RESEARCH TRIANGLE INSTITUTE

Engineering and Environmental Sciences Division
Research Triangle Institute
Post Office Box 12194
Research Triangle Park
North Carolina 27709

BIOMEDICAL APPLICATIONS OF NASA SCIENCE AND TECHNOLOGY

Contract No. NSR-34-004-056
RTI No. EU-411

Quarterly Progress Report 3
15 December 1968 to 14 March 1969

Prepared for

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

Preface

This report covers the activities of the Research Triangle Institute's Biomedical Application Team during the period from 15 December 1968 to 14 March 1969. These activities were supported by the National Aeronautics and Space Administration under Contract No. NSR-34-004-056. This work was performed in the Engineering and Environmental Sciences Division of the Research Triangle Institute under the technical direction of Dr. James N. Brown, Jr. Other team members were Ernest Harrison, Jr. who participated full time and Dr. F. T. Wooten who participated three-quarter time on the project.

Medical Research consultants at the participating medical schools who contributed to the project are Dr. E. A. Johnson, Professor of Cardiac Pharmacology, Duke University Medical Center, Durham, North Carolina; and Dr. G. S. Malindzak, Jr., Associate Professor of Physiology, Wake Forest University, Bowman Gray School of Medicine, Winston-Salem, North Carolina. Institutions with which the Biomedical Application Team maintains liaison are Duke University Medical Center, Durham, North Carolina; Bowman Gray School of Medicine, Wake Forest University, Winston-Salem, North Carolina; the Dental Research Center and the Medical School of the University of North Carolina, Chapel Hill, North Carolina; North Carolina State University, Raleigh, North Carolina; New York University Medical Center, New York, New York; and Veterans Administration Hospital, Durham, North Carolina.

Abstract

During the period 15 December 1968 to 14 March 1969, the NASA-supported Biomedical Application Team at the Research Triangle Institute identified 15 new problems, performed significant activities on 10 of the active problems identified previously, performed 5 computer searches of the NASA aerospace literature, and maintained 3 current awareness searches. As a partial result of these activities, 9 technology transfers were accomplished. As a part of continuing problem review, 4 problems were classified inactive.

Significant transfers of technology include adaptation of the spray-on electrode technique to two new applications. Also a respiratory monitor that was developed at NASA Ames Research Center and a cardiac R-wave detector that was developed at NASA Lewis Research Center were involved in transfers.

Other activities of the team included initiation of effort at the Institute of Rehabilitation Medicine (IRM) of the New York University. During the next quarter information searching will begin on several problems defined at IRM. The team has also contacted several industrial companies in regard to developing hardware and software in relation to team problems.

Activities planned for the next quarter include identification of new problems and a special effort on previously identified problems which appear to have a high probability of solution.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1.0 Introduction and Summary

This project has as its objective the transfer of scientific and technological results of the nation's aerospace programs into the biological and medical sciences. To facilitate the transfer of scientific and technological information to clinicians and medical researchers, the National Aeronautics and Space Administration supports three multidisciplinary Biomedical Application Teams. The methods used by the application teams are: (1) to identify problems and needs existing in the medical field which appear to be "solvable" by the application of aerospace science and technology, (2) to identify the specific technologies or concepts which may lead to solutions of these problems, and (3) to document these transfers of science and technology so as to achieve maximum utilization of the results of the program. A further objective of this program is to contribute to an increased understanding of the elements involved in the information and technology transfer process in order to perform the transfer process more efficiently and effectively. This understanding is primarily gained as a result of the identification of difficulties which impede transfer efforts in specific practical biomedical problems and the observation of those elements which contribute to efficiency and speed in the transfer process. The teams are to apply this increased understanding of the transfer process to their field operations so as to provide a more effective interface and information channel between the life sciences and the physical sciences in general.

To achieve these objectives, members of the application team discuss with researchers and clinicians at the participating medical institutions those problems that are being encountered in biological and medical research. These meetings and discussions are coordinated and, to a great extent, given direction and purpose by consultants who are staff members at the medical institutions. The team seeks to understand fully both the nature of the problems and how they affect the progress of research or hinder

patient treatment and care. Following these discussions, the team members specifically identify each discrete problem and translate these problems into the terminology of the engineering and physical sciences.

When appropriate, a biomedical problem abstract, a concise statement of the problem, is prepared and disseminated through the Technology Utilization Division of NASA to the NASA research centers and other participating organizations in the space program to solicit information pertinent to a solution. At the same time, the team employs the services of NASA Regional Dissemination Centers, such as the Science and Technology Research Center located adjacent to the Research Triangle Institute, to search the computerized aerospace information bank maintained by NASA's Technology Utilization Division. All information obtained from information searches, biomedical problem abstract responses, or the experience of application team members and consultants is then evaluated. In addition to the team members, the medical consultants plus the researchers and clinicians who originated the problems contribute to the evaluation process. Finally, the Biomedical Application Team encourages and, when possible, aids researchers in the application or adaptation of technology identified by these activities.

Section 2.0 of this report contains a discussion of the transfers of technology made by the Research Triangle Institute's Biomedical Application Team during this quarter. In Section 3.0 the potential transfers are described. Section 4.0 enumerates the new problems which have been identified. Section 5.0 details significant activities of the team on previously identified problems. The Problem Review in Section 6.0 indicates those problems which have been classified as inactive, along with the reason for such classification.

Section 7.0 summarizes the information searching activities of the team, which include computer searches of the NASA information banks, manual searches of the NASA information banks, and a variety of miscellaneous searching procedures. Other activities of the team are presented in Section 8.0, and the financial summary for the quarter is tabulated in Section 9.0. Appendixes A through D contain: (1) computer evaluation reports on all computer searches conducted during the quarter,

(2) a listing of transfer criteria, (3) a bibliography of documents supplied to the researchers and, (4) a list of abbreviations used in this report respectively.

2.0 Technology Transfers

2.1 Introductory Information

The documentation of technology transfers contains the following information: (1) Description of Problem, (2) Description of Solution, (3) Successful Searching Method, (4) Source of Solution, (5) Benefits to be Derived from Transfer, (6) Current Status, (7) Cost of Biomedical Application Team Activities to Date, and (8) Elapsed Time to Complete. The criteria which have been used to establish technology transfers are listed in Appendix B.

The transfers documented here represent a solution to the following problems:

2.2 Transfer Documentation

DU-37

Localized Cooling of Heart Muscle

Dr. Madison S. Spach, Duke University Medical Center

Description of Problem:

One method of studying heart function is to study the mechanical contractile process while observing the progress of electrical activity over the surface of the heart wall. These observations are more informative when coupled with selective, local inactivation of small sections of the heart wall. Local inactivation can be accomplished by cutting the muscle, but an improved technique would be to locally cool the individual muscles.

A probe capable of cooling a small (3mm x 3mm) section of the heart wall to 15°C is desired. Dr. Spach has previously tried a liquie coolant, but this has been unsatisfactory because of the bulk of the input and output tubes. A small probe with miniature leads is required.

Description of Solution:

A search of the NASA data bank revealed several pertinent articles about thermoelectric cooling. Because of the availability of commercial thermoelectric coolers, several manufacturers were contacted and quotations were obtained on suitable units. In addition, a manufacturer of cryosurgical tools was contacted and a modified cryosurgical probe was discussed. A quotation was obtained on this system.

Successful Searching Method:

Computer search of NASA data bank and manual search of commercial literature.

Source of Solution:

The solution to this problem was obtained by a search of the NASA data bank and a search of the commercial literature.

Benefits to Be Derived From Transfer:

The research planned by Dr. Spach will add to the ever-expanding bank of knowledge on the heart function. The hope of all research on heart function is to reduce the high death rate due to heart disease. Approximately 50 percent of all deaths in this country are due to heart disease.

Current Status:

The researcher has evaluated the information and is considering means of obtaining financial support for this program.

Cost of Biomedical Application Team Activities to Date:

Approximately $950.00.

Elapsed Time To Complete:

8 months.

MISC-1

Biomedical Tape Recorder

Dr. C. H. Waddington, University of Edinburgh,
Scotland

Description of Problem:

Dr. Waddington contacted the Biomedical Application Team while visiting Duke University. The contact was made at the suggestion of a Duke faculty member who is familiar with the Biomedical Application Team activities.

Dr. Waddington is interested in the effect of the environment on the human. Although the differences in the urban, suburban, and rural environments have been carefully studied, the effects of these environmental differences have not been as carefully studied. Dr. Waddington is considering a study of the effects of environmental changes on the human. The study will include comparisons of the urban, suburban, and rural environments as well as changes within each environment.

In order to carry out the study, the researcher requires a portable tape recorder on which various physiological variables will be recorded. The recorder should be lightweight and capable of recording for several hours. The data will be sampled by turning the recorder on for brief intervals by a clock mechanism. The researcher wants to know what biomedical tape recorders have been used by NASA and also wants to know what recorders are commercially available.

Description of Solution:

The researcher was provided with a summary of the NASA work on tape recorders including information on handling large amounts of biomedical data.

A search of the commercial literature disclosed several suitable tape recorders. This information was delivered to the researcher.

Successful Searching Method:

Manual search.

Source of Solution:

Commercial literature and NASA document SP-5038, "Magnetic Tape Recording".

Benefits To Be Derived From Transfer:

The transfer will allow Dr. Waddington to engage in a study (when funds are available) to determine the effect of environment on humans. Without the information, the study could not be planned. The results of the study should be a better understanding of the relationship between man and his environment.

Current Status:

Dr. Waddington has evaluated the information and is seeking funding to support the research program.

Cost of Biomedical Application Team Activities to Date:

Approximately $300.00.

Elapsed Time to Complete:

2 months.

NCSU-5

Oxygen Content of Ichthyological Ovarian Fluid

Robert E. Stevens, North Carolina State University

Description of Problem:

One of the most popular fish for fresh water reservoirs is the striped bass. With the rapid increase in the number of sport fishermen and the number of available reservoirs, the interest in this fish has increased. The striped bass requires about 40 miles of river for spawning because the eggs drift with the current instead of remaining fixed in a bed. Because many reservoirs do not have an adequate spawning area, government hatcheries often supplement the natural supply.

One of the difficulties encountered by the hatcheries is the short "ripe" period of the eggs, which is the time between ovulation and spawning. The reasons for this short period (1 hour) are being explored. Mr. Stevens wants to determine if the reason is lack of oxygen in the ovarian fluid. He requires an oxygen sensing electrode that can be placed in the ovary. Telemetry is not required initially but would be desirable at a later date.

Description of Solution:

Information gained from a previous search #1135, Oxygen Tension in Tissue, was applied to this problem. In addition, an updated search on oxygen measurement #1469, Oxygen Tension in Tissue and Biotelemetry, was made. These searches revealed several articles of general interest and they confirmed the researcher's suspicion that no work had been done on the exact subject. These articles showed that the appropriate technique was a polarographic technique. The primary difficulty arises in that the polarographic techniques measure oxygen partial pressure and not the amount of oxygen chemically bound, i.e., oxygen in blood. The researcher

was made aware of this possible problem but is satisfied with the approach. The articles of interest to the researcher were the following: A66-81467, N65-17768, N64-27634, N64-29278, N63-22411, N65-27028, N65-17769.

The commercial literature was searched and an appropriate oxygen electrode identified. Care was taken to obtain the correct shape factor.

Successful Searching Method:

Computer search of the NASA literature bank and search of commercial literature.

Source of Solution:

Beckman Instruments, Inc., Spinco Division, Palo Alto, California.

Benefits to Be Derived from Transfer:

Now the researcher will be able to determine if lack of oxygen is the cause of the short "ripe" period. This research will improve the knowledge of hatchery personnel in regard to the spawning process. The end result of all research in this area is to increase the availability of striped bass for sport fishing.

Current Status:

The researcher has decided to purchase the oxygen electrode.

Cost of Biomedical Application Team Activities to Date:

Approximately $350.00.

Elapsed Time to Complete:

4 months.

UNC-48

An Improved EMG Electrode for Hand Therapy

Miss Irene Hollis, Director of Occupational Therapy
Hand Rehabilitation Center
University of North Carolina Medical School

Description of Problem:

In the treatment of hands in which muscles have been damaged or have become atrophied, it is necessary to implement a program of exercise and therapy to permit the patient to regain use of the hand. In these therapy programs, specific muscles in the hand must be exercised by the patient. It is frequently difficult to determine if the patient is performing the exercise pattern by using the proper muscle or by some other combination of muscles. Damaged muscle is frequently favored by bringing into play some other combination of muscles to produce the prescribed motions. As a result, an EMG muscle trainer is employed to determine whether or not a specific muscle is being used. The trainer consists of two electrodes and an EMG amplifier. The amplifier drives a speaker, allowing the therapist to determine audibly whether the specific muscle is being used by the patient. The electrodes currently in use consist of stainless steel cups approximately 5/16 inch in diameter which are filled with electrode paste and attached to the muscle with masking tape. These electrodes are too large. Their size plus the attachment method obscure the muscle being exercised. Frequently, it is desirable to perform other therapeutic procedures on the muscle while it is being exercised. The present electrodes and associated attachment tape prevent this because in most cases the muscle is completely covered.

Description of Solution:

The use of small "painted-on" electrodes using the NASA-developed spray-on electrode formulation was suggested to the therapist by a member of the Biomedical Application Team. An electrode solution was formulated, and preliminary trials were made to determine the applicability of these

electrodes to clinical use in hand therapy. The preliminary tests were completely satisfactory. The electrodes could be made very small, no further attachment mechanism was needed for the wires, and the electrodes provided extremely satisfactory input signals to the EMG muscle trainer. In addition, almost complete visual and physical access to the muscle being exercised was afforded, thus permitting the use of other therapeutic procedures during exercise.

Successful Searching Method:

The NASA technology employed as a solution to this problem had been previously identified by the MRI Biomedical Application Team as a result of information searching on other problems.

Source of Solution:

The technology employed in the solution to this problem was published in NASA TN D-3414, "Dry Electrodes for Physiological Monitoring", by Charles W. Patten, and Frank B. Ramme, Spacelabs Inc., and James Roman, NASA Flight Research Center.

Benefits to be Derived from Transfer:

The use of these small "painted-on" electrodes, borrowed from the NASA developed spray-on electrode formulation, permits visual and physical access to the muscle being exercised that could not be obtained using the conventional electrodes. Visual and physical access to the muscle being exercised will permit the use of other therapeutic procedures during exercise leading to an overall improvement in patient care at the Hand Rehabilitation Center. In addition, therapists have found that the "painted-on" electrodes are much easier to apply to the specific area on the skin, leading to increased convenience and more exact electrode placement. Another advantage of the "painted-on" electrodes is that they are very flexible when applied, so that they remain in intimate contact with the skin as the muscles are being exercised.

Current Status:

Preliminary tests have indicated the dry electrode technique to be very useful in this application. Continuing clinical trials are being held under normal therapy procedures on appropriate patients to ensure its usefulness in clinical practice.

Cost of Biomedical Application Team Activities To Date:

Approximately $275.00.

Elapsed Time to Complete:

1 month.

UNC-49

A Manipulator for Therapy in Abductor Transfer Cases

Miss Irene Hollis, Director of Occupational Therapy
Hand Rehabilitation Center
University of North Carolina Medical School

Description of Problem:

Frequently, patients receive injuries that destroy the usefulness of the thenar muscles which operate the thumb to permit opposition of the thumb and fingers. When this occurs, the usefulness of the hand is significantly reduced. To provide opposition between the thumb and fingers, a surgical operation is performed in which the abductor muscle is transferred and takes the place of the thenar muscles. Using this transferred abductor muscle, it is then possible for the patient to obtain thumb-to-finger opposition and regain usefulness of the hand. Use of this muscle in its new function, however, is difficult for the patients. Therefore, an intensive program of physical therapy must be undertaken to train the patient in using the muscle properly to obtain pad-to-pad contact of the thumb with the fingers. The natural tendency of the untrained patient is to abduct the thumb keeping it near the palm of the hand so that, instead of obtaining pad-to-pad contact with the fingers, the tip of the thumb is in contact with the pad of the fingers. As a consequence, the physical therapy training procedures must be employed to reeducate the patient in the use of this muscle. One very excellent exercise which is employed in this training consists of grasping a spherical object, such as a ball, in the hand with the thumb and all four fingers. It is desired that the pads of the fingers and the thumb come in contact with the ball while holding the ball. Opposition between the thumb and the fingers holds the ball in place in the hand. With the pad of the thumb pressed down firmly on the ball, the patient is then taught to roll the ball back and forth, essentially across the finger tips, while maintaining pad contact of the thumb on the ball. This is difficult for the patient to do at first. Unless a therapist essentially maintains a constant vigil over the patient as he exercises,

he has a tendency to abduct the thumb so that the side of the thumb, rather than the pad, is pressing the ball. The result is that he no longer performs the exercise in a useful fashion. Some form of indicator is desired to indicate to the patient when he is doing the exercise properly. This accomplishes two functions. First, it permits the therapist to leave the patient while he is performing these repetitive exercises and work with another patient. Second, it provides an incentive to the patient to perform the exercise properly.

Description of Solution:

A member of the Biomedical Application Team suggested that a conductive ball be used in the therapy and that an electrode be placed upon that portion of the thumb which it is desired to keep in contact with the ball. Using the ball and the electrode on the thumb as a switch to operate a battery-powered light, the light would remain on as long as the patient is performing the exercise properly. The light would go out when the patient shifts his thumb so that the pad of the thumb is no longer making contact with the ball. This simple type of signaling device then permits the patient to perform the exercises and to know exactly whether he is doing the exercise properly or improperly. The electrode to be used on the thumb was considered, and the "painted-on" electrode developed by NASA was considered to be an obvious choice. Using nothing more than a battery, a light, a conductive ball, and a small dab of the "painted-on" cement, a very inexpensive trainer can be made which provides positive indication of when the patient is performing the therapy in the prescribed manner.

Successful Searching Method:

The concept of using a conductive ball and an electrode placed on the pad of the thumb was suggested by a member of the Biomedical Application Team. The "painted-on" electrode which was suggested for use on the thumb had been previously identified by the Biomedical Application Team as a result of information searching on other problems.

Source of Solution:

The Research Triangle Institute's Biomedical Application Team and NASA publication TN D-3414, "Dry Electrodes for Physiological Monitoring", by Charles W. Patten and Frank B. Ramme, Spacelabs Inc., and James Roman, NASA Flight Research Center.

Benefits to be Derived from Transfer:

Incorporation of a positive indication to the patient, which indicates when the exercise is being properly performed, will permit more effective rehabilitation of patients and will mean that full use of their hands will be regained more rapidly, permitting them to assume a useful role in society more quickly. This simple indicating device will also reduce the amount of time that the therapist must devote to patients which are engaged in these exercise procedures, thus freeing the therapist to treat other patients.

Current Status:

The proper configuration and design of the indicating system for the manipulator has been evaluated and approved by the investigator. Steps are underway to modify the equipment in the clinic and to begin clinical trials of the unit.

Cost of Biomedical Application Team Activities to Date:

Approximately $150.00.

Elapsed Time to Complete:

1 month.

WF-30

An Improved Blood Vessel Constrictor

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

In cardiac and vascular studies at the Bowman Gray School of Medicine, Wake Forest University, investigators frequently need some device that can be placed around the blood vessels of the heart of an experimental animal during an experiment to produce a controlled occlusion of the vessel. Currently used devices possess several disadvantages. First, these devices are relatively difficult to use and awkward to handle. Second, and more important, the devices are difficult to release rapidly (especially when the heart is involved). It is important that the constriction of the blood vessel be removed rapidly because experiments frequently require that the blood flow be reduced to the point that the test animal will die unless immediate release of the constrictor can be accomplished. Loss of such an animal represents a significant loss of time and money. Consequently, instant release of the constriction is of great importance.

The basic requirements which such a blood vessel constrictor should meet are outlined below. The constrictor must be able to apply a known and controllable amount of constriction (in terms of diameter reductions or some other equally identifiable parameter) to the blood vessel. The ability to release the constrictor instantly is considered of prime importance. The manner in which the constriction is applied to the blood vessel must be such that the constrictor itself does not cut into the blood vessel as constriction is applied. This requirement must be met even to the point where the blood vessel is completely closed. The amount of space available for the constrictor is limited. Specifically, the length of blood vessel exposed for the purpose of attaching an occluding device is less than one-half inch. The device must provide a graded occlusion for vessels from 3 mm to 10 mm in circumference.

Description of Solution:

A commercially available, manually operated blood vessel occluder was identified in conjunction with this problem. The occluder is not useful in this particular application because of its size (it is too large) and because it does not permit a controlled graded occlusion. Occlusion with this unit is, however, purely qualitative as to the degree of occlusion. The concept involved in actual occlusion of the vessel on this particular occluder, however, led to formulation of a potentially acceptable device for use in this application. A design for the proposed occluder was accomplished by a member of the Biomedical Application Team and approved by the researcher as being capable of providing a solution to this problem.

Successful Searching Method:

Selective searching of commercial literature and experience of NASA Biomedical Application Team member.

Source of Solution:

A member of the Biomedical Application Team recognized the possibility of employing the occlusion principle in a commercially available device as the basis of the design of a unit which can provide graded occlusion and instant release.

Benefits to be Derived from Transfer:

Employing a blood vessel constrictor to provide some quantitative measure and control of the amount by which an elastic vessel is constricted is an approximation to what happens pathologically in the hardening and narrowing of the vessel as a result of vascular disease. In this particular project, the effects of the constriction of blood vessels of the heart itself are being studied. The solution of this problem will permit the design of research models to simulate what is observed pathologically in vascular disease.

Current Status:

The basic design of the occluder has been evaluated by the researcher and found to be suitable for this application. Detail drawings of the occluder have been prepared and submitted by the researcher to the Biomedical Engineering Department of Bowman Gray School of Medicine to obtain a quotation on the price of fabrication of such a device.

Cost of Biomedical Application Team Activities to Date:

Approximately $750.00.

Elapsed Time to Complete:

15 months.

WF-37

An Implantable Valve Which Can Be Remotely Opened and Closed from Outide the Body

Dr. D. L. Kelly, Jr., Bowman Gray School of Medicine

Description of Problem:

This problem is related to biomedical problem WF-36, "Implantable Pressure Sensor and Telemetry Unit for Measurement of Fluid Pressure in the Cranial Cavity." Both of these problems were identified as a result of discussions with Dr. Kelly of the Department of Neurosurgery at Bowman Gray School of Medicine. Dr. Kelly is engaged in research activities associated with the buildup of fluid pressure in the cranial cavity. Many people have a fluid buildup, called hydrocephalus, that occurs in the cranial cavity, and this pressure must be relieved. Relief is usually accomplished by inserting a pickup tube inside the cranial cavity and running a piece of tubing down underneath the skin in the rear of the head, finally discharging the fluid into one of the blood vessels where the fluid is dispersed.

A special one-way valve known as a Holter valve is used to prevent reflux of blood into the cranial cavity and to permit drainage from the cranial cavity into the blood. Not infrequently, this valve will stick closed, and pressure will begin to build up in the cranial cavity of the individual. In addition to this particular difficulty, the present valve does not permit any control over flow; i.e., it is a one-way valve which is always open in the forward direction and always closed in the reverse direction.

It is desirable on certain occasions to be able to close off the valve and to observe the rate of pressure buildup. Then, at some selected pressure level, the valve would be opened, permitting the fluid to drain out of the cranial cavity. Since the drain tube and valve are permanently implanted (unless it becomes necessary to remove the valve because it becomes clogged), operation of the valve must be accomplished from outside the body without external wires or connections.

Description of Solution:

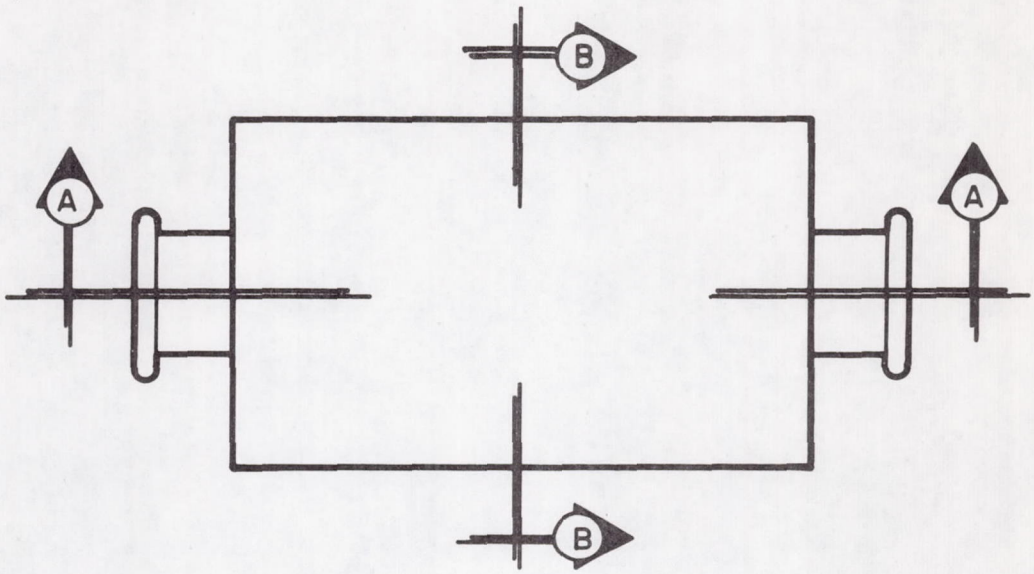
A ball type check valve with two positions (one position normally open and the other position normally closed) has been designed (see Figure 1). The body of the check valve is constructed of a flexible silastic material. A set of flexible detents holds the ball in place in the normally closed position. When it is desired to open the check valve, it is only necessary to press on the valve body with the thumb and forefinger, thus deforming the valve housing and forcing the ball over the detents which retain it in place. Once the ball has been forced over the detents into the open position and the pressure has been released on the body of the valve, the detents hold the ball in the open position, permitting fluid to pass through the valve. The researcher, upon evaluation of the device, feels that such a unit can be used in this particular application and that it will permit operation of the valve through the skin by means of manual manipulation with the fingers.

Successful Searching Method:

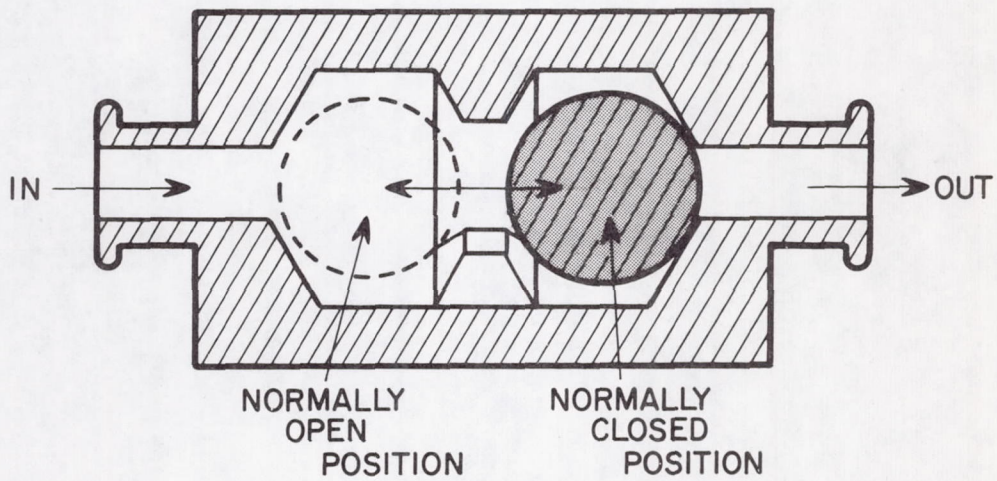
A flexible-bodied check valve which permitted operation of the valve by means of pressure was designed for use in the prosthetic urethral valve, biomedical problem WF-3, "Prosthetic Urethral Valve". The successful functioning of this check valve led to a consideration of the possibility of employing the same principle on the valve in this particular application. As a result, a member of the Biomedical Application Team modified the check valve design so that two positions, normally closed and normally open, could be achieved.

Source Of Solution:

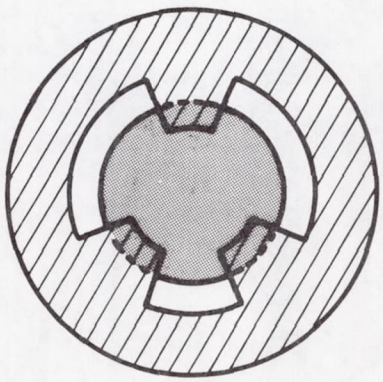
This solution was obtained as a modification of a flexible-bodied check valve originally designed for use in a solution to biomedical problem WF-3, "Prosthetic Urethral Valve".



TOP VIEW



SECTION A-A



SECTION B-B

Figure 1 — Proposed Valve Configuration

Benefits to be Derived From Transfer:

The required valve, which would be used in conjunction with the instrumentation and telemetry system described in biomedical problem WF-36, "Implantable Pressure Sensor and Telemetry Unit for Measurement of Fluid Pressure in the Cranial Cavity", would be used to permit the gathering of data which is not now available on pressure buildup in the cranial cavity. It is anticipated that accumulation of this data will permit correlation of the data with other clinical observations which may in turn yield information on the actual mechanism of fluid production in the brain.

Current Status:

The valve design has been evaluated by the researcher and found acceptable. At the present time, a source of fabrication for such valves is being sought.

Cost of Biomedical Team Activities to Date:

Approximately $900.00.

Elapsed Time to Complete:

14 months.

WF-52

Methods of Triggering From a Fixed Reference Point on the EKG Waveform

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

Dr. Malindzak at Bowman Gray School of Medicine, as a part of his research, is accumulating large amounts of data on the cardiovascular system. These data all bear a fixed relationship to the heart cycle. In order to simplify the data processing and recording aspects of his research, it is desirable to obtain a fixed reference point in each cardiac cycle which can be used as a trigger. The solution involves a cardiac R-wave detector developed at the Lewis Research Center.

Description of Solution:

Dr. Malindzak, with the aid of an electrical engineer, has evolved a circuit which will provide the desired timing signal. Information on the cardiac R-wave detector developed at Lewis Research Center was extremely helpful in the design of the required circuit. The unit developed at Lewis Research Center would perform the desired function as well as other functions; however, its sophistication and complexity were more than was required for this simple application. Consequently, it was desirable to design a simpler circuit based on the principles of the Lewis unit to perform the function.

Successful Searching Method:

A cardiac R-wave detector was originally brought to the attention of the Biomedical Application Team by a Tech Brief. Followup with Mr. Paul Foster, the Technology Utilization Office at the Lewis Research Center, provided the detailed information on circuitry required for instrumentation.

Source of Solution:

Mr. Paul Foster, Technology Utilization Officer at Lewis Research Center was contacted to obtain further information on the "Cardiac R-Wave Detector". The tech brief back-up package, including a complete description of the circuit by Mr. Vernon D. Gebben, was received from Mr. Foster.

Benefits to be Derived from Transfer:

Each heartbeat is preceded by an electrical signal which, in one of its forms, is known as an EKG signal. The QRS complex of this EKG signal is closely synchronized in time (almost simultaneous) with the contraction of the heart, which initiates arterial pressure and blood flow to all distribution points in the body. The R-wave detector will be used to generate an appropriate pulse bearing a specific time relationship to the QRS complex and thus the initiation of arterial pressure. This will provide a more accurate means of determining the period of the cardiac cycle. This pulse wave form will in turn be used by the data processor as a timing signal defining the initiation and termination of the basic cardiac cycle.

It will be used in the following ways. First, these signals and spectral analysis techniques will be used to characterize pressure and flow functions in terms of their Fourier coefficients (thus permitting the differentiation between normal and abnormal pressure or flow functions on this basis). This kind of analysis only has meaning if the period of the cardiac cycle can be accurately defined. Further applications of Fourier (spectral) analysis include complex cardiovascular impedance analysis, evaluation of vascular transmission line parameters, determination of reflection coefficients, and the evaluation of changes of physical characteristics of vessel composition in health and disease.

The second application is related to volume pulse transit time in peripheral vascular diseases. Peripheral vascular disease can manifest itself in one of two general forms. In vasospastic disease there is a

general overall involvement of peripheral vasculature. In occlusive disease, one or more branches of the major aortic vascular complex may become constricted or partially occluded for reasons that are not well understood at this time. In a patient having occlusive disease, the volume pulse transit time from the heart to the digit (finger or toe) will be different (longer) in the occluded branch from that in the normal branch. In this manner, one could clinically detect the approximate location of such an occlusion by noninvasive techniques. The pulse from the R-wave detector and the transit times measured from the onset of the R-wave pulse to the onset of the volume pulse in the periphery permit contralateral and ipsilateral comparisons of transit time between like pairs of digits in patients with known vascular disease.

Current Status:

Information on the cardiac R-wave detector was supplied to the researcher. Analysis of the proposed circuitry revealed that the functional operation of the cardiac R-wave detector was considerably more sophisticated than that required in this particular application. As a result, Dr. Malindzak has asked the Biomedical Engineering Department of Bowman Gray School of Medicine to produce a modified and simplified unit to detect the cardiac R-wave and provide a suitable trigger output. This unit is in process of fabrication.

Cost of Biomedical Application Team Activities to Date:

Approximately $375.00.

Elapsed Time to Complete:

10 months.

WF-55

A Simple Means of Sensing Whether a Respirator is Actually Performing the Respiratory Function on Humans

Dr. R. A. Kemp, Bowman Gray School of Medicine

Description of Problem:

Dr. Kemp is interested in a very simple and reliable means of sensing whether a respirator is actually performing the respiratory function on the patient or whether, through some malfunction, the patient is not being respired by the respirator. The type of respirator in use by the researcher is designed so that it pumps into the respiratory passages of the patient until a fixed pressure is obtained. When the fixed pressure is reached, the ventilation phase is ended, and the expiration phase of the cycle begins. If, because of some obstruction or because of a kink in the respirator hose, the patient is cut off from the respirator, the machine is unable to sense this condition. It merely pumps up against the pressure in the hose until the desired pressure is reached and then cuts off and begins the remaining part of the cycle.

As a result, it is possible for the respirator to be operating perfectly, from a mechanical standpoint, and the patient can be deprived entirely of his air supply and thus die. Nose clip type sensors have been employed, but they are not very satisfactory because they are very difficult to maintain in place and are bulky. In addition, quite frequently the airway resistance through the nasal passages is such that it is desirable for the respirator input to be shunted so as to enter through the throat.

Description of Solution:

A respiratory failure alarm system has been developed at the Ames Research Center. This unit is capable of fulfilling all the requirements of this problem.

Successful Searching Method:

Mr. George Edwards of the NASA Ames Research Center read a description of this problem in our Monthly Status Report, May 15, 1968 through June 14, 1968, and furnished information on a suitable unit designed at Ames Research Center.

Source of Solution:

The technology employed to solve this problem originated with Mr. Jack M. Pope and Mr. John Dimeff of the NASA Ames Research Center. Complete information on the design and fabrication of the respiration failure detection system contained in Technical Support Package for NASA Tech Brief 68-10365, "Automatic Patient Respiration Failure Detection System with Wireless Transmission," was obtained from Ames Research Center.

Benefits to be Derived from Transfer:

As outlined in the description of the problem, the result of obstructions in the respirator passage can lead to death of the patient. Because of the severity of these results, it obviously becomes necessary that a nurse or other trained individual constantly keep check upon the patient who is receiving respiration from a respirator. Even with this type of surveillance, however, it is not impossible for a constriction to occur and go undetected. The benefits of this transfer therefore are twofold. First, a fool-proof method of sensing whether the respirator is performing its function or not can lead to a reduction in patient mortality in those few cases where the respirator is obstructed and goes undetected by persons monitoring the patient and respirator. Second, the use of such a respirator sensor can greatly reduce the amount of attention required of medical personnel on patients receiving respiration from respirators.

Current Status:

The Biomedical Engineering Department of the Bowman Gray School of Medicine, Wake Forest University, is in the process of fabricating a respiratory failure alarm system using the complete schematic diagrams and constructional information obtained from the Ames Research Center.

Cost of Biomedical Application Team Activities to Date:

Approximately $450.00

Elapsed Time to Complete:

9 months.

3.0 Potential Transfers

In the case of potential transfers, the initial evaluation of a proposed solution is only partially complete. Potential transfers are subject to the same criteria established for completed transfers and discussed in Appendix B.

During the preceding quarter, five potential technology transfers were identified. Documentation of these potential transfers is presented in the remainder of this section.

DU-41

Electrode Vest for EKG Measurement

Dr. W. E. Hammond, Duke University Medical Center

Description of Problem:

Dr. Hammond has a general interest in health screening clinics. He is studying ways to improve the measurement techniques for such clinics. One important measurement for such clinics is the electrocardiogram (EKG). This measurement normally is made using less than ten electrodes. However, Dr. Hammond plans to use up to 150 electrodes. In order to facilitate the placement of such electrodes, the researcher wants a vest implanted with electrodes. The vest should be adaptable for both sexes from ages 3 to 16 years and should cover the area from the neck to the waist. Because of the wide range of patient size, several vests will be required.

Description of Solution:

A computer search #1595, "EKG Electrodes",disclosed several articles of interest on electrodes but no information was available on vests. A team member then contacted a local NASA contractor, Payne and Associates, who has experience in life vest design and manufacture. The contractor has agreed to build a prototype vest for evaluation. Discussions are now underway to start design and fabrication.

Successful Searching Method:

Team knowledge of local commercial contractors.

Source of Solution:

Payne and Associates, P. O. Box 12285, Raleigh, North Carolina.

Benefits to be Derived from Transfer:

This transfer will enable the researcher to evaluate vests for EKG measurements in health screening clinics. The clinics will provide vital information in screening large numbers of patients for health problems.

Current Status:

Payne and Associates is discussing the design of the vest with the researchers. Fabrication of the vest is estimated to begin shortly.

NCSU-4

Telemetry from Wood Ducks in Natural Environment

Dr. F. Eugene Hester, North Carolina State University

Description of Problem:

Dr. Hester is interested in the population management of waterfowl. In particular, he is interested in the wood duck which has the largest nesting population in North Carolina. It is also the most popular among hunters in terms of numbers killed.

The particular area of interest in population management of wood ducks is the nesting behavior. Dr. Hester is studying the type of natural cavity used by the ducks. He also wants to know if the ducks will move to manmade boxes when available. Further information is desired on the movement and mobility of the brood.

In order to accomplish this study, the researcher requires a miniature transmitter for tracking the ducks during the nesting period. Approximately a one-mile range is required as well as a portable receiver.

Description of Solution:

Information from computer search #679,"Biotelemetry", was applied to this problem. An updated search #1469,"Oxygen Tension in Tissue and Biotelemetry", was made. Analysis of the search revealed many ideas regarding small telemetry units that had been built and tested for biomedical research.

A search of the commercial literature was made and the Bioinstrumentation Advisory Council was contacted. This resulted in the identification of a source of telemetry equipment for avian research. The equipment is made by Dr. W. W. Cochran of Urbana, Illinois.

During this time a manual search revealed that suitable equipment was available at the Naval Research Laboratories. Discussion with

NRL personnel revealed the possibility of loan of this equipment for Dr. Hester's research. Loan of this equipment is being pursued by team members.

Successful Searching Method:

Contact with the Bioinstrumentation Advisory Council and manual search of literature.

Source of Solution:

Dr. W. W. Cochran and Naval Research Laboratories.

Benefits to be Derived from Transfer:

The identification of suitable equipment will enable Dr. Hester to conduct research that would not be possible otherwise. The benefits of his research will be improved population management of waterfowl.

Current Status:

Equipment from Dr. Cochran has been ordered. The Naval Research Laboratories is studying the request for loan of the equipment.

WF-36

Implantable Pressure Sensor and Telemetry Unit for Measurement of Fluid Pressure in the Cranial Cavity

Dr. D. L. Kelly Jr., Bowman Gray School of Medicine

Description of Problem:

This problem is related to biomedical problem WF-37, "An Implantable Valve Which Can Be Remotely Opened and Closed From Outside the Body". Both of these problems were identified as a result of discussions with Dr. Kelly of the Department of Neurosurgery at the Bowman Gray School of Medicine. Dr. Kelly is engaged in research activities associated with a buildup of fluid pressure in the cranial cavity. Many people have a fluid buildup, called hydrocephalus, that occurs in the cranial cavity, and this pressure must be relieved. Relief is usually accomplished by inserting a pick-up tube inside the cranial cavity and running a piece of tubing down underneath the skin in the rear of the head, finally discharging the fluid into one of the blood vessels where the fluid is dispersed. A special one-way valve known as a Holter valve is used to prevent reflux of blood into the cranial cavity and to permit drainage from the cranial cavity into the blood.

Dr. Kelly is interested in monitoring the pressure buildup in people with hydrocephalus. Using a pressure transducer and telemetry system which can be implanted, along with a special one-way valve that can be remotely opened and closed from outside the body, the cranial cavity can be closed off. Pressure buildup can then be monitored as a function of time on a given individual. This data is the information which is of interest to Dr. Kelly, i.e., the rate of pressure buildup in the cranial cavity of people afflicted with hydrocephalus.

Description of Solution:

There are numerous sources of technology which can be identified as directly applicable to this problem. Indeed, much of the work on

biotelemetry equipment at Ames Research Center could be applied to this problem if access to this technology could be arranged. One promising approach to the solution of this problem has resulted from the interaction of the Biomedical Application Team with researchers at the University of North Carolina Medical School. Contact was made with Mr. Stan Hutcheson who is an electrical engineer in the Parapsychology Laboratory at the University of North Carolina Medical School. Mr. Hutcheson revealed that, in addition to his work at the University of North Carolina Medical School, he is also a member of Microtronics Corporation, Carrboro, North Carolina which fabricated custom biomedical instrumentation. A conference was arranged between Mr. Hutcheson and the researcher, along with one of the members of the Biomedical Application Team and the consultant at Wake Forest University. The problem was discussed extensively and thoroughly. The final evaluation was that a telemetry system which would fulfill the requirements of this application could be fabricated using the facilities of Mr. Hutcheson's firm. The only significant area of uncertainty lies in the selection of a transducer to provide the signal to the telemetry system. There are several commercially available transducers small enough for use in this application. None of these transducers have been proven in long-term implantation. In fact, some of the units have been tried in such an application but have failed in less than a year. This problem is not considered to be insurmountable, however, and a survey is being made of sources for such a transducer.

Successful Searching Method:

As a result of contacts by the NASA-supported Biomedical Application Team at the University of North Carolina Medical School, a commercial source of miniature telemetry systems was identified.

Source of Solution:

Mr. Stan Hutcheson, Microtronics Corporation, Carrboro, North Carolina.

Benefits to be Derived From Transfer:

The instrumentation and telemetry system, which would be used in conjunction with the valve described in biomedical problem WF-37, "An Implantable Valve Which Can Be Remotely Opened and Closed From Outside the Body", would be used to permit the gathering of data which is not now available on pressure buildup on the cranial cavity. It is anticipated that accumulation of this data will permit correlation of the data with other clinical observations which may in turn yield information on the actual mechanism of fluid production in the brain.

Current Status:

The researcher is seeking a source of funds to initiate procurement of the required telemetry systems from the Microtronics Corporation. At the same time, the Biomedical Application Team is obtaining data on the reliability of commercially available sensors to permit choice of the sensor most suitable for this application. Contact with commercial suppliers of pressure transducers small enough for this application has revealed that only one manufacturer has units of sufficient reliability and long-term stability. A special testing and quality control effort would be required by the manufacturer; however, he is willing to undertake such a program without cost to the researcher because of the significance of this problem both to his own company and the medical sciences.

UNC-38

Electromyography as an Aid to Hand Rehabilitation

Miss Irene Hollis, Hand Rehabilitation Center
University of North Carolina Medical School

Description of Problem:

The Hand Rehabilitation Center of the University of North Carolina Medical School is engaged in a program of occupational and physical therapy to help in restoring the function of the hand to people who have received injuries resulting in incapacitation. Therapy is also administered to regain function in hands where surgical corrective procedures have been accomplished.

One important aspect of therapy is the fact that it is desirable to exercise certain particular muscles in specific fashions, in order to strengthen or regain function in these muscles. Damaged muscles are frequently favored by bringing into play some other combination of muscles to produce the motions prescribed by the therapy. As a result, a method of determining if the specific muscle involved is actually being exercised is required.

In the past, the Hand Rehabilitation Center has used a simple electromyographic (EMG) device which picks up the EMG signal from the specific muscle that is being exercised. Electromyography is a general term which includes any procedure for registering the electrical activity of muscle. A simple way to detect the electrical activity or action potentials of skeletal muscle is to place small metal disks (surface electrodes) on the skin over the muscle. No electrical activity occurs over the resting muscle. During voluntary contraction, an irregular oscillation of 0.1-2 millivolts, often with a frequency of about 50 hertz, occurs. Electrical activity is an indication of voluntary or reflex contraction of the muscle. The electrical signal magnitude is approximately proportional to the tension produced by the muscle. Thus, the magnitude of the signal can be used to judge how much neuromuscular activity is being exerted by the muscle being monitored. The device which has been used by the Hand Rehabilitation

Center was damaged beyond repair, and a suitable commercial replacement could not be found. Miss Hollis, Director of Occupational Therapy at the Hand Rehabilitation Center, located an EMG training device which had been designed at the U. S. Army Medical Biomechanical Research Laboratory, Walter Reed Army Medical Center in Washington, D. C. The Biomedical Application Team was consulted to determine the possibility of fabricating a muscle training unit according to the design produced at the Walter Reed Army Hospital.

Description of Solution:

The Instrumentation Section of the Engineering and Environmental Sciences Division of RTI was asked by the Hand Rehabilitation Center to furnish a quotation on the cost to fabricate an EMG muscle trainer from the design developed at the Walter Reed Hospital, Washington, D. C.

Successful Searching Method:

This problem essentially involved the identification of a suitable supplier to fabricate the desired EMG muscle trainer. As a result of NASA-supported Biomedical Application Team activities at the University of North Carolina Medical School, this problem came to the attention of one of the team members who, in turn, pointed out to the Hand Rehabilitation Center that a fabrication capability was available at the Research Triangle Institute.

Source of Solution:

As a result of NASA Biomedical Application Team interaction with the University of North Carolina Medical School, the investigator with an electronic equipment fabrication problem was placed in contact with a suitable fabrication source.

Benefits to be Derived From Transfer:

Conventional EMG machines cannot be readily used in this application because of their large size, as well as their large cost. The unit discussed herein is small enough to be used in the clinic during therapy (which is the primary need) and is also inexpensive enough to be used in normal clinical practice. In use, the EMG amplifier is used as a training device to induce the patient to use a specific muscle during the therapy process. Use of the EMG device provides a direct indication as to whether the muscle is being used or not. This device will be used to provide training and therapy on 90 percent of the patients which enter the Hand Rehabilitation Center. Normally, the Hand Rehabilitation Center treats 30 to 40 patients per month.

Current Status:

The EMG muscle trainer is now being fabricated at the Research Triangle Institute. When the unit is complete, testing and clinical trials will be conducted at the Hand Rehabilitation Center.

UNC-47

An Improved Splinting Material

Miss Gloria DeVore, Hand Rehabilitation Center
University of North Carolina Medical School

Description of Problem:

Therapists at the Hand Rehabilitation Center at the University of North Carolina Medical School treat large numbers of patients who require custom-fitted splints on the fingers and the hands. Some of the fitting involves shaping to complex contours. The presently used splint material is plaster of paris. It is time consuming to construct the plaster splints, but the materials cost is low. In addition, its strength and resistance to the mechanical shock and temperatures normally encountered is adequate. An inexpensive material which is easy to fabricate into intricate shapes is desired. The material when made into a splint must be able to withstand the mechanical shock which would be encountered by the device worn on the hand and should be able to withstand direct sunlight and hot water. Various plastic materials have been marketed as cast and splint materials, but none of those tested to date have the desired properties. Most are expensive, difficult to form, and unable to withstand direct sunlight and heat.

Description of Solution:

A lightweight thermoplastic splinting material marketed by Smith & Nephew, Ltd., of Lachine, Canada, has been identified as potentially useful in this application. The material, trade name "Plastazote", is a cellular, cross-linked plastic made from low density polyethylene. It is available in sheets of 24 inches by 36 inches with thicknesses from 1/8 to 1 inch. Available colors are black, white, and flesh color. The material is perforated to reduce problems with heat retention and sweating. The material can be cut to size or pattern with a knife. It is then placed in an oven at 140° Centigrade until the temperature throughout the material is 140° Centigrade. The material is then removed from the oven,

directly molded to the finger or other member, and held in place for three minutes until it hardens. If smoothing is required, sandpaper can be used. The material is nontoxic, washable, reusable, and economical.

Successful Searching Method:

A commercial supplier for a material potentially useful in the solution of this problem was identified as a result of the systematic searching of biomedical engineering journals and literature on commercial suppliers. This searching is performed routinely as a part of the NASA Biomedical Application Team activities.

Source of Solution:

Smith & Nephew,Ltd., Lachine, Canada.

Benefits to be Derived from Transfer:

Most of the 30 to 40 patients which are treated at the Hand Rehabilitation Center each month require some form of splinting or orthotic device. An improved splinting material can provide a savings in two ways. First, if the materials cost is significantly lower, the cost of splints will be reduced. Second, if the material reduces the fabrication time required to produce the splints, not only will the cost of splints be reduced, but the efficiency of personnel at the Hand Rehabilitation Center will be increased.

Current Status:

Samples of the material have been ordered by the researcher. The splinting material has been received from the manufacturer, and preliminary tests have been conducted with the material. The manufacturer has available a reinforcing material to be used with Plastazote in those applications requiring splints more rigid than can be obtained with Plastazote alone. Tests have revealed that splints fashioned from

Plastazote alone do not possess sufficient ridigity for this application. Unfortunately, the manufacturer did not supply any of the reenforcing material. As a consequence, final evaluation of the material has been postponed until the reinforcing material has been obtained and a new series of tests have been conducted.

4.0 New Problems

During the preceding reporting period, fifteen new problems have been discussed with medical investigators. Problem statements for these fifteen new problems have been prepared and are presented herein.

DU-41

Electrode Vest for EKG Measurement

Dr. W. E. Hammond, Duke University Medical Center

A potential solution to this problem has been identified. Current status and description of the potential solution is given in Section 3.0.

MISC-1

Biomedical Tape Recorder

Dr. C. H. Waddington, University of Edinburgh, Scotland

Technology applicable to this problem has been identified. Documentation of transfer is given in Section 2.0.

UNC-47

An Improved Splinting Material

Miss Gloria DeVore, University of North Carolina Medical School

A potential solution to this problem has been identified. Current status and description of the potential solution is given in Section 3.0.

UNC-48

An Improved EMG Electrode for Hand Therapy

Miss Irene Hollis, Director of Occupational Therapy
Hand Rehabilitation Center
University of North Carolina Medical School

Technology applicable to this problem has been identified. Documentation of the transfer is given in Section 2.0.

UNC-49

A Manipulator for Therapy in Abductor Transfer Cases

Miss Irene Hollis, Director of Occupational Therapy
Hand Rehabilitation Center
University of North Carolina Medical School

Technology applicable to this problem has been identified. Documentation of the transfer is given in Section 2.0.

DU-42

Avian Aerodynamics

Dr. V. A. Tucker, Duke University

Description of Problem:

Dr. Tucker has a general interest in avian flight. He is interested in both the aerodynamics of flight and the energetics of flight. In order to conduct these studies, he carries out wind tunnel tests on birds. Next, he correlates his results with studies of birds in a natural environment. This is done by careful flight path analysis of free flying birds using theodolite cameras. These cameras produce a film of the bird with azimuth and elevation readings. By using two cameras simultaneously and computer analysis, the flight path is determined. A manual process if used to translate the film recording into computer cards. The researcher would like to know if automatic techniques are available to replace this manual process.

Status:

A computer search of the NASA literature was conducted and the researcher has ordered several documents.

DU-43

Small Low-Velocity Flight Balance

Dr. V. A. Tucker, Duke University

Description of Problem:

Dr. Tucker has a general interest in avian flight. He is interested in both the aerodynamics and energetics of flight. In order to conduct these studies, he carries out wind tunnel tests on small airfoils that are related in shape to birds. These wind tunnel tests are unusual in regard to size of object (small) and air speed (low). One of the basic tools of wind tunnel testing is a flight balance. It is used to obtain the three moments and three forces acting on an airfoil.

Dr. Tucker would like to be advised of any NASA developments in flight balances.

Status:

A computer search of the NASA literature was conducted and the researcher has ordered several documents.

DU-44

Reflectance Spectrum of Snail Shells

Dr. Knut Schmidt-Nielsen, Duke University

Description of Problem:

The researcher has a general interest in thermal exchange between animals and radiation sources. One interesting aspect of this area concerns a snail that lives in the North African desert. The snail will die if its temperature exceeds $50^{\circ}C$, although the temperature of the desert sand reaches $70^{\circ}C$. This problem has applications to the aerospace field because spacecraft use passive temperature control. Dr. Schmidt-Nielsen is trying to determine how the snail accomplishes this feat of passive temperature control without water for evaporative cooling. One possibility is a high reflectance of infrared radiation by the snail's shell. The researcher wants to measure the reflectance spectrum of the snail's shell in the near-infrared spectrum. The measurement will only take a short time and the researcher does not have sufficient funds to purchase a reflectance spectrophotometer. He would like to make a measurement using NASA equipment, if available.

Current Status:

Mr. Charles Schumaker, the Technology Utilization Officer at Langley Research Center, Hampton, Virginia, has been contacted. He is trying to determine if suitable equipment is available.

DU-45

Low Velocity Anemometry

Dr. Steven Vogel, Duke University

Description of Problem:

Dr. Vogel is interested in passive temperature control mechanisms in biology. In particular, he is concerned with the passive temperature control used by leaves of trees. It is well known that leaves have a high infrared reflectance in order to reduce temperature. It is also well known that the shape of a leaf varies from top to bottom of a tree. Dr. Vogel suspects that this shape variation is related to passive temperature control.

In order to check his hypothesis, he is measuring heat dissipation of various shapes of metal sheet. Because heat dissipation is a function of ambient wind velocity, he makes his measurements in a low-speed wind tunnel. His technological difficulty arises in measuring wind velocities less than 2 mph. Dr. Vogel would like information on low-speed anemometers.

Status:

A search of the NASA data bank, #1609,"Low Velocity Anemometry," was delivered to the researcher.

MISC-2

Fast X-ray Field Hospital

John R. Beall,
U. S. Army Medical R & D Command

Description of Problem:

A part-time member of the Biomedical Application Team, while engaged in activities unrelated to the team, discovered a problem that was related to NASA-developed technology.

The Army is interested in improving its field hospital facilities. One of the problem areas is the field X-ray units. In a field hospital, casualties arrive that have undetermined battlefield injuries. The injuries are largely untreated except for first aid. One common source of injury is shrapnel. Because of the peculiar path of a piece of shrapnel passing through the body, an X-ray is required to determine the extent of injury. Present X-ray techniques are too slow to be adequate, and fluoroscopes do not have adequate resolution. The problem is to find a high speed X-ray or high resolution fluoroscope suitable for field hospitals.

Status:

Tech Brief #68-10363, "Improved Radiographic Image Amplifier Panel", and the associated back-up package were delivered to Mr. Beall. The documents deal with a fluoroscope-like device with image retention capability. The device was designed for nondestructive testing but is applicable for medical use.

UNC-50

A General Purpose, Indicating, Pressure-Sensitive Muscle Trainer

Miss Irene Hollis, Director of Occupational Therapy
Hand Rehabilitation Center
University of North Carolina Medical School

Description of Problem:

Many of the exercise and therapy procedures employed at the Hand Rehabilitation Center require that the patient exert a small amount of force against a static load. Proper placement of the forearm and the hand, along with static restraints suitably situated, can permit the exercise of a number of muscles in the hand. Many times the patient is unable to exert a sizable force; however, it is desired to know even if he is able to produce a very small force with the muscles in question. A small multipurpose pressure-sensitive indicator is desired which can be placed at the point of application of pressure to indicate when the patient is exerting force using his muscles. A sensitivity of one to two ounces is required, and the pressure-sensitive area against which the patient is to apply the force measures approximately ½ inch by 1½ inch. This means that the pressure-sensitive area must be at least that large. Thickness is not critical; however, a normal value of ¼ inch is desired. This pressure-sensitive device should light a lamp when the pressure threshold is exceeded.

Status:

This problem has just been identified, and information searching is beginning.

WF-64

Improved Methods of Making Volume Plethysmographic Measurements Related to Volume Changes in Tissue Caused by Influx and Efflux of Blood During the Cardiac Cycle

Dr. G. L. Malindzak and Dr. H. D. Green,
Bowman Gray School of Medicine

Description of Problem:

Devices are presently available which can be slipped over the fingers or the toes and used to sense the change in volume of the member which results from the influx of blood pumped into the member during the cardiac cycle. These devices generally consist of an inflatable cuff which is placed over the finger. The cuff is then inflated to tightly fit the finger, and the pressure in the inflated cuff is monitored. When the finger increases in volume as blood flows into the finger, the pressure in the cuff increases. The output of the pressure transducer is therefore a pressure pulse which reproduces the time rate of change of volume of the finger. The shape of this pulse is modified by various abnormalities in the cardiovascular system.

First, it is desired to obtain better data in order to investigate the relationships between the wave shape and various abnormalities. Secondly, a means to make these measurements at points on the body, other than at the extremities, is desired. With such a device, troubleshooting could be accomplished in order to isolate the location of abnormalities in the vascular system.

Status:

The problem identification has been completed. A search of the aerospace literature, Bibliography No. 1578, "Plethysmography", has been conducted. The search has been evaluated, and pertinent documents cited in the search have been ordered.

WF-65

Function Multipliers to Compute Derivable Physiological Parameters

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

There exists a requirement in the instructional program of the Bowman Gray School of Medicine for a small unit which will accept measurable physiological data and compute derivable parameters therefrom. For example, with the parameters of blood pressure and blood flow as input data, it might be desired to derive resistance. Resistance is obtained simply by dividing pressure by flow. This type of operation can be accomplished with two function multipliers and peripheral equipment. The units would be used in classrooms and laboratories to perform computations and obtain the desired derived parameters in real time as the primary data is being taken. The researcher has asked the Biomedical Application Team for help in locating technology which will permit the fabricating of such units at a low cost.

Status:

The problem identification phase has been completed.

WF-66

An Analog Computer with Interchangeable Problem Boards

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

At the Bowman Gray School of Medicine, the use of computers in medicine is being introduced into the undergraduate teaching program. Instruction is given on the application of computers in various physiology areas, neurology, pharmacology, etc. There are several approaches to implementing an instructional and practical application program of this nature. The researcher has elected to use a general purpose analog computer in the laboratory in order for the students to obtain practical experience with the application of computers to problems in their field of interest or instruction. In this particular situation, it was decided that a general purpose analog computer with interchangeable program boards would be desirable. The use of interchangeable program boards will permit the users of the computer to employ their own program boards for their individual problems without the necessity of completely reprogramming the computer. The Biomedical Application Team has been asked to determine if low cost units are available that can be used in this application.

Status:

The problem identification phase has been completed.

WF-67

A Filter to Separate Physiologic Data Occurring at Nominal Heart Rates from Lower Frequency Data

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

In the Department of Physiology at Bowman Gray School of Medicine, large quantities of data have been and are being accumulated on blood flow, blood pressure, heart rate, and other measureable and derivable quantities that are related in time to the heart rate. These data are recorded on magnetic tape and strip charts. The heart rate is, of course, periodic, nominally occurring approximately once per second. superimposed on this data, and appearing as noise, is a much slower occurring waveform. The undesirable long period data appears to be related in some fashion to the respiration cycle. The amplitude of this slower rate waveform is large with respect to the heart rate-related data. It causes serious baseline distortion and makes interpretation of the data difficult. The researcher desires to separate the low rate waveform from the heart rate data and to obtain a filter which will accomplish this function. The researcher has requested that the Biomedical Application Team aid him in identifying a low-cost filter design that can be used in this application.

Status:

The problem identification phase has been completed on this problem.

5.0 Activities on Previously Identified Problems

This section describes the activities of the Biomedical Application Team during this quarter on active problems which were identified prior to this quarter. In addition, follow-up action on potential transfers and transfers which were identified prior to this quarter are discussed.

DU-36

Cervical Cancer Diagnosis

Dr. W. W. Johnston, Duke University Medical Center

Description of Problem:

The general area of interest is detection of cancer. The specific problem is detection of cancer of the cervix. Cervical cancer is detected by scraping cells from the neck of the womb and smearing them on a microscope slide. The malignant cells have a different shape from healthy cells when observed under the microscope. All women over 20 should have this test annually. If detected early, the disease is curable. If not, the disease is fatal.

The problem arises because this test is manual, and the large number of samples tested in Dr. Johnston's laboratory is at present burdensome. The researcher desires a method of automatically screening the samples.

Status:

A computer search of the literature, #817, "Image Processing," failed to reveal any significant information; therefore, a search of the commercial literature was made disclosing two instruments that appeared to be suitable. Analysis of the instruments by the researcher indicated that they would detect some cancerous samples but not all. Further discussions of the problem apprised the team of the extreme difficulty of detection of cancer cells.

A search of the open literature revealed a recent article on a new manual technique that may be suitable for automation. The team is now pursuing this latest development.

DU-39

Miniature Pediatric Pulse and Respiration Rate Monitor

Dr. Susan C. Dees, Duke University Medical School

Description of Problem:

The area of general interest is allergy in children. Dr. Dees is interested in both the research and clinical aspects of pediatric allergy. The specific area of interest is asthma. Asthma affects from 2 to 5 percent of the population and is characterized by recurrent periods of severe respiratory difficulty. Between attacks the patient is free of symptoms.

It is desirable to have an early warning of the onset of an asthmatic attack. This would be helpful in treating known asthmatic patients and also for diagnosis. Asthmatic attacks usually occur at night and affect both pulse and respiration rate. The researcher desires a small pulse and respiration rate monitor that can be worn by children at night. The monitor would telemeter the information to a bedside receiver.

Status:

Information from two previous searches, #679,"Biotelemetry;"and #1469,"Oxygen Tension in Tissue and Biotelemetry;" was applied to this problem. These searches revealed many ideas for small telemetry units. A search of the commercial literature disclosed several units technically suitable for the problem but the units were rejected by the researcher as too expensive ($1,000 each). The Biomedical Application Team then found a local contractor who could custom-design the units for a lower cost ($500 each). This was rejected by the researcher also. Finally, the team suggested the alternate approach of recording voice sounds. Coughing could be used as a measure of asthma onset. The researcher is now considering this approach.

UNCD-25

A Miniaturized Electrical System to Shock the Tongue of Patients When It is Pressed Against the Rear of Their Teeth

Dr. R. M. Nelson and Dr. G. Helmers,
University of North Carolina Dental School

Description of Problem:

This problem is closely related to the behavior pattern described in UNCD-17, "A Method of Measuring Tongue-Lip Pressures on the Teeth." When children acquire the habit of pressing against the rear of their teeth with their tongues, they persist in doing it unconsciously over long periods of time and cause movement of the teeth. This results in an improper spatial configuration of the mouth which is structurally undesirable and cosmetically unappealing. Some means of training children to refrain from this behavior pattern is needed. The researchers have indicated that their choice would be some means of shocking the tongue when it is pressed against the rear of the teeth and exceeds a certain predetermined pressure. This particular approach would, of cource, require an extremely small device. Other approaches which could achieve the correction in behavior pattern are welcomed.

Status:

Initial problem specification has been completed, and several attempts have been made to formulate a search strategy which would permit obtaining useful information from the NASA information banks. As a result of several trials, a search, "Aversion Therapy," No. 1503, has been completed for the Research Triangle Institute's Biomedical Application Team by the North Carolina Board of Science and Technology Research Center. This search was conducted to reveal methods employed by investigators in the past in bringing about behavioral changes in subjects. By screening the various techniques employed, it was hoped that a technique useful in this particular problem would be identified. The search was reviewed, and no useful information relating to this problem was found.

As a result, a search was conducted of the computerized MEDLARS system of the National Library of Medicine. This search has been received and is currently being evaluated.

WF-3

Prosthetic Valve for Urinary Tract

Dr. W. S. Montgomery, Bowman Gray School of Medicine

Description of Problem:

A number of different injuries and diseases can result in loss of control of urinary function. Victims of congenital defects, neurogenic bladder diseases, stroke, and multiple sclerosis, as well as war and automobile accident casualties, frequently experience bladder and urethral malfunctions. These malfunctions usually involve an inability to contract the muscles in the bladder wall or an inability to relax muscles which close the urethra, i.e., the passage through which the bladder is emptied. This condition generally results in gradual deterioration of the bladder, infections of the urinary tract, and in some cases damage to the kidneys and subsequent death. This condition is the most frequent cause of death of paraplegics.

In treating patients who cannot control urinary function, it is important that the bladder be allowed to fill and then be emptied rapidly every 3 to 4 hours. This periodic functioning allows the muscles of the bladder to be exercised and, as a result, to remain healthy. One approach that has been taken is to attach electrodes to the bladder muscles so that contraction of the bladder can be electrically induced by the patient. This electrical stimulation unfortunately also induces contraction of other muscle groups--i.e., sphincters--which close the urethra. As a result, fluid pressure inside the bladder becomes dangerously and painfully high.

A valve which can be implanted in the urethra and can be controlled by the patient is needed to successfully treat the loss of urinary function. In cases where bladder muscle is healthy when the valve is implanted, the bladder would contract when the valve is opened without

stimulation due to the inherent elasticity of healthy muscle tissue. If bladder muscle deterioration has occurred, electrical stimulation can be used simultaneously with opening of the valve without causing excessive internal pressure.

Status:

Efforts are continuing to obtain a source which can inexpensively fabricate a prosthetic urethral valve for implantation. At the present time an evaluation is underway to determine whether the Biomedical Engineering Department at Wake Forest University has sufficient equipment and shop facilities to fabricate the unit.

WF-13

Radiation Detector for In Vivo Measurement of Absorbed Dose

Dr. D. D. Blake, Bowman Gray School of Medicine

Description of Problem:

This problem involves the measurement of local dosage in radiation therapy and treatment. Essentially, a small direct reading intracavitary dosimeter for use in radiation therapy is needed. This would permit the making of in vivo measurements of dose rate to various anatomic sites in patients undergoing radiation therapy. In the past few years, this development has consisted primarily of integrating systems such as glass beads or the thermoluminescent dosimeters. These require placement of tiny dosimeters within the tissues for a period of time during exposure to radiation, then removal of the dosimeters and calculation of the amount of exposure received. Primary disadvantages of such methods are large size, very low response, delayed readout, and limited flexibility. The major advantages of using a solid state radiation dosimeter are its small size, high sensitivity to radiation, rapid response, simple immediate readout, and flexibility. It will permit actual dose rates to be available during treatment which would permit alterations in the treatment as indicated.

Status:

The researchers are continuing to make preliminary measurements and calibration tests to accumulate the data necessary to begin in vivo tests on humans.

WF-28

Blood Flow and Blood Flow Rate In Vascular Systems Using Indicator Concentration Methods

Dr. C. E. Rapela, Bowman Gray School of Medicine

Description of Problem:

The use of indicator concentration curves to compute mean flow through and the volume of blood contained in a portion of the vascular system is an attractive technique. Much theoretical and experimental work has been done in this area. Researchers at Bowman Gray School of Medicine, Wake Forest University, have been engaged in an experimental program to accurately define the methods and techniques which can be used to obtain reliable data from these types of measurements. Because of the complexity of biological systems, initial studies have been made using a model in which an indicator, dye or radioactive, is injected mechanically at a constant rate into a uniformly flowing stream of blood in a plastic tube of uniform diameter. The time of injection can be varied in order to control the amount of dye injected. The injection rate is 0.01 cm^3 of indicator per second. The injection time can be varied from one-tenth second up to about 10 seconds. The range of volumetric flow of the fluid in the tube is between 2.5 and 25 cm^3/minute (flow velocity of 0.3 cm/second to 3 cm/second). Downstream from the site of injection is a counter or photocell, depending upon the type of indicator used, whose output is recorded on a strip chart. The output of the detector is proportional to the concentration of the dye or radioactive substances in the stream. Under experimental conditions flow is maintained laminar or streamlined. Because of this flow characteristic, the injection of dye is exceedingly critical depending upon whether the injection point is near the center of the tube or near an edge of the tube.

To overcome this problem in the model system, a rotary mixer is installed immediately upstream from the injection site. This mixer

induces turbulence, breaking up the laminar flow so that in the region of the injection site, the fluid flow is turbulent. Therefore, the velocity is approximately uniform across the entire diameter of the tube just below the mixer. Laminar flow is soon restored in the tube and makes it necessary to use another mixer at the sampling site. This occurs because the counter has a finite aperture. If one considers equal quantities of indicator which are traveling at different speeds, it is easily seen that the slower moving fluid will remain for a longer period of time under the counter aperture, therefore, producing more counts than the rapidly moving indicator. This means that indicator concentration is biased so that equal concentration and lengths of laminae of indicator fluid do not produce the same number of counts; i.e., a fixed volume and a fixed concentration of indicator fluid moving at a higher rate produces fewer counts than the same volume and the same concentration of indicator moving at a lower rate.

To overcome this measurement difficulty, a mixer has been placed in the experimental apparatus upstream from the sampling site. This produces turbulence, thoroughly mixing the indicator components which were traveling at different velocities in the laminar flow region, so that the velocity of all the indicator is approximately the same as it passes under the counter aperture. Without the use of mixers to produce turbulence at both the injection and the sampling sites, it has not been possible to obtain reliable data on blood rate of flow and volume.

In order to make the transition from the idealized model--with which reliable data may be obtained--to measurements on a biological system, some means of inducing thorough mixing immediately preceding the injection and sampling sites is needed. This type of measurement would normally be conducted in arteries or veins near the surface of the skin. A simple device which can be employed to produce mixing and turbulence at the injection site and the sampling site in the veins and arteries is needed.

Status:

During this quarter, a potentially useful device that might be useful in aiding the mixing of blood and dye has been identified. The unit, a commercially available ultrasonic device manufactured under the trade name "Sonifier", is used for cellular disruption. The device is basically a metal rod energized into vibration by a piezoelectric transducer driven at a frequency in the ultrasonic range. The researcher is considering the practicality of the unit for this application. If reaction of the researcher is favorable, a demonstration unit will be obtained to test it in the researcher's experimental set-up.

WF-53

Means of Obtaining the Velocity Spectrum of Blood Flowing in Arteries and Veins

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

Blood flow in blood vessels is generally considered to be laminar; thus, the blood flow velocity is at a maximum in the center of the blood vessel and essentially zero on the edges. The result is that, if one were to consider a cross section of such a model, the maximum velocity would exist in the center of the vessel, and concentric rings indicating equal velocity contours would radiate out to the walls of the vessel where the velocity is essentially zero. The average flow velocity is obtained through a number of different types of measurements; however, it is felt that information on the entire velocity spectrum of the blood flowing in veins and arteries would be of great value. Doppler flowmeters offer the possibility of obtaining the velocity spectrum and the shape of the velocity distribution curve. Present commercially available Doppler flowmeters indicate average velocity. It is desired to determine if the required information can be obtained by modification of existing Doppler flowmeters or other simple means.

Status:

During this quarter, the search #1502,"Ultrasonic Doppler Spectrum Analysis," performed by the North Carolina Science and Technology Research Center for the Biomedical Application Team has been evaluated. No information relevant to a solution to this problem has been found. Other information sources in this field are being consulted.

WF-54

An Improved Sensing System for Indicator-Dilution Studies

Dr. H. D. Green and Dr. C. E. Rapela, Bowman Gray School of Medicine

Description of Problem:

Indicator-dilution techniques have proved very useful in obtaining: (1) blood volume within a segment of the vascular system, (2) mean blood flow through a segment of the vascular system, and (3) particulate velocity. Fundamentally, the technique consists of adding a known concentration of an indicator (dye or radioactive) to a volume of fluid. Then, when the indicator is thoroughly mixed with the volume of fluid, a measurement of the concentration of the indicator permits calculation of the volume of fluid. First employed in a static system, the technique has been extrapolated to dynamic systems. Researchers at Bowman Gray School of Medicine have been engaged in an experimental program to define accurately the methods which can be used to obtain reliable data from these types of measurements.

Initial studies have been made using a simplified model of a vascular segment, i.e., a cylindrical tube. In this experimental model an indocyanine dye, sensitive in the infrared spectrum, is injected into a moving stream of liquid which is being pumped through a polyethylene tube of uniform diameter. Dye is injected into the flowing liquid stream by a hypodermic syringe driven by a constant speed linear actuator. The total length of time that the dye is being injected into the stream can be varied from 0.1 second to 10 seconds to control the total amount of dye injected. Flow velocity of the fluid in the tube is approximately 20 cm^3/ second.

Within the tube, flow is usually considered to be laminar, which (when viewed in cross section perpendicular to the tube axis) corresponds to a series of concentric isovelocity rings of fluid with the highest velocity nearest the axis of the tube and the lowest velocity nearest the wall of the tube. Because of this characteristic, dye injected near the center of the tube propagates through the system much more rapidly than

dye injected near the wall, making the point of dye injection very critical. To overcome this problem, a rotary, mechanically-operated mixer is installed immediately upstream from the injection site. This mixer induces turbulence, breaking up the laminar flow pattern so that, in the region of the injection site, the fluid flow is turbulent, producing a velocity profile which is approximately uniform across the entire diameter of the tube just below the mixer.

Windows on opposite sides of the polyethylene tube have been used to observe the indicator dye concentration in the flowing stream. A source of radiant energy is used to illuminate one of the windows, and a photocell sensitive in the absorption spectrum of the indicator dye is placed on the opposite side of the tube in the other window. From the photocell reading, the concentration of indicator in the liquid flowing past the photocell can be determined. This dye concentration is an average of the concentration across the entire diameter of the tube.

It is desired to examine small portions of the volume of the tube so as to determine the regional characteristics of the dye distribution within the tube. In order to permit such a determination to be made, the researchers desired to obtain an indicator absorption apparatus which could examine these small volumes of fluid within the tube. They felt that an approach using fiber optics offered the best possibility of yielding meaningful measurements at a reasonably low cost. The Biomedical Application Team was asked to consider the feasibility of performing such measurements using fiber optic illuminators and pickup devices. In addition, it was desired to examine any other techniques capable of performing this measurement which could be identified. It was also desired to obtain a device which could be used not only in the transmission mode but in a backscatter mode if such proved feasible.

Status:

This problem was documented as a transfer and discussed in the first quarterly report.[1] During this quarter the unit was demonstrated to the

[1] Biomedical Applications of NASA Science and Technology, Quarterly Progress Report 1, 15 June 1968 to 14 September 1968.

researchers, and preliminary tests were conducted. Figure 2 is a block diagram showing the function relationships of the system. Figure 3 is a view of the front panel showing the fiber optics. Figure 4 shows the front of the unit with the fiber optic bundles inserted into the fluid mixer. Figures 5 and 6 show the interior of the unit.

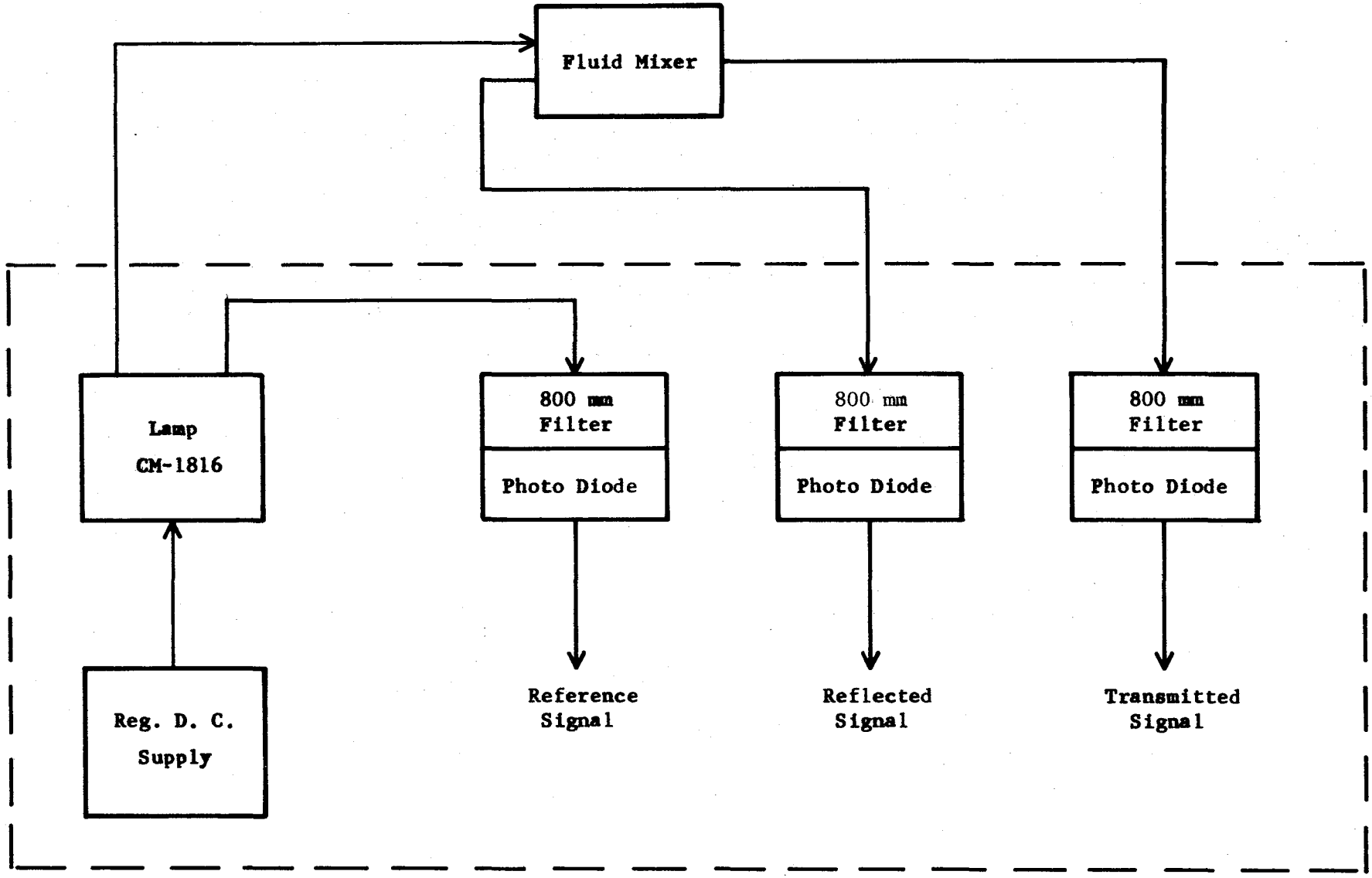


Figure 2 — Dye Detector System

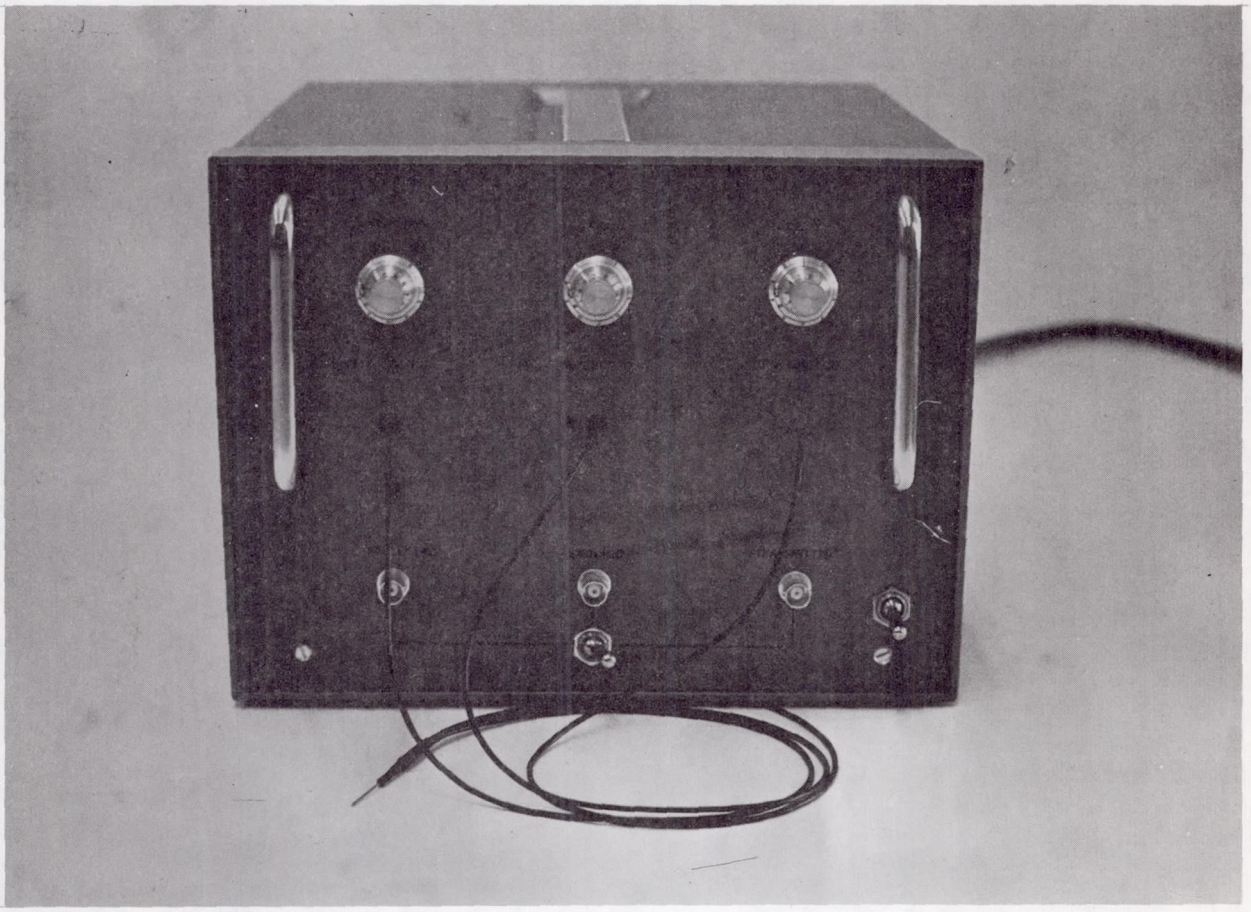


Figure 3 — Fiber Optic Dye Detector Unit,
Front Panel View

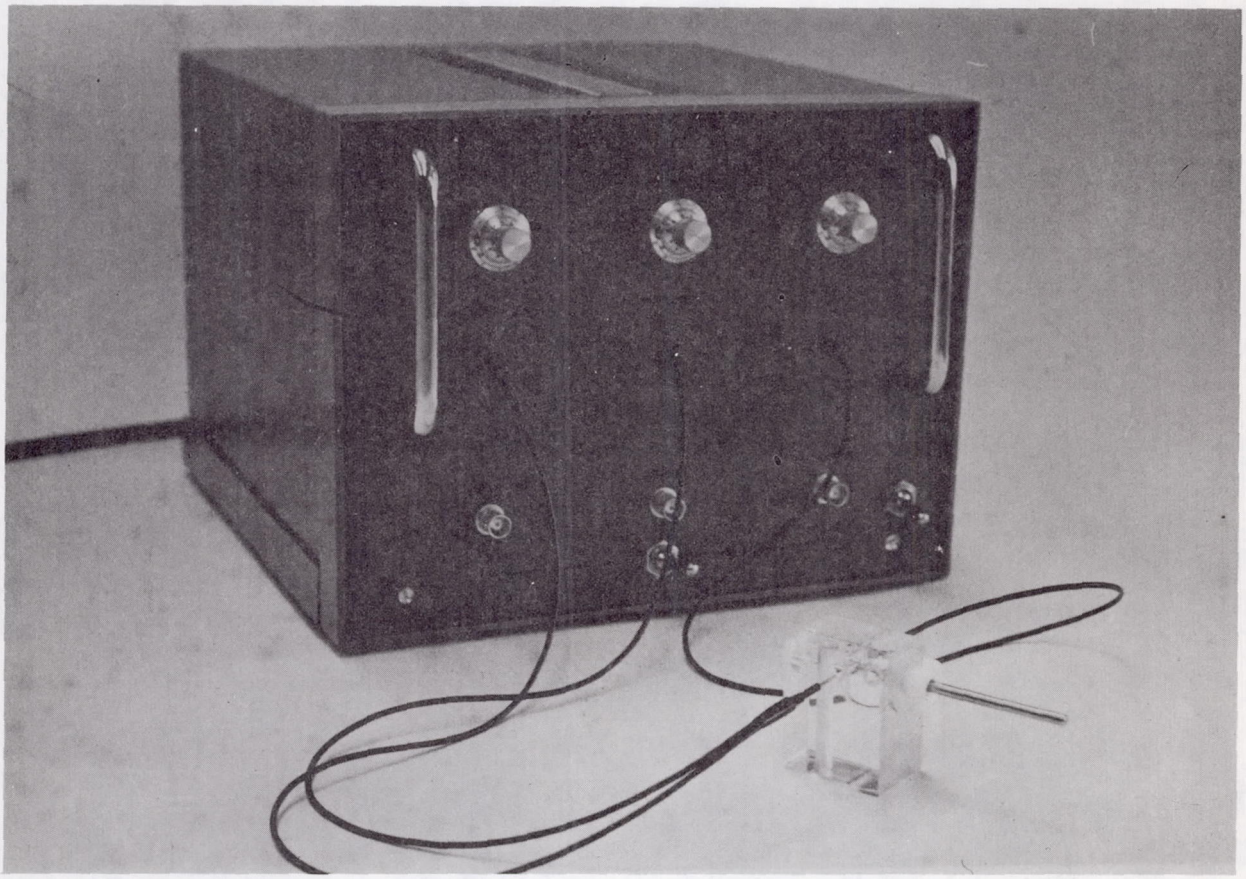


Figure 4 — Fiber Optic Dye Detector Unit with
Fiber Optic Bundles Inserted Into the Fluid Mixer

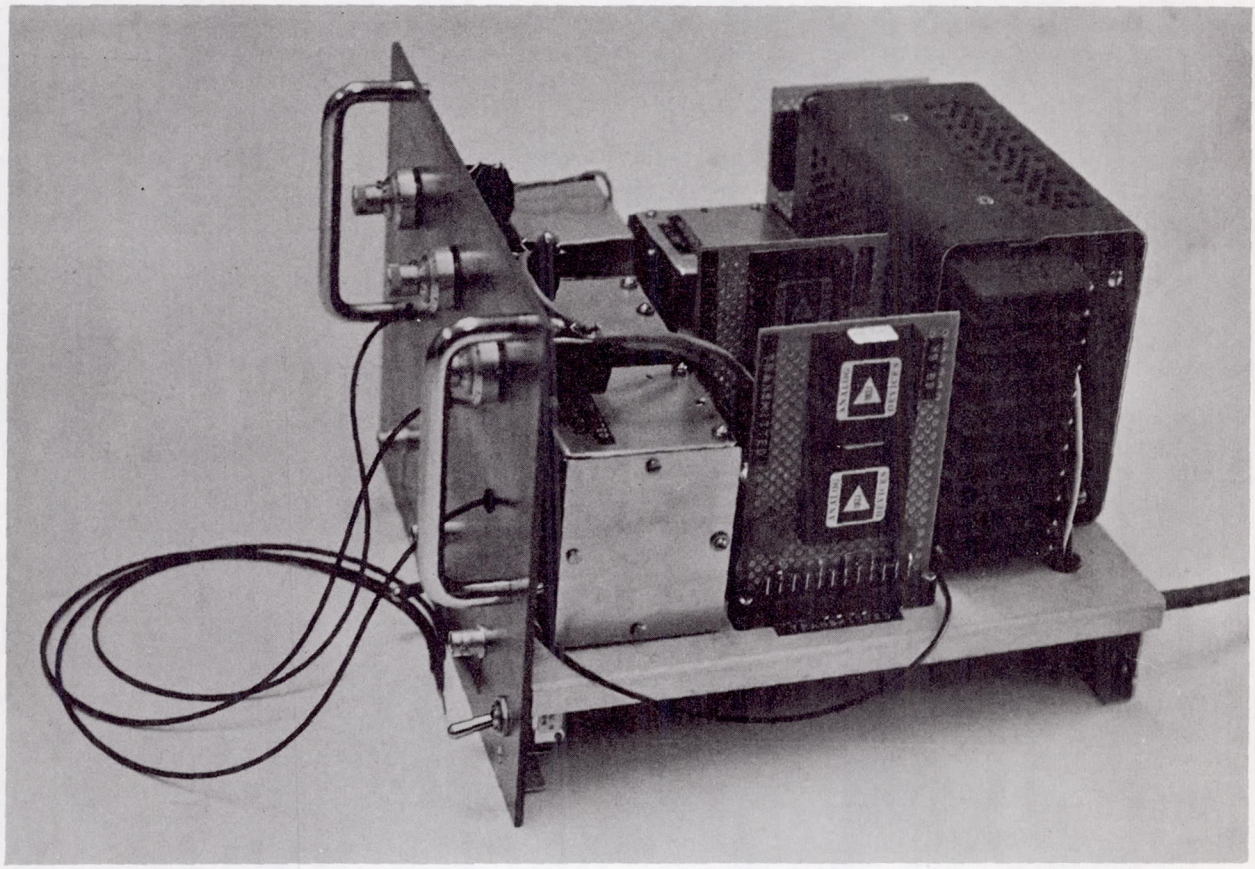


Figure 5 — Fiber Optic Dye Detector Unit,
Interior

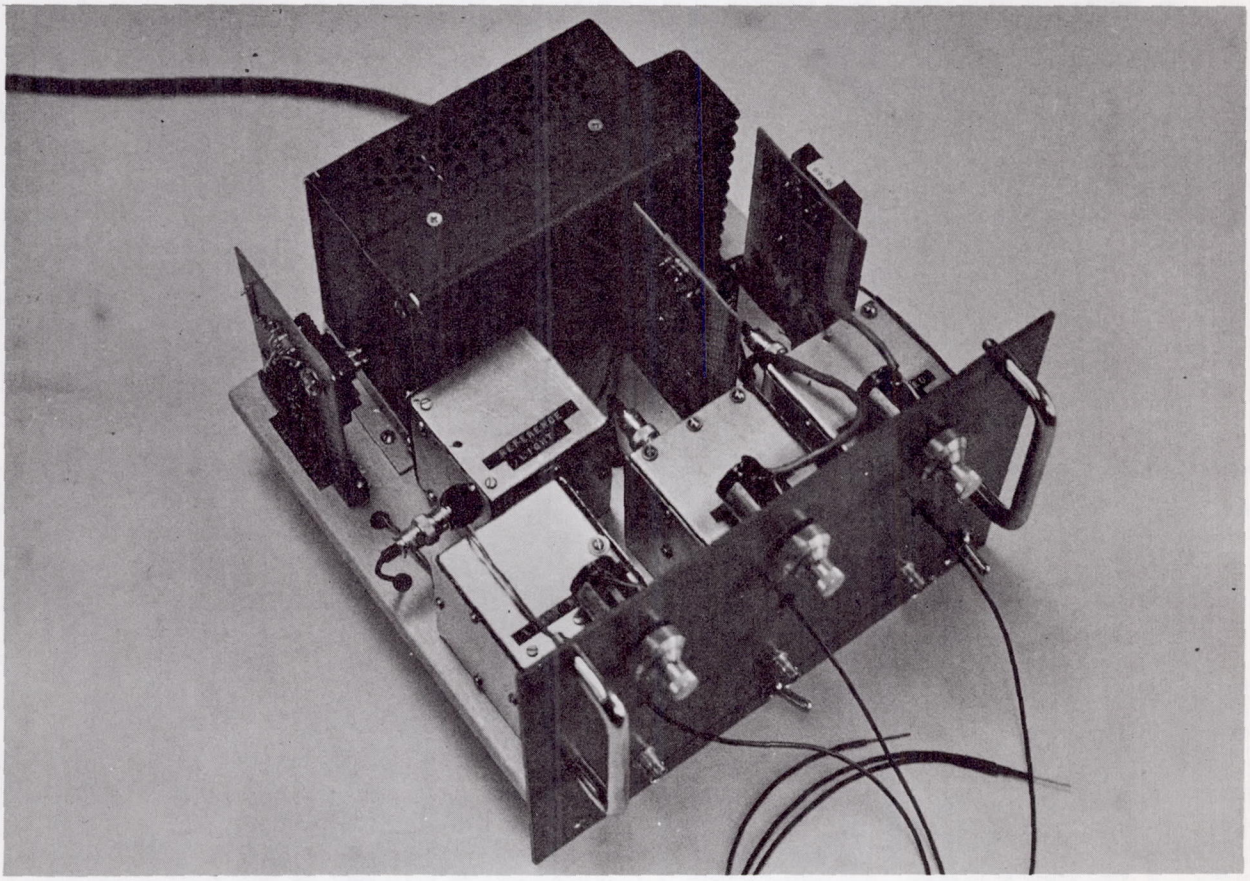


Figure 6 — Fiber Optic Dye Detector Unit,
Interior

WF-56

An Improved Fluid Pressure Calibration System

Dr. G. S. Malindzak, Jr., Bowman Gray School of Medicine

Description of Problem:

The Department of Physiology of the Bowman Gray School of Medicine, Wake Forest University, maintains a fluid pressure calibration system which is used as a standard for calibrating arterial pressure transducers used by medical researchers in that department. The system consists of an electromechanical transducer and a fluid-filled pressure chamber with provision for connecting external pressure measuring transducers into the pressure chamber.

The electromechanical transducer currently employed is a commercially available underwater loudspeaker which is energized by a low frequency sine wave function generator. The response characteristic of the underwater speaker in the present system is very poor and not accurately known at the low frequencies (<10 Hz.).

It is desired to generate pressures within the pressure chamber that have constant amplitude and phase characteristics with frequency. Two different approaches suggest themselves as means of solving this problem. First, the ideal solution would be to obtain a pressure generator which can produce constant pressure sinusoidal pulsations over a frequency range from near 1/10 hertz to 150 hertz. A second approach is to use the present underwater speaker and modify the driver-amplifier system which actuates it. This requires that the frequency response characteristics of the speaker be accurately determined throughout the frequency range of interest. Next, it requires the design of an amplifier whose frequency amplification characteristic is such that the combination of amplifier and transducer produces a constant amplitude pressure wave over the frequency range of interest.

Status:

As discussed in previous quarterly reports, the Engineering and Environmental Sciences Division of the Research Triangle Institute has

agreed to conduct a series of tests to determine the frequency response characteristics of the transducer presently used. Tests to determine the response of the transducer have been conducted during this quarter. The researcher has evaluated the results which have proved the feasibility of constructing a system to solve this problem. During the next quarter, the Engineering and Environmental Sciences Division of the Research Triangle Institute will provide a quotation to the researcher on the cost of designing and fabricating such a unit.

WF-62

An Extremely Thin Pressure Transducer to Measure the Pressures Exerted on Tissue by Support-Type Hosiery

Dr. H. D. Green, Bowman Gray School of Medicine

Description of Problem:

One of the researchers at Wake Forest has been asked by a leading textile manufacturer to undertake a program to evaluate the pressure effects of support-type hosiery on the vascular circulation in human legs wearing such stockings. One of the first requirements is to determine the magnitude of the compressive force exerted by the stockings on the leg. A very thin pressure transducer is needed for placement at various points between the stocking and the leg so that the pressure can be measured. Small size, particularly extreme thinness, is required so that introduction of the transducer itself will not increase the measured pressure by essentially increasing the leg volume. The pressure to be measured is, of course, relatively small so that a sensitive transducer is required.

Status:

Spitz Laboratories, who had marketed a device that seemed suitable for this application, was contacted. They informed us, however, that they had experienced difficulties with the units and had discontinued production of the units, so that they are no longer available.

During this quarter, we received a copy of an article relevant to this problem from Mr. John W. Johnson of the Biological Sciences Communication Project of George Washington University. Mr. Johnson had read a description of this problem in our Monthly Status Report for the period November 15, 1968 through December 14, 1968. The article described an investigation of pressure measurements on patients using elastic hose at the Veterans Administration Prosthetics Center in New York. This article is very pertinent to Wake Forest Biomedical Problem WF-62, and the researcher is currently evaluating the reported work in terms of his problem area.

6.0 Problem Review

During this quarter, a number of problems have been reviewed to determine whether further action was needed by the Biomedical Application Team. As a result, four problems have been classified as inactive.

There are various reasons for which problems are classified as being inactive. These reasons are:

(a) Transfer accomplished.

(b) Researcher has no further interest in the problem.

(c) Researcher has found his own solution.

(d) As a result of personnel transfer in the medical institutions, the problem has either been closed or transferred to another institution along with the investigator and has been given a new number.

(e) No present or foreseeable future NASA technology applicable.

(h) Satisfactory solution identified by team and verified by researcher but transfer cannot be completed by researcher for reasons of economy or lack of resources temporarily to implement findings.

(i) Problem as originally stated was too broad or general.

(j) Problem is too difficult; i.e., the problem as given to the Biomedical Application Team is presently the focus of large expenditures of money research and development effort making the likelihood of success by the Biomedical Application Team too low to warrant its expenditure of error worthwhile.

(k) Problem priority, e.g., Cost/Benefits ratio, team resources available, researcher's resources and enthusiasm, etc., compared to these aspects on other problems too low.

The problems which were classified inactive are listed below. The letter designation following the problem title indicates the reason for such classification as explained above.

UNC-41 Materials for and Fabrication of Vasectomy Clip. (c)

UNC-43 Instrumentation for Automatic Read-Out of Tissue Temperature as a Function of Time and Distance from a Probe Maintained at -40°C. (c)

WF-27 An Electrode or Other Type System with Rapid Response to Measure CO_2 Content of Blood in the Brain. (i)

WF-60 A Simple Means of Detecting Volume Elasticity of Blood Vessels. (d)

7.0 Information Searching

7.1 Computer Searches

During this quarter, a total of five new retrospective information searches were made of the NASA aerospace literature. The searches were performed for the Biomedical Application Team by the North Carolina Science and Technology Research Center. Information obtained from these searches has been used to support the searching activities associated with the medical problems which have been active during the quarter. Computer Evaluation Reports on each search are given in Appendix A. Retrospective computer information searches made during this quarter are listed below:

Subject	Search No.
Aversion Therapy	MEDLARS-52
Plethysmography	1578
EKG Electrodes	1595
Optical Tracking Readout	1604
Low Velocity Anemometry	1609

In addition to these retrospective searches, three Current Awareness Searches have been maintained by the Biomedical Application Team during this quarter.

Subject	Search No.
Surveys and Program Reports	1115
Image Processing	817
Prosthetics and Bioengineering	6002

In addition to formalized computer searching of the aerospace literature, we have extensively used another searching method to obtain information from the NASA information banks. Namely, we have on numerous occasions requested a manual search on very specific topics in the aerospace literature. These manual searches are performed in somewhat the following manner. If the subject of the problem is considered to be extremely specific, then the NASA index and thesaurus are consulted using specific

indexing terms to determine the number of documents in that subject area that are available in the NASA information system. If the number of documents is small--i.e., generally in the order of 10 or less--then it is more feasible to merely pull all the documents under that index term and evaluate either them or their abstracts without resorting to a computer search. This is not only less expensive, but it is also much quicker. This procedure has been an extremely effective and a very useful adjunct to our normal computer searching procedures. These types of manual searches have been undertaken on some 30 percent of the active problems during this quarter.

7.2 Other Searching Methods

In addition to these more or less formalized methods for obtaining information which relates to the solution of biomedical problems, the Biomedical Application Team has utilized three other information sources in seeking answers to biomedical problems. First, in every case the combined experience of the Biomedical Application Team members has been applied to the problems to ascertain if there exists within their knowledge and experience practical solutions to each problem. Indeed, this particular method of searching using the experience of technically trained personnel has not been limited only to members of the Biomedical Application Team. In fact, many specialists in the various disciplines of engineering and research have been routinely consulted to obtain information and advice on specific problems as deemed appropriate.

Another source of information relating to Biomedical Problems is the open literature. The Biomedical Application Team scans many of the related technical journals and biomedical engineering journals on a routine basis in order to maintain an awareness of techniques and equipment which are being developed. Access to the medical literature is maintained by use of Index Medicus which is available to all members of the Biomedical Application Team.

Finally, in all biomedical problems which involve measurement, instrumentation, or hardware, the commercial literature is surveyed to

insure that items have not already been developed which will fulfill the researcher's need. If commercial items are identified which can fulfill the researcher's need, he is, of course, apprised of the availability of such equipment. Keeping abreast of the product output of all the manufacturers of biomedical instrumentation is, however, a formidable task. To permit a reasonable degree of thoroughness in surveying the available instrumentation and hardware for use in the biomedical field, a file of available equipment from biomedical manufacturers is maintained by the Biomedical Application Team.

8.0 Other Activities

During this quarter, arrangements have been completed for the Research Triangle Institute's Biomedical Application Team to extend its services to the Institute of Rehabilitation Medicine (IRM) of the New York University Medical Center. Mr. Myron Youdin, Research Scientist at IRM, was selected by the Institute of Rehabilitation Medicine as the communicator who would interact directly with our team. The first meeting of the Biomedical Application Team was held on March 12, 1969 at IRM. Mr. Youdin had already obtained preliminary problem descriptions from a number of people. In addition to personnel from IRM, those in attendance at the meeting were Mr. L. S. Wilson, Biomedical Sciences Communication Project, George Washington University, Dr. J. N. Brown, Jr., and Mr. Ernest Harrison, Jr., Biomedical Application Team, Research Triangle Institute. Individual meetings were held with available researchers who had previously submitted brief problem descriptions,

During the next quarter, regular liaison will be maintained at IRM. Problem identification and information searching activities will receive major emphasis.

In another area of activity, an attempt is being made by the Biomedical Application Team to develop interest by smaller industries. Many of the possible problem solutions are unavailable to the researcher because of inadequate fabrication facilities. Attempts to find industrial fabrication sources are often frustrating because larger firms decline prototype work. One small firm, Perry Electronics, Raleigh, North Carolina, was contacted. The company expressed an interest in electronic prototype development and fabrication.

A meeting was held with Mr. Charles A. Barefoot, Vice-President of Carolina Medical Electronics, to acquaint this organization with NASA's Biomedical Application Team Program and the overall Technology Utilization Program.

A further industrial contact was made during the quarter by Dr. J. N. Brown, Team Director, who visited IBM in Washington, D. C. Dr. Brown

discussed with Dr. Hans Langlietz and other representatives of IBM the potential applications of digital image processing in biology and medicine and the ways that IBM can contribute to the development of these applications. Two problems which were discussed in detail at the meeting are DU-1, "Techniques for Calculating Left-Ventricular Volume," and DU-23, "Methods for Improving Resolution and General Quality of Electron Micrographs". Representatives of IBM offered to make available to investigators at RTI and Duke University a high-resolution image scanning system which is located in IBM's Federal Systems Division in Washington, D. C. Also discussed were the possibilities of IBM's developing software for digital image processing in the biomedical field and of IBM's locating an image processing system in the Research Triangle area to stimulate the development of new applications.

9.0 Plans for Next Quarter

In addition to the routine activities of the Biomedical Application Team as outlined in the Introduction and Summary, the team will direct a significant effort toward the following specific tasks:

(1) Follow-through on contacts with IBM regarding digital image processing. Specifically, electron micrographs and cineangiocardiograms and related information (problems DU-23 and DU-1 respectively) will be sent to IBM and processing of these data will be initiated.

(2) Quantitative data on the effort which has been applied in the various phases of the transfer process and which has been reported and submitted on a monthly basis to NASA during the preceding three contract quarters will be analyzed and prepared for presentation in our Final Report. Additionally the team's overall activities, successes, and failures will be studied in detail and recommendations for enhancing the Biomedical Application Team program will be formulated and prepared for presentation in our Final Report.

(3) Activities related to problems identified at the New York University Medical Center, Institute of Rehabilitation Medicine will be accelerated in order to establish an effective working relationship.

(4) The team will continue to attempt to stimulate increased involvement in the application of aerospace technology by Perry Electronics, Carolina Medical Electronics and other small manufacturing firms.

10.0 Financial Summary

A summary of the biomedical portion of the contract expenditures for the period 15 December 1968 through 14 March 1969 is presented in the table below:

Item	Expenditure
Material	$ 86.85
Services	275.03
Travel	365.02
Consultant	1,801.00
Overhead	12,053.57
Fee	1,642.68
Total Quarterly Costs	$16,224.15

APPENDIX A

COMPUTER EVALUATION REPORTS

COMPUTER EVALUATION REPORT

Title Search & RDC Number: Aversion Therapy 52 (MEDLARS)

Problem Name & Number: "A Miniaturized Electrical System to Shock the Tongue of Patients When It Is Pressed Against the Rear of Their Teeth", UNCD-25

Date Search Initiated: January 8, 1969

Descriptors:

Aversion Therapy
Behavior Therapy

Date Search Received: February 7, 1969

Number of Hits: 80

Date Documents Requested by Researcher:

Number of Documents Requested & Document Numbers:

Team Evaluation of Search:

Researcher Evaluation of Search:

Plans for Use of Information:

COMPUTER EVALUATION REPORT

Title Search & RDC Number: Plethysmography 1578

Problem Name & Number: "Noninvasive Means of Making Volume Plethysmography" WF-64

Date Search Initiated: January 22, 1969

Descriptors:

Body Volume /Biol/
Electroplethysmography
Body Measurement
Body Size /Biol/
Plethysmogram
Biometrics
Bioengineering
Bioinstrumentation
Volume

Date Search Received: February 3, 1969

Number of Hits: 68

Date Documents Requested by Researcher:

Number of Documents Requested & Document Numbers:

Team Evaluation of Search:

Researcher Evaluation of Search:

Plans for Use of Information:

COMPUTER EVALUATION REPORT

Title Search & RDC Number: EKG Electrodes 1595

Problem Name & Number: "Electrode Vest for EKG Measurement", DU-41

Date Search Initiated: February 3, 1969

Descriptors:

Sensors
Transducers
Electrodes
Electroplethysmography
Pneumography
Plethysmography
Electrocardiography
Electroencephalography

Date Search Received: February 6, 1969

Number of Hits: 53

Date Documents Requested by Researcher: March 6, 1969

Number of Documents Requested & Document Numbers: 3

N65-16607
N68-34548
A68-80127

Team Evaluation of Search:

Researcher Evaluation of Search:

Plans for Use of Information:

COMPUTER EVALUATION REPORT

Title Search & RDC Number: Optical Tracking Readout 1604

Problem Name & Number: "Avian Aerodynamics", DU-42 and "Small Low Velocity Flight Balance", DU-43

Date Search Initiated: February 13, 1969

Descriptors:

Theodolites
Cinetheodolites
Photographic Tracking
Optical Tracking
Readout
Data Reduction

Date Search Received: February 15, 1969

Number of Hits: 56

Date Documents Requested by Researcher: February 21, 1969

Number of Documents Requested & Document Numbers: 3

N67-21381
A67-11270
N62-12293

Team Evaluation of Search:

Researcher Evaluation of Search:

Plans for Use of Information:

COMPUTER EVALUATION REPORT

Title Search & RDC Number: Low Velocity Anemometry 1609

Problem Name & Number: "Low Velocity Anemometry", DU-45

Date Search Initiated: February 20, 1969

Descriptors:

Hot-Wire Measurement
Hot-Wire Anemometer
Anemometer
Low Velocity
Low Speed

Date Search Received: February 21, 1969

Number of Hits: 56

Date Documents Requested by Researcher: March 6, 1969

Number of Documents Requested & Document Numbers: 17

N68-38045
N68-23744
N67-39257
A67-27020
A67-11122
N66-30303
A66-35806
N68-21993
A68-29567
N67-39489
N67-29969
N67-21992
A67-28159
A67-22822
N66-12541
A65-32062
N63-22753

Team Evaluation of Search:

Researcher Evaluation of Search:

Plans for Use of Information:

APPENDIX B
TRANSFER CRITERIA

Appendix B

Transfer Criteria

As a result of the combined experience of the Biomedical Application Teams at the Research Triangle Institute, Midwest Research Institute, and Southwest Research Institute, it has been observed that information supplied to biological and medical investigators can be used in a variety of immediately useful or potentially useful ways. In order that there will exist a uniform procedure for designating successful technology transfers, the following criteria for successful or completed transfers have been established:

(a) Results in a new biomedical product, technique, or professional conclusion.

(b) Accelerates the application of the state of the art in biomedical or medical research procedure.

(c) Exposes technology which the investigator has re-engineered for his purposes.

(d) Is used by an investigator to develop a proposal.

(e) Allows the investigator to complete his research project which might otherwise have been delayed or not finished.

(f) Causes the investigator to redirect his effort to phase with other research which came to his attention as a result of the work of the team.

(g) Conserves an investigator's resources by avoiding duplicatory research.

(h) Causes the investigator to cancel or defer his project because it may be premature or forecasted costs are too high.

APPENDIX C
BIBLIOGRAPHY

Bibliography

A63-16763 Eichhorn, R. L., "A Review of Thermoelectric Refrigeration", Proceedings of the IEEE, May 1963, pp. 721-725

A64-24828 Montoya, P. M., and A. H. Henice, "A Telemetering System for Measuring and Transmitting Human Respiration Rate and Depth".

A65-25369 Fryer, Thomas B., and Gordon J. Deboo, "A High-Performance Miniature Biopotential Telemetry System", Engineering in Medicine and Biology, Proc. of 17th Annual Conference.

A66-16405 Coats, Alfred C., "Temperature Effects on the Peripheral Auditory Apparatus" Science, Vol. 150, pp. 1481-83, December 10, 1965.

A66-35806 Champagne, Francis H., and John L. Lundberg, "Linearizer For Constant Temperature Hot Wire Anemometer", The Review of Scientific Instruments, Vol. 37, No. 7, pp. 838-843, July 1966.

A66-80242 Fryer, Thomas B., Gordon J. Deboo, and Charles M. Winget "Miniature Long-Life Temperature Telemetry System".

A66-81467 Mayers, Lester B., and Robert E. Forster, "A Rapid Method for Measuring Blood Oxygen Content Utilizing the Oxygen Electrode".

A67-11122 Leak, John, "A Review of Low Airspeed Measurement Techniques"

A67-11270 Marsden, J.A.C., "A Three Component, Strain Gauged Sting Balance For Use in Small Low-Speed Wind Tunnels", Journal of the Royal Aeronautical Society, Vol. 70, October 1966.

A67-22822 Miyake, Mikio, and F. I. Badgley, "A Constant Temperature Wind Component Meter and Its Performance Characteristics", Journal of Applied Meteorology, Vol. 6, pp. 186-194, February 1967.

A67-28159 Wyngaard, J. C., and J. L. Lumley, "A Constant Temperature Hot-Wire Anemometer", Journal of Scientific Instruments, Vol. 44, pp. 363-365, 1967.

A68-24338 Fryer, Thomas B., "Survey of Biomedical Instrumentation Developments at Ames Research Center".

A68-27026 Pauley, J. D., H. W. Shirer, and D. D. Pippitt, "A Simple Pulsed Transmitter for Telemetering Body Temperature From Free Ranging Animals".

A68-31850 Shafer, W. A., "Non-Contact Physiological Sensing".

A68-80127 Baule, Gerhard M., "Biomagnetic Instrumentation of Heart", New York State Journal of Medicine, pp. 3095-3100, December 1, 1967

A68-80818 Murray, R. H., A. Marko, A. T. Kissen, and D. W. McGuire, "A New Miniaturized, Multichannel, Personal Radiotelemetry System", Journal of Applied Physiology, Vol. 24, No. 4 April 1968, pp. 588-592.

N62-12293 Davies, P. O. A. L., "The New 7 x 5½ ft. and 15 x 12 ft. Low Speed Wind Tunnel at the University of Southampton", University of Southampton, Department of Aeronautics and Astronautics, December 1961.

N63-22411 Johnson, Louis F., J. Ryan Nelville, Richard W. Bancroft, Thomas H. Allen, "Physical Transducers for Sensing Oxygen", August 1963.

N63-22753 Kovasznay, Leslie S. G., Leslie T. Miller, and B. R. Vasudeva, "A Simple Hot-Wire Anemometer", July 1963.

N64-27634 Kavalenko, Ye. A., V. L. Popkov, I. N. Chernyakov, "Application of Polarographic Method of Determination of Oxygen Tension in Tissues of Brain During High-Altitude Flight".

N64-29278 Kovalenko, Ye. A., V. L. Popkov, and I. N. Chernyakov, "Stud of the Tension of Oxygen in the Tissue of the Live Brain During Extended Acceleration", Byulleten' Eksperimental' noy Biologii i Meditsiny, Nr. 1, 1963, pp. 43-47.

N64-29989 Pieper, Heinz, "Catheter-Tip Flowmeter for the Measurement of Coronary Arterial Blood Flow in Intact Anesthetized Dogs",

N65-16607 Patterson, R., W. G. Kubicer, E. Kinnen, D. Watson, and G. Noren, "Development of an Electrical Impedance Plethysmograph System to Monitor Cardiac Output".

N65-17768 Kovalenko, Ye. A., V. L. Popkov, and I. N. Chernyakov, "Polarographic Method in Study of Tissue Hypoxia in the Living Organism".

N65-17769 Kovalenko, Ye. A., V. L. Popkov, I. N. Chernyakov, "Oxygen Pressure in Tissues of Dog Brain During Respiration of Gas Mixtures".

N65-27028 Berezin, I. P., et al., "Use of a Gold-Iron Electrode Pair for the Electrochemical Recording of Tissue Oxygen in Vivo", June 28, 1965.

N66-12541 Mattioli, Ennio, "Some Problems on the Performances and Measurements in a Wind Tunnel at Low Velocity", April 1965.

N67-21992 Mushkin, I. G., "A Microclimatic Station for Measurements in Herbage".

N68-23744 Wieghardt, K., and J. Kux, "Experimental Methods in Wind Tunnels and Water Tunnels, with Special Emphasis on Hot-Wire Anemometers", August 1967.

N68-34582 Alinker, M., W. E. Moritz, and E. Ogden, "Transmission Characteristics of Axial Waves in Blood Vessels", April 1968.

N68-38045 Armendariz, Manuel, and Virgil D. Land, "Wind Correlation and Variability in Time and Space", July 1968.

N69-11610 Frank, O., "The Basic Form of the Arterial Pulse, First Treatise, Mathematical Analysis", October 1968.

Search #1578 Plethysmography

Search #1609 Low Velocity Anemometry

Search #1604 Optical Tracking Readout

Evans, N. T. S., and P. F. D. Naylor, "The Design and Use of Electrodes for Tissue Oxygen Measurements".

"Information on Elastic Hose Testing", Bulletin of Prosthetics Research, Department of Medicine and Surgery, VA., Washington, D. C.

Lees, Sidney, and Frank E. Barber, "Looking Into Teeth with Ultrasound", Science, Vol. 161, pp. 477-478, August 2, 1968.

Thompson, R. D., and D. L. Ruhberg, "A Miniaturized Four-Channel Radio Transmitter with Receiving System for Obtaining Physiological Data from Birds", Medical and Biological Engineering, Vol. 5, pp. 495-504, 1967.

Tuck, W. H., "New Substances in Orthopaedic Appliances", Extracted from Physiotherapy, November 1967.

Watson, B. W., H. C. Riddle, and J. C. M. Currie, "The Measurement of Intracranial Pressures in Man Using Radio Telemetry".

Descriptive Literature on Commercially Available Equipment

Clark Electronics, Pressure-Sensitive Paints

Geonetics Corporation, Linear Hot Wire Velometer

Howard Apparatus Company, Inc.
Respiration Equipment

Heat Systems Company
Sonifier Cell Disruptor
Price List for Sonifier and Attachments
Condensed Application List For Sonifier Disruptor

Instrumentation Associates, Inc.
Local and Remote Clinical Monitors
Diagnostic and Rehabilitation Work Physiology Capnograph

Precision Electro-Mechanical Engineering Co.
EKG Dry Electrode Applicator
Descriptive literature and price list

Smith and Nephew, Ltd.
Plastazote Thermoplastic Splinting Materials

APPENDIX D

LIST OF ABBREVIATIONS

LIST OF ABBREVIATIONS

The abbreviations used in the body of the report are identified below:

ARC	Ames Research Center Mountain View, California
cm	centimeter
DU	Duke University Medical Center Durham, North Carolina
Hz	cycles per second (Hertz)
IBM	International Business Machines Washington, D. C.
IRM	Institute of Rehabilitation Medicine New York, New York
LRC	Langley Research Center Hampton, Virginia
MISC	Miscellaneous problems
mm	millimeter
MRI	Midwest Research Institute Kansas City, Missouri
NASA	National Aeronautics and Space Administration Washington, D. C.
NCSTRC	North Carolina Science and Technology Research Center Research Triangle Park, North Carolina
NCSU	North Carolina State University Raleigh, North Carolina
NIH	National Institutes of Health Bethesda, Maryland
RTI	Research Triangle Institute Research Triangle Park, North Carolina
SwRI	Southwest Research Institute San Antonio, Texas
UNC	University of North Carolina Medical School Chapel Hill, North Carolina
UNCD	University of North Carolina Dental School Chapel Hill, North Carolina
WF	Wake Forest University, Bowman Gray School of Medicine Winston-Salem, North Carolina