several response to this abstract have been obtained from the Technology Utilization Officer at JPL as well as from North American Aviation, Inc. Evaluations of some of these responses at UNC are not complete.

The application of a thin film oxygen detector being developed at the Research Triangle Institute under a NASA contract was mentioned in Quarterly Report No. 2. During the preceding quarter, an evaluation of this application was initiated. It was demonstrated experimentally that the thin film sensor could detect oxygen partial pressure in the anesthetic mixture. However, the high sensor temperature required is possibly causing some chemical changes in the anesthetic mixture. Further experiments will be required before the evaluation can be completed.

4.3 Microforce Transducer

The need for a very sensitive force transducer in studying the contraction of cardiac muscle tissue is described in Problem Abstract DU-7.

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* Research Triangle Institute, Solid State Laboratory, Biomedical Applications of NASA Science and Technology, by J. N. Brown, Jr., Quarterly Progress Report No. 2, Contr. No. NSR-34-004-035, Research Triangle Park, N.C., 15 September 1966 to 14 December 1966.

A sensitive pressure transducer being developed at RTI for NASA is thought to offer one solution to this problem. Construction of an experimental sensor modified to directly measure force was begun during the preceding quarter. It was determined, however, that mechanical stability problems existed in the device. At present, a modification of this force sensor is being sought which will eliminate this instability.

4.4 Intracavitary Radiation Probe

In Quarterly Report No. 2 was discussed briefly the need for an intracavitary beta detector. During the preceding quarter, it has been learned through the Technology Utilization Officer, Mr. John T. Wheeler at the Manned Spacecraft Center in Houston that Solid State Radiation, Inc. in California has the capability for fabricating radiation sensors with the desired characteristics. At present, Solid State Radiation is in the process of developing eye and stomach radiation sensors for the Atomic Energy Commission. The applications team has contacted Dr. Frank Ziemba of Solid State Radiation and is attempting to create some kind of arrangement between that organization and the Bowman-Gray School of Medicine for developing the desired sensor.

4.5 Prosthetic Urethral Valve

Problem Abstract No. WF-3 in Appendix A describes briefly the need for and some preliminary specifications of a practical fluid valve which can be implanted in the urinary tract to control the flow of urine in males. This problem abstract has not yet been distributed to the NASA centers and thus no responses to the abstract have been received.

Dr. Montgomery and his associates at Baptist Hospital have for some time been experimenting with an electromagnetically-controlled valve. The valve consists essentially of a ball and seat and a coil which, when electrically energized, produces a magnetic field that "pulls" the ball from its seat and opens the valve. The valve is normally closed by the action of a spring which forces the ball against the valve seat. The coil is to be energized in this configuration by the propagation of electromagnetic energy to a receiving antenna inside the body.

The major difficulty with this approach (at least, prior to experiments with animals) is the large power required to actuate the valve. We have suggested changes in both the valve configuration and materials aimed at reducing the air gap in and reluctance of the magnetic circuit involved in opening the valve. These changes can significantly decrease power requirements and make the operation of the valve more reliable. Dr. Montgomery is presently having a new experimental valve incorporating these changes fabricated.

A completely different concept based upon the flexible tubing described in NASA Technical Brief 66-10450 was also suggested. This particular tubing is made from a relatively inelastic material and its cross section is designed such that it can be easily bent and closed. The tubing was developed so that it can be stored in a spacecraft in a small volume. It was suggested that a similar tube covered with silastic be inserted in the urethra extending from the bladder into the external urethra (i.e., into the penis). Thus, with the tube held straight the path from the bladder would be open; but, when bent, by holding the penis in the extreme up position the "valve" would be closed. This suggestion was not received well for several reasons: the tissue involved is relatively motile, it is probable that significant discomfort would be involved and the possiblity for tissue irritation and even infection is very significant.

4.6 Biomedical Tape Recorder

Dr. James Toole at the Bowman-Gray School of Medicine has expressed the need for a small, light-weight, seven-channel, biomedical tape recorder that can be used for recording physiological parameters of subjects in their normal environment. Basic requirments for the recorder are simplicity of operation and the capability for recording at least eight hours. The Technology Utilization Officer at NASA Flight Research Center in California, Mr. Clint Johnson, has supplied technical information to the applications team on a recorder which appears to satisfy the requirements. This recorder was developed by Garrett Airesearch for NASA. Specifications on this recorder as well as other similar commercially available recorders have been supplied to Dr. Toole.

4.7 Methods of Studying Diseased Bone Joints

Dr. Grace Kerby, Professor of Medicine, Duke University Medical Center, is presently planning a long-term program directed toward identifying ways of diagnosing diseased joints at very early stages. These diagnostic techniques must be able to detect thickening of membranes and accumulation of fluids between the load-bearing surfaces in various body joints; i.e. finger, knee, etc. We suggested that this data may be obtainable by ultrasonic scanning of the joint. A brief survey of the literature and discussions with Dr. F. L. Thurstone uncovered no previous ultrasonic studies of this nature. According to Dr. Thurstone the present state-of-the-art in ultrasonics should allow the determination of positions of the particular membranes of interest, thickness of the membranes and any accumulation of fluids. He indicated that the most significant problem would be the interpretation of the resulting scan data.

Dr. Kerby is also interested in the use of thermograms as a diagnostic tool. As a result of previous investigations in this area, it is known that diseased joints are characterized by increased temperatures which can be identified from thermograms. In the investigation which Dr. Kerby is planning, a large amount of data will be involved and the time required to obtain and record this data will be significant. We suggested that a flexible sheet of silastic or similar material in which a matrix of small thermistors is embedded and which can be wrapped tightly around the joint would allow the measurements to be made conveniently and rapidly. By including electronic scanning circuits in the system, the matrix of thermistors can be scanned automatically and the data recorded automatically in both digital and graphic form, possibly as isothermal contours. We investigated available thermistor characteristics and determined that this approach should allow one to obtain thermographs with spatial resolution of 0.1 inch and sensitivity of 0.1°C. This apparently is quite sufficient for Dr. Kerby's purposes.

4.8 Bone Growth and Resorption

The importance of understanding the mechanisms of bone growth and resorption and of methods of stimulating these phenomena were described in Problem Abstract UNC-2. A program for experimentally investigating these phenomena have been initiated at the UNC Dental Research Center. These experiments involve direct-current stimulation of tissue adjacent to bone in rats. The applications team has suggested both electrode configurations to be used in these experiments and a mechanism which allows a constant current to be supplied from a source external to the rat while allowing the rat freedom to move without restraint in his cage. The Solid State Laboratory at RTI has fabricated both electrodes the associated equipment for stimulating tissue in these experiments.

5.0 Biomedical Problem Abstracts and Information Searches

During the preceding quarter, Biomedical Problem Abstracts WF-3 and WF-4 were submitted to NASA. Copies of these abstracts are attached to this report in Appendix A.

Recently there has been considerable discussion in NASA's Technology Utilization Division and the RTI Biomedical Applications Team concerning the purpose of biomedical problem abstract concept and the manner in which it is implemented. It is felt that the problem abstract concept will become one of the most effective means for identifying advanced technology which can be applied to problems existing in the medical field as well as other fields. As a result, it is felt that considerable effort should go into the preparation of these abstracts as well as the selection of problems to be stated in abstract form. The following guidelines are being used in the preparation of problem abstracts. The problem abstract must:

(1) State the problem concisely with emphasis on functional requirements, and

(2) Show significance of possible solutions to medical research, clinical practice or patient treatment and care.

The abstract should not:

(1) Limit possible approaches to solutions,

(2) Request solutions or information which can be obtained by searching the literature or other more direct means, or

(3) Present problems which appear to be "impossible" or are generally known to require relatively long periods of research and development.

The present status of information searches which have been initiated in this program is reviewed in Appendix B. The open bar in the chart in Appendix B indicates progress during the third quarter. The solid bar indicates the situation at the beginning of the third quarter. Search No. 12 which shows a complete transfer is discussed in Section 3.4.

6.0 Changes in Organization of Biomedical Applications Team

During the preceding quarter, two members of the RTI staff have been added to the applications team. These additional team members are Mr. Ernest Harrison, Jr., Engineer and Mr. J. W. Murrell, Physicist.

As a result of the experience which has been gained during this program, we have made some rather significant changes in the organization of the RTI Biomedical Applications Team. These changes are specifically aimed at making the team more effective. Previously, responsibilities of the RTI members of the team were dictated primarily by geography. With the addition of two full-time team members, we have found it possible to make individuals responsible for specific areas of medical related technology. This assignment of specialties is as follows:

(1) Dr. J. N. Brown, Jr., Director, Biomedical Applications Team, electronic systems and image processing.

(2) Mr. Ernest Harrison, Engineer, materials science and optical and mechanical systems.

(3) Mr. J. W. Murrell, Physicist, transducers (solid state, capacitive, etc.) and monitoring systems.

(4) Dr. H. G. Richter, Radio Chemist, radioisotope tracing and monitoring and chemical analyses techniques.

This specialization should allow the team to respond more rapidly and effectively to problems identified at the medical institutions. The arrangement will also allow the team to collectively become more familiar with advancements in these specific areas as they occur. This organization is also more appropriate when dealing with remote medical institutions such as Rockefeller University, Monte Fiore Hospital and the Hospital for Special Surgery in New York.

7.0 Fourth Quarter Activities

The present increased size of the applications team organization will allow an increased level of effort during the fourth quarter. In addition to the activities at Duke, UNC and Wake Forest, the team will direct a significant portion of its efforts toward problems identified at medical institutions in New York as well as at the Veterans Administration Hospital in Durham, North Carolina. Also, during the fourth quarter, the team will continue to analyze its activities and more specifically will make an effort to better understand the process of searching for information using the information dissemination centers supported by NASA.

APPENDICES

APPENDIX A

Biomedical Problem Abstracts

<u>BIOMEDICAL PROBLEM ABSTRACTS</u>

WF-3

"Prosthetic Urethral Valve"

Prepared for

National Aeronautics and Space Administration
Technology Utilization Division
Washington, D. C. 20546

"This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent application may be made. Thank you."

Problem Abstract

WF-3
January 1967

Needed

A fluid valve which can be implanted in the male urethra to allow the bladder to be emptied. The valve must be controllable from outside the body.

Background

The most important functional parts of the male urethra and bladder are illustrated on the attached illustration. The urethra is normally constricted at two points by the external sphincter and the sphincter vesicle. These sphincters are bands of muscle tissue which under normal conditions do not allow urine to flow from the bladder. To empty the bladder, the external sphincter is relaxed or opened. This is normally a voluntary act. Following relaxation of the external sphincter, the bladder involuntarily contracts and the sphincter vesicle opens. Thus, urine is forced from the bladder through the urethra and out of the body.

A number of different injuries and diseases can result in loss of control of the external sphincter, the inability to contract the bladder, or both. In some instances, the bladder must be emptied by inserting a catheter through the urethra to the bladder. The condition generally results in gradual deterioration of the bladder, infections in the urinary tract and in many cases damage to the kidneys and subsequent death. This is one of the more frequent complications which occur in paraplegics.

In treating these patients, it is important that the bladder be allowed to fill periodically and drained rapidly so that the bladder muscles are exercised and remain healthy. Electrodes contacting bladder muscle tissue have been implanted in large numbers of these patients. Electrical stimulation of the bladder muscle causes it to contract and empty. This electrical stimulation, however, also results in contraction of the external sphincter and as a result, pressure inside the bladder becomes dangerously high. An additional problem is that both sphincters may not normally be constricted sufficiently to prevent a continuous leakage of urine from the bladder.

A valve which can be implanted in the urethra and controlled by the patient would decrease the severity of these problems. The valve should be a tube-like structure passing through both external sphincter and sphincter vesicle so that these two constrictions do not restrict the flow of the urine. Thus, by opening the valve and electrically stimulating bladder muscle, the individual can periodically and safely empty his bladder. In cases where bladder muscle tissue is still healthy, the need to electrically stimulate this tissue would be eliminated because of the inherent elasticity of healthy muscle tissue. Typical flow rates of urine and related data for a normal male are included in the figure. The most important requirements on such a valve are summarized in the following:

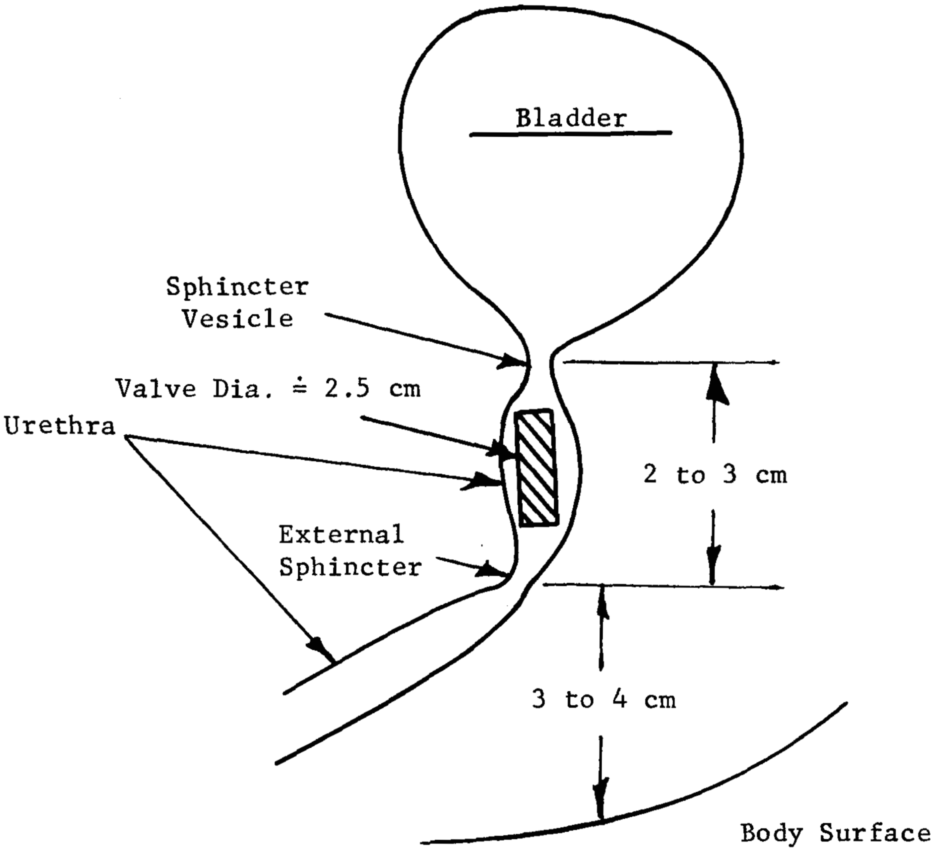
1. The valve should be operated by coupling energy into the body by electromagnetic radiation or by externally applied pressure or other similar means. Wires and/or tubes should not pass through the skin.

2. The valve should be made such that all surfaces can be covered with a layer of "physiologically acceptable material" such as silicon rubber.

3. The space inside the urethra which can be used to accommodate the valve is approximately 2 to 3 centimeters long with a diameter not greater than 2.5 centimeters. It should be noted that the section of the urethra between the sphincter vesicle and the external sphincter in which the valve would be implanted is inside the body trunk, although it is quite near the surface (approximately 3 to 5 centimeters).

4. One should, of course, be aware of the corrosion problem which should be roughly equivalent to that posed by a salt water or spray environment.

5. Simplicity and functional reliability of the valve are necessary characteristics.



Accumulation of urine: 2 - 3 ml/min, 1200 - 1500 ml/day

Total capacity of bladder: 500 ml

Initial pressure in bladder when contracting: 40 cm H_2O

Average flow rate in urethra: 20 ml/sec

Time to empty bladder: 20 - 30 sec

For more information contact

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N67-32618

BIOMEDICAL PROBLEM ABSTRACTS

WF-4

"Non-directional Small-aperture Transducer

for Ultrasonic Holograms"

Prepared for

National Aeronautics and Space Administration
Technology Utilization Division
Washington, D. C. 20546

"This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent application may be made. Thank you."

Problem Abstract

WF-4
January 1967

Needed

An ultrasonic energy detector having a large capture angle and small aperture.

Background

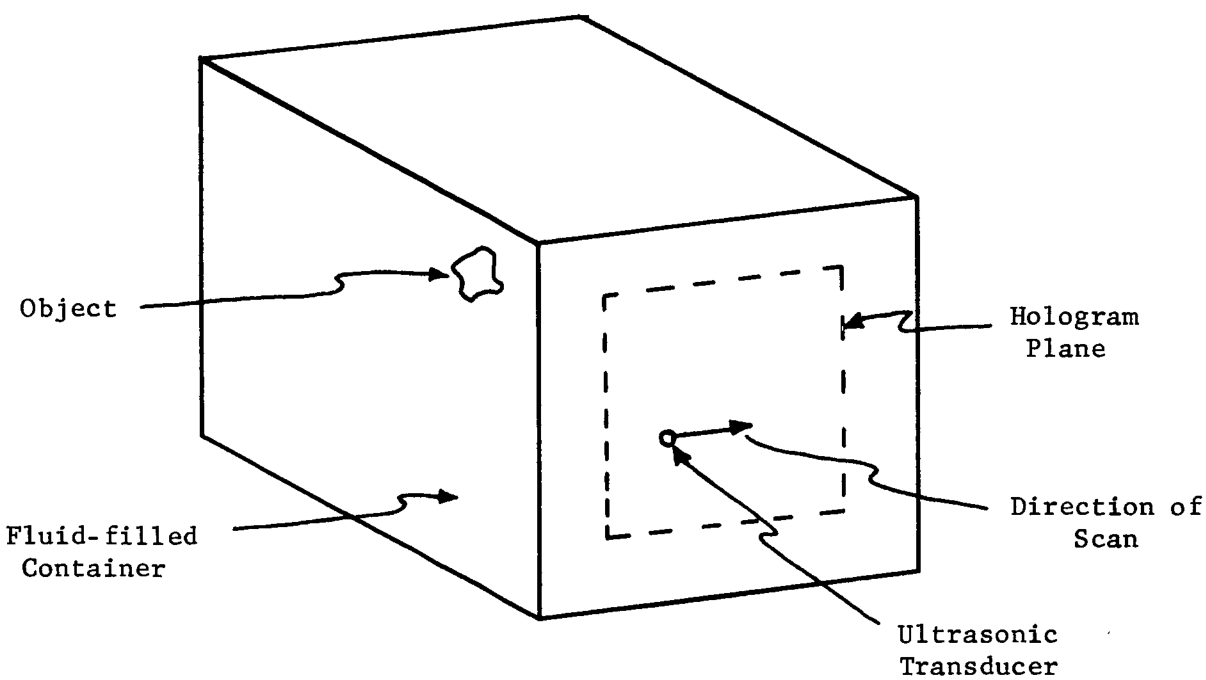
At present, research efforts are being directed toward generating three-dimensional visual images of optically opaque objects. This research involves the formation of optical holograms from intensity and phase information in reflected ultrasonic energy. Upon realization, this technique could greatly enhance investigations of the internal structure of the human body. Advantages of this technique as compared to conventional radiographic studies are (1) ultrasound at the energy levels normally employed are not dangerous to the body; (2) the internal structure of the body can be viewed in three-dimensions.

One method of obtaining ultrasonic holograms is illustrated on the attached figure. The object under study is placed in a container filled with water so that a relatively large fraction of incident ultrasonic energy can be transmitted into and out of the body. The object is "illuminated" with ultrasonic energy (400 kHz to 25 MHz) by one or more transducers which are not illustrated in the figure. Amplitude and phase of the ultrasonic energy scattered by the object contain information on the surface as well as the interior of the object. Amplitude and phase are determined over the surface of a plane inside the container by scanning this plane with a detecting transducer. This particular plane is referred to as the hologram plane. A sinusoidal waveform having the same frequency as the ultrasonic energy source is added to the signal obtained from the detecting transducer. The resulting signal is used to modulate the intensity of a small light source which is mechanically scanned synchronously with the detecting transducer. This light source is focused on photographic film, and the resulting image is analogous to an optical hologram made using a coherent light source. The only difference is in the wavelength used to construct the holograms. The wavelength of ultrasonic energy usually used is approximately 1,000 times as great as the wavelength of red light.

This ultrasonic hologram can either be illuminated directly with a laser or it can be first reduced photographically and then illuminated. In either case, one obtains a three-dimensional virtual image of the internal structure of the object being studied. The major limiting factor in the quality of this real image is the detecting ultrasonic transducer.

Ideally, this transducer should respond uniformly to radiation incident upon it and originating from any point within the container. Most transducers, however, are highly directional and respond only to incident energy within an effective capture angle of less than 10 degrees. In most ultrasonic applications, this highly directional characteristic is desirable. In generating ultrasonic holograms, however, the ideal capture angle is 180 degrees. Additionally, the detecting transducer should appear as a point receiver. The effective size or aperture of the transducer limits the resolution of the final hologram. This limitation may be thought of as removing the higher frequency interference lines in the hologram. At present, the aperture of transducers used in this work are on the order of millimeters.

Any method of detecting ultrasonic energy in a plane with a large capture angle and small effective aperture would significantly improve the quality of ultrasonic holograms constructed by two-dimensional scanning techniques.



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APPENDIX B

Status of Information Searches

Table 1. Status of Information Searches

Search Title, Number and Problem Abstract Number	Search Initiated	Report Titles Received	Initial Evaluation at RTI	Selected Reports Received	Review By Medical Staff	Possibly Useful Technology Identified	Detailed Evaluation	Potential Transfer	Transfer Complete
1. Radiation Detection									
2. Prosthetics									
3. Solid State Vidicons DU-6									
4. Circadian Rhythms									
5. Effect of Drugs on Complex Motor Actions									
6. Selection Techniques for Astronauts									
7. Analysis of Sequential Visual Displays DU-1									

Table 1 (Continued)

Search Title, Number and Problem Abstract Number	Search Initiated	Report Titles Received	Initial Evaluation at RTI	Selected Reports Received	Review By Medical Staff	Possibly Useful Technology Identified	Detailed Evaluation	Potential Transfer	Transfer Complete
8. Analog and Digital Toplogical Data Analysis DU-1									
9. Biotelemetry									
10. Optical Beam Scanning Technique DU-2									
11. Heart Volume Measurements DU-1									
12. Ultrasound Imaging Techniques									
13. Microcalorimetry									
14. Image Processing									

Table 1 (Continued)

Search Title, Number and Problem Abstract Number	Search Initiated	Report Titles Received	Initial Evaluation at RTI	Selected Reports Received	Review By Medical Staff	Possibly Useful Technology Identified	Detailed Evaluation	Potential Transfer	Transfer Complete
15. Physiological Pressure Transducer									
16. Computer Analyses of Physiological Data									