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**SOUTHWEST RESEARCH INSTITUTE ASSISTANCE  
TO NASA IN BIOMEDICAL AREAS OF  
THE TECHNOLOGY UTILIZATION PROGRAM**

**SEMI-ANNUAL REPORT  
25 August 1970 - 28 February 1971**

**Contract No. NASW-1867  
SwRI Project No. 13-2538**

**Prepared for  
Chief, Dissemination Branch, Code (UT)  
Technical Utilization Division  
Office of Technology Utilization  
NASA  
Washington, D. C. 20546**

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Prepared by:

David F. Culclasure, Ph. D.  
Linda Eckhardt

APPROVED



C. William Hall, M. D.  
Director  
Department of Bioengineering

## ABSTRACT

The NASA Biomedical Applications Team at Southwest Research Institute continues its activities in an experimental program of transferring aerospace technology to the biomedical research field. The team, a multidisciplinary group of scientists and engineers, acts as an information and technology interface between NASA and the biomedical community. Presently the Southwest Research Institute Biomedical Applications Team is staffed by:

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Samuel G. Schiflett  
Earl K. Calvert  
Linda L. Eckhardt  
Dennis C. Jamvold

The following 50 medical institutions participated in the Biomedical Applications Team program during the report period.

Baylor University Medical School, Houston, Texas  
Brooke General Hospital, Ft. Sam Houston, Texas  
Callier Hearing and Speech Center, Dallas, Texas  
Caruth Memorial Rehabilitation Center, Dallas, Texas  
Children's Hospital of Los Angeles, Los Angeles, California  
Community Mental Health Service, San Diego, California  
Doheny Eye Foundation, Los Angeles, California  
Fitzsimmons General Hospital, Denver, Colorado  
Gallup Indian Medical Center, Gallup, New Mexico  
General Rose Hospital, Denver, Colorado  
Hollywood Presbyterian Hospital, Los Angeles, California  
Hot Springs Rehabilitation Center, Little Rock, Arkansas  
Huntington Memorial Hospital, Pasadena, California  
Loma Linda Medical Center, Loma Linda, California  
Los Angeles County Hospital, Los Angeles, California  
Northwest Institute for Rehabilitation, Seattle, Washington  
Palo Alto Medical Research Foundation, Palo Alto, California  
Rancho Los Amigos Hospital, Downey, California  
Rosewood General Hospital, Houston, Texas

St. Josephs Hospital, Phoenix, Arizona  
Scott and White Hospital & Clinic, Temple, Texas  
Stanford University School of Medicine, Stanford, California  
Texas A & M University, College Station, Texas  
Texas Institute for Rehabilitation and Research, Houston, Texas  
University of Alabama Medical School, Birmingham, Alabama  
University of Arizona Medical School, Tucson, Arizona  
University of California Medical School, Davis, California  
UCLA College of Medicine, Los Angeles, California  
University of Florida, Gainesville, Florida  
University of Florida Medical School, Gainesville, Florida  
University of Oklahoma Medical School, Oklahoma City, Oklahoma  
University of Southern California Medical School, Los Angeles, Calif.  
University of Texas Medical Branch, Galveston, Texas  
University of Texas Medical School, San Antonio, Texas  
University of Texas Southwestern Medical School, Dallas, Texas  
University of Utah Medical School, Salt Lake City, Utah  
University of Washington Medical School, Seattle, Washington  
Veterans Administration Hospital, Albuquerque, New Mexico  
Veterans Administration Hospital, Bay Pines, Florida  
Veterans Administration Hospital, Birmingham, Alabama  
Veterans Administration Hospital, Dallas, Texas  
Veterans Administration Hospital, Gainesville, Florida  
Veterans Administration Hospital, Long Beach, California  
Veterans Administration Hospital, Sepulveda, California  
Veterans Administration Hospital, Shreveport, Louisiana  
Veterans Administration Hospital, Temple, Texas  
Veterans Administration Regional Office, San Antonio, Texas  
Veterans Administration Southern Research Support Center Hospital,  
Little Rock, Arkansas  
Western Research Support Center, Sepulveda, California  
Wilford Hall Hospital, Lackland AF Base, Texas

In addition, problems from several private practitioners in Salt Lake City, Utah, were accepted by the team as part of an experimental effort to assess the extent to which problems identified within this context hold potential for helping advance the state of the art in biomedicine.

Interaction with a total of 14 new institutions was begun during this period.

During the period covered by this report the Biomedical Applications Team has identified 83 new problems for investigation. It accomplished 7 transfers and has identified 21 potential transfers. On February 28, 1971, the team had a total of 185 problems under active investigation.

Significant transfers of technology were achieved during the period of this report. They include an improved method for taking EEG in infants and children with a NASA-developed helmet and electrode system, an infant apnea alarm, an electro-optical call signal for quadriplegic patients activated by head movement, a low cost signal conditioning system which permits recording and playback of ECG signals on a home tape recorder, and a system which permits totally paralyzed patients to use eye movements to control such assist devices as page turners. Significant progress toward several transfers of aerospace technology has been made through an in-house applications engineering program. Present efforts are being concentrated upon the completion of a catheter-mounted radiation detector for monitoring cerebral blood flow in head injury patients and a probe designed to permit precise measurement of radioactive isotope uptake by eye tumors as a possible aid in improving diagnosis of such tumors.

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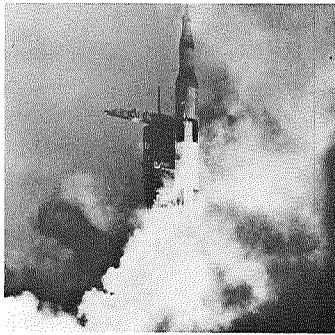
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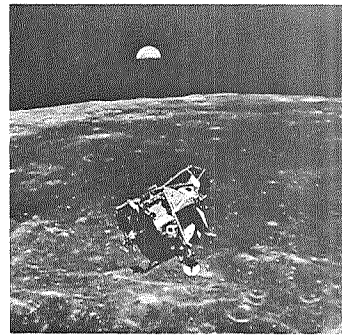
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## I. INTRODUCTION

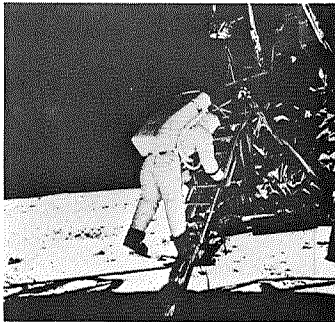
Over the past two decades, billions of dollars have been invested in aerospace research and development. These efforts, designed to maintain this country's leadership in pushing forward the frontiers of man's knowledge concerning the universe, have enabled the United States to span a distance of 240,000 miles, place astronauts on the lunar surface, and then return them safely to earth.



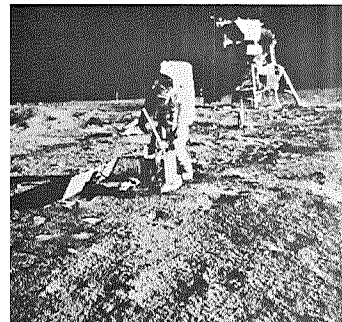
Apollo Liftoff



Lunar Module Over  
the Moon's Surface



Aldrin's First Step  
on the Moon



Aldrin Conducting Scientific  
Experiment on the Lunar Surface

The Nation's aerospace effort has resulted in an unprecedented stockpile of technological knowledge.



### Need for Dissemination

Research and development associated with the space effort has created a tremendous stockpile of knowledge. This stockpile, which presently consists of more than 750,000 scientific and technical documents, is increasing at the rate of approximately 75,000 documents per year. Much of the new knowledge and technology found in this stockpile is directly applicable to areas other than the aerospace effort. For this reason, several years ago NASA initiated an active program to assure the widest practicable dissemination of scientific and technological developments resulting from the Nation's space effort.

### Special Communications Problems

It soon became apparent that the usual methods of communication, such as special publications and news releases, were failing to meet the particular needs of biomedical researchers and practitioners. Special problems were encountered in communicating knowledge gained by physical scientists involved in the space effort to scientists in the biomedical community. This resulted in the great stream of information flowing from the aerospace research centers to those in clinics, hospitals, and rehabilitation centers becoming known indirectly and belatedly, if at all.

### Formation of Biomedical Applications Teams

An interface or two-way communication system between physical and biological scientists was clearly needed to permit feedback between aerospace and biomedical communicators. Consequently, an experimental approach involving Biomedical Applications Teams was devised by NASA's Office of Technology Utilization to close this communications gap. These teams consist of small groups of biological and physical scientists located at selected independent research centers. Each team is equipped with first-hand knowledge of areas of active research at NASA and contractor facilities, is familiar with NASA's computer-indexed collection of scientific and technical information, and is adept at designing search strategies which optimize information retrieval. The teams thus represent a human connection between

NASA, its research centers and contractors, and the biomedical researchers and practitioners at work in medical schools, institutes, and hospitals. They also provide an experimental framework by which the process of finding new applications for technology can be analyzed.

### Biomedical Applications Team Functions

Whereas NASA purposely selected the different Biomedical Applications Teams to contain different professional backgrounds—in physics, engineering, and medicine—each team's operational approach to the application of aerospace knowledge to medical research problems is essentially the same. The teams filter, encode, and amplify communications, functioning as an interface between the aerospace and biomedical researchers, helping to identify biomedical problems to which aerospace technology may be applicable. NASA's Office of Technology Utilization has three Biomedical Applications Teams in operation at present: at Midwest Research Institute, Kansas City, Missouri; at Research Triangle Institute, Durham, North Carolina; and at Southwest Research Institute, San Antonio, Texas.

### Problem Acceptance

Understandably, the teams are empowered primarily to attack problems which (1) bear most meaningfully and directly upon advancing research and development in the biomedical community and (2) are likely to benefit from some aspect of prior or ongoing research and development being conducted as part of the Nation's space effort. Several years' experience in the technology applications process, plus an awareness of the scope of the aerospace research effort, enables the teams to realistically evaluate the probability of an application being effected in a given case. Problems submitted are accepted—or rejected—only after careful study by the team.

### The First Step—Problem Definition

Each problem accepted is stated in functional, nondisciplinary language which is understandable by aerospace engineers as well as medical

researchers in the form of a "Problem Statement." This statement is used not only to devise a strategy for computerized searching of the NASA Aerospace Data Bank, but may also be circulated to Technology Utilization Officers at NASA field installations, who will seek possible solutions to the problem from NASA scientists and engineers.

Two points are especially worthy of note at this juncture. The first is that the Biomedical Applications Program is a problem-solving endeavor as opposed to a research oriented literature searching activity; the Teams' activities resolve around seeking solutions for discrete, well-defined technical problems. The second point is that only problems which meet certain criteria can be accepted, due to both limited manpower and the basic purpose of the effort—which is to apply aerospace related technology to biomedicine.

### The Next Steps

The problem-solving approach used by the Biomedical Applications Teams embodies a problem definition-solution search methodology which:

- . Provides access to NASA scientific and engineering expertise,
- . Focuses multidisciplinary expertise on discrete, technological problems, and
- . Facilitates innovative secondary applications of aerospace related technology.

Basically, the methodology employed is to carefully define important biomedical problems for which it appears relevant aerospace technology may exist, and then systematically search both computerized aerospace data files and NASA research centers for potential solutions.

After an item, or groups of items, of aerospace technology have been identified as potentially useful, the team collects the maximum information available. This could involve retrieving pertinent information or obtaining hardware or models for evaluation if such is indicated and feasible. The team then makes a preliminary evaluation to determine whether the item or information, either in present or modified form, is applicable to the problem at hand. Items that survive this preliminary evaluation are then transmitted to the researcher or practitioner who posed the original problem for more thorough trial in laboratory and clinic. Often, the problem originator's evaluation will indicate that some modification or adaptation is needed to make an item suitable for biomedical application. The adaptation required may range from minor change to a substantial development effort.

The evaluation and adaptation stages of the technology applications process are closely interrelated; and, frequently, a number of evaluation-adaptation-evaluation cycles are needed to establish the medical value of an item of aerospace technology.

#### Technology Applications—The Program's Ultimate Aim

An application of technology—utilization of aerospace technology for purposes other than that for which it was intended—represents the ultimate aim of the Biomedical Applications Teams' effort. Technology applications are of singular importance in the continuing NASA effort to insure, for the public sector, the greatest possible return for dollars invested in the space effort. When a technology application has been accomplished, the problem originator is asked to aid in documenting it so that the information can be distributed. After such an application has been effected, the participating researcher or practitioner may prepare papers for presentation at medical meetings and for publication in medical journals, and the engineers or physical scientists involved may also prepare papers to present to their own professional groups. Also, information pertaining to the new application of technology may be presented by NASA to equipment manufacturers through seminars, written reports, and personal contacts.

## II. SOUTHWEST RESEARCH INSTITUTE BIOMEDICAL APPLICATIONS TEAM ACCOMPLISHMENTS DURING THE REPORT PERIOD

### Application of Technology Accomplished

Employing the techniques described in the Introduction, the SwRI Biomedical Applications Team was able to achieve a number of significant applications of technology. The problems solved and a description of the aerospace technology which facilitated their solution are outlined in the following problem summaries:

#### CLA-1: Newborn Infant Respiration Monitor and Apnea Alarm

During respiratory arrest or apnea, the individual simply ceases to breathe and death rapidly ensues from deprivation of oxygen to sustain life. All too frequently this has occurred in the past, and this has contributed significantly to infant and small child mortality statistics.

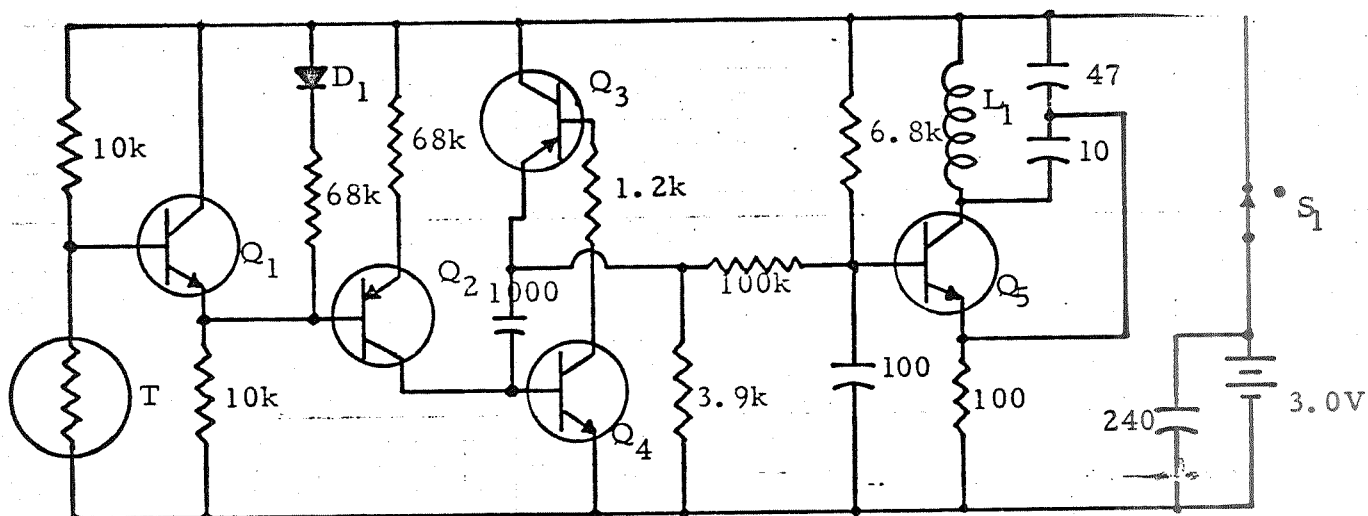
A number of newborn infants and small children are subject to onset of respiratory distress with little or no warning. There are many causes for respiratory distress ranging from factors surrounding childbirth to injuries and illnesses. Respiratory distress is significant in all instances. The child may die unless onset of distress is quickly noted and immediate, positive remedial action is taken. This is particularly true if the baby was born with or developed respiratory or cardiac complications. These children rapidly succumb and require very close observation.

The problem originator was concerned with the inordinate amounts of clinician and nursing staff time which was expended at the cribside during the required monitoring of infant breathing in this large, western children's hospital. He knew that similar conditions existed in all hospitals which provide care for newborn and infant children. Technology was needed that could accurately monitor breathing and thereby relieve the doctors and nursing staff personnel for other important tasks. The device must be able to monitor changes in breathing on a "go" or "no go" basis and thus alert patient care personnel in the event of significant changes.

The Southwest Research Institute BA Team searched NASA literature for possible applications of aerospace technology to this problem. They retrieved NASA Technical Brief 64-10365, "Automatic Patient Respiration Failure Detection System With Wireless Transmission," and the Technical Package related to it. An attempt was made to apply this technology to the problem. However, the system was considered by the problem originator to be too complex and expensive. Further search led the team to NASA Technical Brief 64-10171, "Subminiature Biotelemetry Unit Permits Remote Physiological Investigations." This document described a high performance,

biotelemetry transmitter designed by Gordon J. Deboo and Thomas B. Fryer in May 1964 that operates in the standard 88 to 108-MHz FM band. The only modification required was to replace the unit's pre-amplifier with a thermistor bridge network.

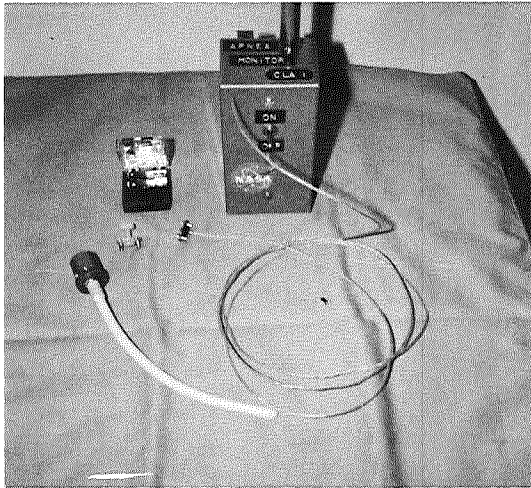
Input to the system is provided from a sensor that is attached with a microminiature connector to the patient's airway. This permits competent operation of the monitor and allows for autoclave sterilization of the airway as needed. The redesigned transmitter hangs on the isolette and transmits a pulsating signal to the nurse's station outside of the nursery. Interruption of the signal indicates the infant is having respiratory distress. The problem originator preferred a continuous signal to indicate respiration rather than the automatic alarm feature mentioned in NASA Technical Brief 64-10365, which sets off an alarm when breathing stops. The problem originator indicated that the quality of the continuous tone transmitted can, to the experienced ear, provide valuable information concerning the infant's respiration.



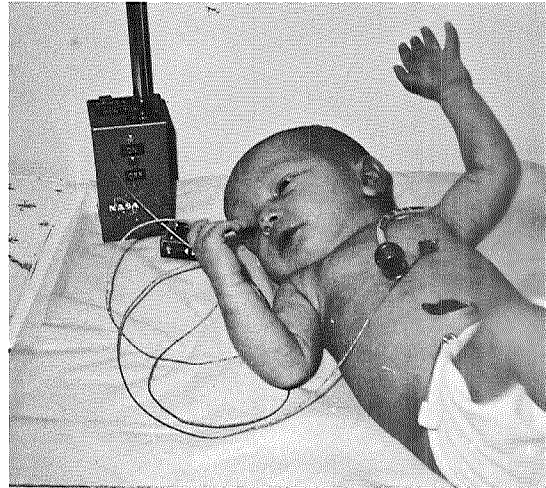
Legend

- Q<sub>1</sub> & Q<sub>4</sub> - 2N2222; Q<sub>2</sub> & Q<sub>3</sub> - 2N2907; Q<sub>5</sub> - MPS6531
- T = VECO 51A32, R<sub>0</sub> = 100k
- L = 12 h 3 turns #28 wire
- D<sub>1</sub> = 1N645

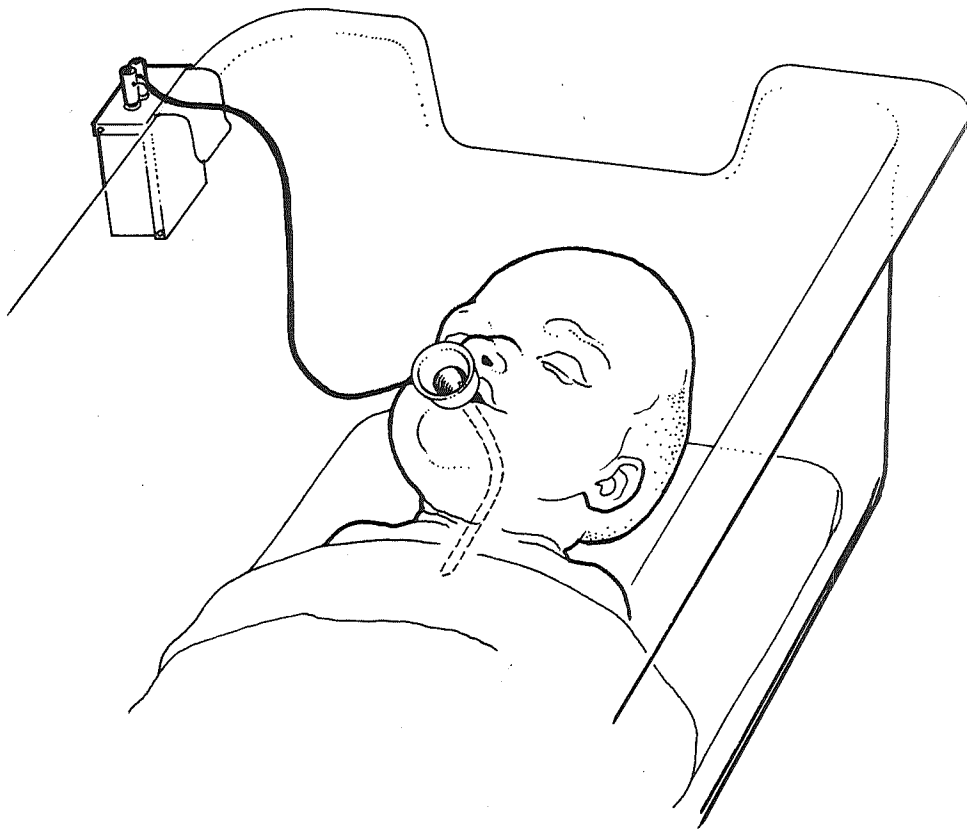
APNEA MONITOR



*The Apnea Monitor*



*Size of apnea monitor components in relation to a newborn infant.*



*Sketch showing the apnea monitor in place. Infants with whom the device will be used are generally so critically ill that they are placed in isolettes and do not require restraining arm straps to prevent removal of the monitor.*

## CMR-2: Call Signal for Quadriplegic Patients

An upswing in accidents and injuries has produced a general increase in the numbers of individuals who suffer injuries to the spinal cord or who have one or more of their limbs amputated. These individuals all require extensive patient care and rehabilitation regimes which are aimed at the restoration of self-help and productive work capabilities as rapidly as possible.

Patients who are paralyzed in all four of their limbs (quadriplegics) and patients who are multiple amputees (quadruple amputees) present very special problems for themselves and for the patient care personnel. They require at least as much attention as any of the other patients and possibly more. Yet, they are unable to operate the usual nurse call switch to obtain assistance when they need it.

The only solution available to relieve this situation in the past has been to provide costly full-time nursing staff attendance at the bedside or at least in the immediate vicinity within voice call. Frequent and wasteful bed stops have had to be scheduled and made by patient care personnel if it is not possible to have the staff remain in the immediate area for any reasons.

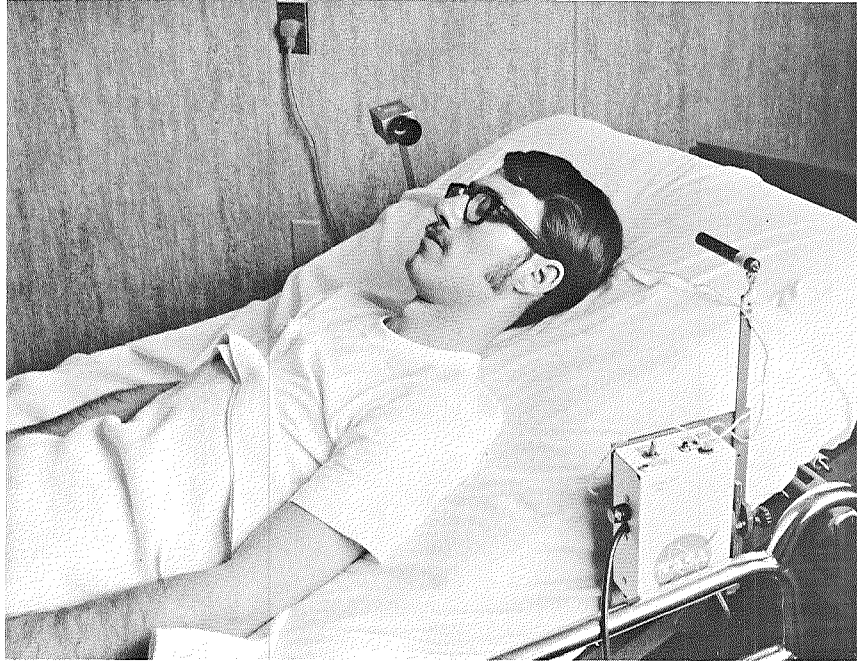
The problem originator sought a means to insure that the patient had nursing staff in attendance when they need it at least on a par with patients who can operate the usual call signal. These patients are limited in movement to face, head and neck muscles because of their handicap and also because of braces. A device was needed which such patients could activate and summon nursing assistance through the usual call switch arrangement by intentional movement of the extent and type as indicated.

The Southwest Research Institute BA Team searched the aerospace literature stored in the NASA data bank and retrieved NASA Technical Brief 63-10378, "Liquid-Level Meter Has No Moving Parts," that described an electro-optical system which used no moving parts to register liquid levels. Southwest Research Institute engineers determined that modest re-engineering effort could modify the existing specifications to the extent required for solution of the problem.

The concept of the existing technology and the proposed modifications were presented to the problem originator who was very pleased with the potentials offered. The problem originator then requested NASA assistance in the fabrication of a prototype unit, since the hospital (a small rehabilitation center) did not have the necessary facilities. The unit was fabricated and found to perform exceedingly well. Use of the unit will not only help increase the comfort and security of totally paralyzed patients (who can now



summon assistance at will) but will also introduce a degree of economy by releasing nursing service personnel from the requirement for close attendance at all times for such patients.



Call signal in place on a hospital bed. Slight movement of the paralyzed patient's head will signal his need for assistance

#### DLM-4: Doppler Probe Holder and Stand for Use in Chronic Fetal Circulation Monitoring

Fetal blood circulation during labor and delivery is being monitored by ultrasonic Doppler techniques to indicate any abnormal changes which could arise during this critical period. A nurse or attendant was required to handhold the probe for extended periods of time during the procedure. BA Team assistance was requested to relieve the need for this tedious and exhaustive task, thereby freeing personnel for other important duties.

A means was needed for probe stabilization during chronic measurements. This was desirable to avoid or reduce any artifact generation caused by movement of the probe. It also eliminated the need for someone to hold it in place. The most desirable configuration for such a probe holder included ease of adjustment in 3-dimensional positioning on the abdomen of the patient during searching maneuvers and a locking arrangement to hold the probe in a firm position when the proper flow signal was located.

A solution which satisfied the specifications of the problem originator was provided from NASA Tech Brief 70-10465 and interaction with the Langley Research Center. The device consists of segmented sections abutting one to another. Its bearing surfaces are threaded together with a cable. In the base is a cam-operated lever which provides the necessary tension on the cable to lock the sections in place. The base also is equipped with magnets which permit easy mounting to a hospital, standard over-the-bed service tray.

One of these probe holders was acquired and successfully applied by the problem originator for his intended purposes. He has determined it to be very portable, easy to use, and sufficiently flexible to avoid causing pain or discomfort to the mother during childbirth. It has effectively relieved the need for a nurse or technician to be present for probe holding and, thereby, has provided savings in personnel and money.

GLM-32: Signal Conditioner Permitting Recording and Playback of  
Electrocardiographic Signals Via Inexpensive Hometype Tape

Heart disease is one of the leading causes of death in the United States according to present data. The medical community has a prime interest therefore in continuing research concerning the physiology of heart function and etiology of heart diseases. Recent technology has provided valuable assistance to the physician for prevention of heart diseases and for patient care.

Electrical potentials from heart action are monitored and recorded by electrocardiogram (ECG) tracings. Doctors now include ECG tracing more or less routinely in physical examinations for those persons who have suffered from a heart attack, or who are considered most likely to suffer from heart disease. Variations from the normal ECG waveform patterns are considered to be good indicators of the severity of a heart attack, reactions to regimens of treatment, and likelihood of another onset of trouble in this area. ECG instruments and monitor capabilities are essential to the intensive care units of a hospital and to the attending physician in his clinical practice.

Simplification and long term applications of electrodes have made it possible to monitor the ECG outside of hospital settings and clinical settings. Doctors seek to be better able to monitor patients to include ECG information that could be obtained while the individual is going about his normal routines. This information can be extremely valuable for both diagnostic and research purposes.

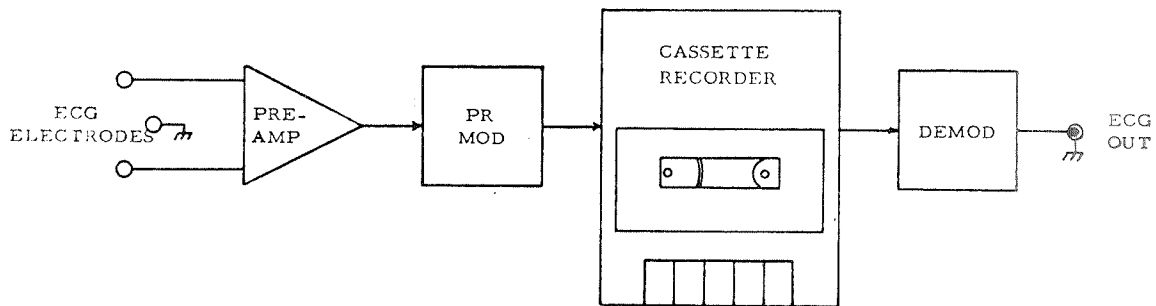
The problem originator is one of a group of researchers in a large southwestern medical school who are seeking to be able to condition the ECG signals and provide an accurate, low-cost interface between the patient and a usual type of home or office, portable tape recorder unit. In this way, they can monitor the ECG of outpatients as they engage in normal home or work routines. A permanent tape recorder record can be provided for later playback and tracings as required.

Many of the components of the heart action generated electrical signals are considerably below the 60 Hz, low limit of pickup for tape recorders. The signals therefore must be conditioned and modulated to higher ranges by means of a subcarrier oscillator having a frequency response from d-c to 100 Hz, a low noise figure, and battery operation for patient protection. The Intermed portable analog recorder is one of the portable recorders on the commercial market. They are suitable for the purpose, but they are exceedingly expensive: \$1625 for the Intermed model. They also require a separate reproducer to play back recorded signals into ECG strip charts or ECG apparatus, at a cost of \$3500 for the Intermed reproducer system. Most physicians resist making a capital outlay of this magnitude. They clearly need a unit within a desired price maximum of \$200. The integrated unit should center upon a low-cost home type of tape recorder with a built-in signal conditioner modulator for ECG signal input to the recorder and a demodulator for direct playback of the recorded signals directly into the ECG apparatus or strip chart.

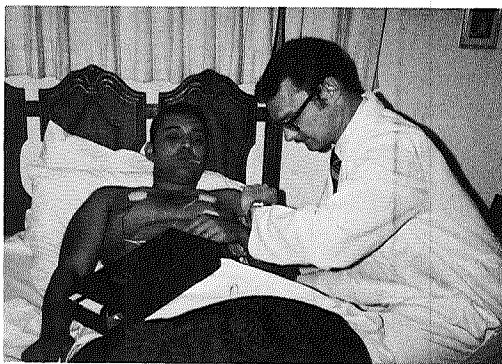
NASA Technical Brief 64-10171, "Subminiature Biotelemetry Unit Permits Remote Physiological Investigations," was retrieved from a data bank search. The document described a high performance, biopotential telemetry transmitter operating in the standard 88 - 108 MHz FM band (Gordon J. Deboo and Thomas B. Fryer, May 1964).

Southwest Research Institute engineers found the circuitry simple, relatively inexpensive to fabricate, and applicable to the immediate problem. They determined that the transmitter circuitry could be removed and a hardwire connection could be made for relay of ECG recordable information through modest re-engineering effort. Signals generated by the heart are conditioned and modulated for presentation as documented in the NASA Technical Brief, and then they are acceptable for recording by the usual type of home or office types of tape recorders. Proven characteristics of the original NASA device seemed to satisfy all of the requirements of the problem.

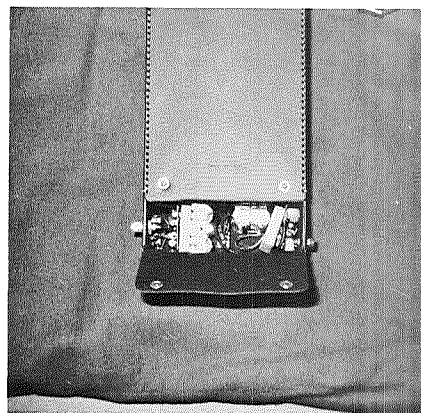
The prototype has been tested by the cardiovascular research team, who expressed enthusiasm for its low cost and operating characteristics. The consensus is that most physicians will be able to obtain a similar unit to carry as standard equipment in their physicians bag for office calls. This will permit them to take ECG's of home bound patients as needed, evaluating the ECG's upon return to the office. This constitutes a distinct aid to diagnosis and prognosis and will preclude the necessity for a patient having to be referred to a hospital or come into the physician's office just to have an ECG made. Considering advances being made in miniaturization of home tape recorders, it is expected that a reduction in size of about 50 percent can be made over that reflected in the prototype.



ECG SIGNAL CONDITIONER

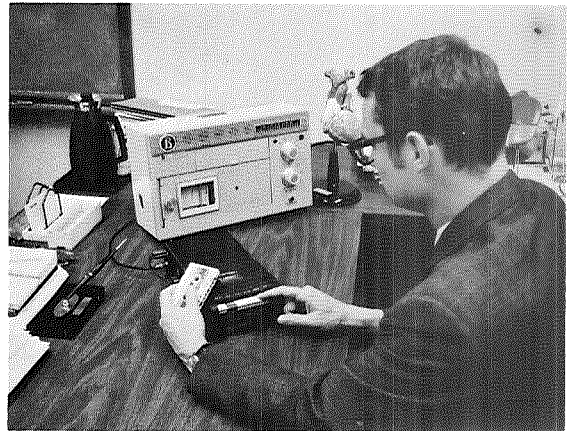


With the modified low cost tape recorder, the physician can record ECG in the patient's home.



A miniaturized version of the signal conditioner shown above is built into a low cost tape recorder.

After returning to his office, the physician can reproduce the ECG signals on the same low cost tape recorder (which has a built-in demodulator), feeding the signals into either a strip chart recorder or ECG apparatus.



#### SWC-1: Improved Techniques for Taking EEG in Infants and Small Children

Investigators at a southwestern medical facility are perfecting a technique for using the EEG to test hearing of small children. Today thousands of children classified as mentally retarded are believed to be suffering not from mental retardation, but rather from hearing difficulties which have cut them off from the auditory interchange and the environmental stimuli which is needed to develop their intellect. The investigators are convinced that if they can identify hearing defects early in infancy and initiate appropriate remedial measures, they can prevent many youngsters from becoming functional mental retardates. An instrumented helmet is needed with EEG electrodes in place; such a helmet, particularly if equipped with earphones for administering the auditory signal, would substantially assist in identifying hearing defects in young children who cannot verbally communicate information regarding whether they hear an auditory stimuli and to what degree they hear it.

Search of the NASA Data Bank revealed two instances of aerospace technology which were appropriate for solution of the

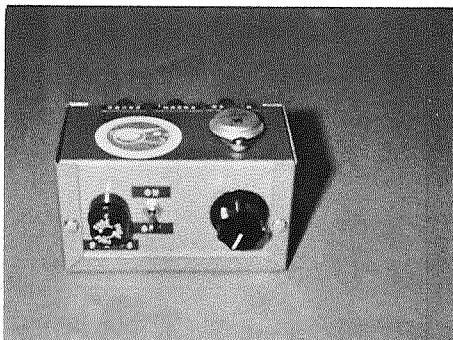


The EEG audiometric helmet in position on the subject. The electrodes can be adjusted to a variety of head sizes, do not require shaving of the head, and do not require use of electrode paste.

problem: NASA Tech Brief 66-10536, which describes a special helmet with built-in electrodes and USAF publication ARL-TR-69-17-6571, which describes a special technique for equipping a helmet with earphones. Using this aerospace-related technology, the team fabricated several helmets for use in speech and hearing clinics. As part of a related problem (SWC-2 EEG Audiometric System For Use With Infants), an effort is underway to develop a low cost, portable evoked response (EEG) audiometry system for use with the helmet. Existing EEG audiometry systems are exceedingly expensive and bulky and are not generally available within the typical speech and hearing clinics where they are most needed.

#### GLM-33: D-C Proportional Oven Temperature Controller

Investigators at the University of Texas Medical Branch, Galveston, are conducting extensive research in the area of biochemical pollutants. The investigative effort requires the use of a constant temperature oven. Conventional A-C control methods, such as silicon controlled rectifiers, create excessive electrical noise, which interferes with other instrumentation being used for the investigation. A d-c powered, proportional controller capable of maintaining a constant temperature from  $75^{\circ}$  to  $225^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$  was needed. Power consumption of the oven is 25 to 35 watts full load, at 24 to 28 volts and 1-1.5 amps. Upon accepting the problem, the SwRI BATeam initiated queries to the NASA centers. Mr. S. W. Billingsley, Goddard Space Flight Center, provided a simple, economical solution which would meet the problem originator's specifications. Schematics of the GSFC design were obtained and the device fabricated as part of the team's application engineering effort.



NASA Oven Temperature Controller

SAV-1: Assist Device for Totally Paralyzed (Quadriplegic)  
Patients

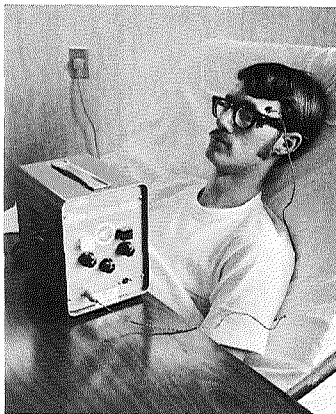
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The Viet Nam conflict, plus the increasing incidence of serious automobile accidents on the Nation's highways, have resulted in a large number of totally paralyzed (quadriplegic) patients being confined to hospitals and extended care facilities. Depending upon the level of spinal cord injury sustained, some may have limited use of, for example, the fingers. Others, however, cannot even move their little finger or move their head. Obviously, such patients must of necessity depend upon others for everything that is done for them—from feeding and bathing to turning off the lights when they wish to sleep. Rendering the matter even more difficult is that such patients—having no control over their appendages—cannot even activate the call system to summon the nurse for assistance when needed. The result for those quadriplegics who survive (many do not for extended periods) is an unending succession of long hours at the complete mercy of others.

The Veterans Administration Regional Office in San Antonio had placed a quadriplegic veteran in one of the local nursing homes and, having learned of the NASA Biomedical Applications Program's efforts in rehabilitation during a BA Team presentation at a recent state-wide rehabilitation conference, solicited the team's help in devising some means for helping the veteran perform such simple functions as turning the page of a book or magazine, or turn on a radio or television set—to help add more meaning to his daily life. The veteran in question, despite the severity of his affliction remained exceedingly alert and desperately wanted to do something other than continually watch the television set in his room—unable to change the station or turn the set off if he did not care to watch the program. He particularly wanted to be able to read books and magazines. This presented quite a problem, because even with the utmost effort, the individual could not move his arms or hands to activate a control mechanism. The matter was complicated even more by the inability to move the head, which motion could perhaps have been used to activate a control device. It appeared to the team that an ideal solution might well be provided by using the NASA-developed sight switch, presently being evaluated as a control mechanism for electric wheelchairs. Accordingly, arrangements were made to obtain one of the sight switches for trial (a unit was obtained from TAC, University of New Mexico with the help of TUD, NASA). The sight switch was found to work exceedingly well with a standard mechanical page turner and required but a modest adaptation to put into use. This adaptation involved designing a circuit that could complete the page turning (or other action) sequence—without the patient having to keep his eyes turned towards the switch while the action sequence was under way. With the modification, one brief glance activates the page turning mechanism which completes its cycle automatically, allowing the patient to return his eyes to the normal forward position, thus avoiding undesirable eye strain. The eye switch is considered superior to possible alternative control methods, such as

intra-oral switches. These are subject to deterioration in the presence of saliva and present problems involving sanitation. A further advantage of the eye switch is that it can, by adding simple logic components, control other functions designed to help give the totally paralyzed patient some measure of control over simple daily activities that can make his day a bit brighter, such as turning on or off his room lights, calling the nurse or attendant when he needs help, turning on a special "talking book" phonograph when he tires of reading (the availability of which is being arranged by the BA Team from SwRI) and—if team interaction with the Southwestern Bell Telephone Company proves successful in adapting a telephone instrument—being able to call family and friends when he wishes, without the intercession of a nurse or attendant to place the call for him.

It is expected that the technology outlined will have considerable application throughout the nation in hospitals and extended care facilities caring for quadriplegic patients who are unable to perform even simple functions for themselves. For this reason, the team proposes to prepare special material outlining the technology use described for use as appropriate to make others aware of what can be done at a most modest cost to add a great deal of meaning to the daily lives of totally paralyzed patients.

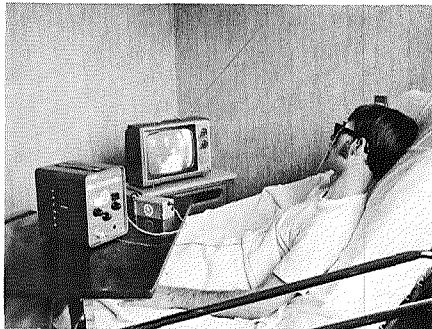
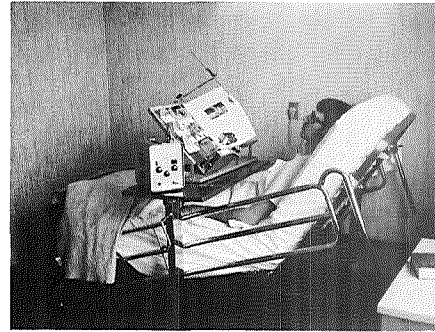


The Sight Switch Set is a unique switching device which requires only movement of the eyes to actuate, and provides a "hands free" mode of control. It is small and suitable for mounting on a normal pair of eyeglasses or eyeglass frames. It consists of a low intensity light source and a photodetector to sense variations in reflected light from the area of the eyes, which can then be used to actuate control mechanism.



## The NASA Eye Operated Switch in Place

The NASA switch (with amplifier interfaced with a mechanical page turner. To turn the page, the paralyzed patient need only turn his eye slightly towards the eye switch. Light reflected from the eye is picked up by the sensing unit built into the switch. In turn, this energy -- upon amplification -- actuates the page turner.



The eye switch also can be used for other purposes such as turning on a television set, radio, room lights, etc.

## Potential Applications of Technology

In addition to the applications of aerospace technology listed above, the team uncovered relevant aerospace technology which holds the potential for solving twenty-one other important biomedical problems submitted for consideration. These are categorized as potential technology applications since final evaluation of the contribution made by the NASA technology identified by the team remains pending for one or a number of reasons. For example, the NASA technology might require modification before it can be used; only a prototype NASA unit might be available which cannot be released to the investigator; or the investigator's existing funding level might not permit evaluation of the suggested technology at the present time. A summary of problems for which potential applications of aerospace technology are envisioned follows.

### RRC-5: On-Line Fabrication of Orthotic Support Devices

Physicians at rehabilitation centers frequently see patients who could be benefitted immediately (in terms of relief from pain and discomfort) if a rapid means were available for immediate custom fabrication of orthotic devices, such as arch supports. Since most rehabilitation centers do not have in-house fabrication facilities, the usual procedure is to measure the patient for the device and then order it from an appropriate commercial source. This results in loss of a great deal of therapeutic time, since about two weeks usually elapse between order and receipt of the finished item.

The problem originator desired to obtain lightweight material — which was both resilient and tough — which could be readily poured "in-house" to form at least a suitable temporary orthotic support.

Search of the NASA data bank revealed several alternatives, the most promising of which was the foam-in-place technique developed at Wright Patterson Air Force Base for developing customized form-fitting helmet liners. The technique was tried for fabricating orthotic support devices and looks exceedingly promising. Indications are that the technique will prove to be an effective, economical means for providing immediate custom fitted temporary orthotic support aids.

Figure 1. In place foaming of arch support provides the patient with a custom fitted support device which can be used immediately. Shown here is the arch support foamed to the contour of the foot.

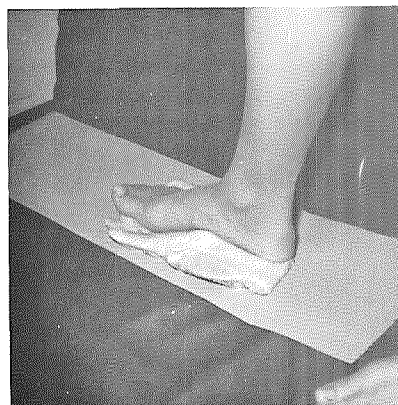


Figure 2. Trimming free foam arch support to fit patients shoe.

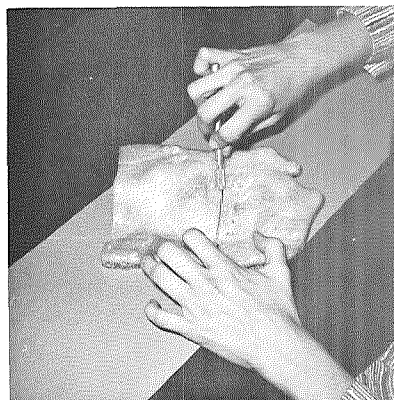


Figure 3. Arch support trimmed and ready for insertion into patients shoe. The entire process from foaming the arch support to placing it in shoe takes only ten to fifteen minutes.

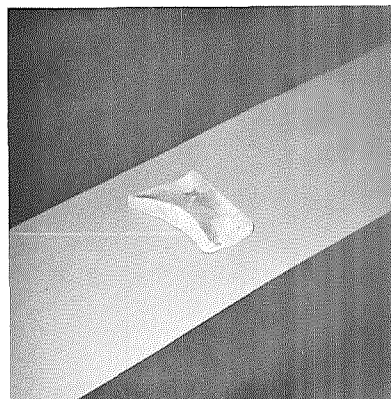
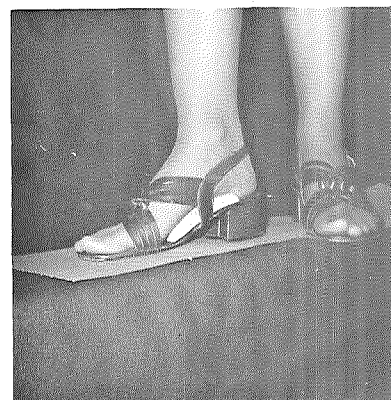


Figure 4. Temporary arch support in place in shoe, ready for immediate use.



## HSR-6: Sight-Switch Operated Prehension Device

Paralyzed and amputee patients comprise a large cross section of the thousands of persons receiving rehabilitation assistance in hospitals and centers throughout the United States. These patients require personal or orthotic support device assistance for self-care or productive work rehabilitations.

Prehension devices are one class of orthotic support devices which have proved to be extremely useful in restoring many functions to this handicapped group. The prehension devices are becoming increasingly more sophisticated as better means are developed to extend limits of operation and to refine the limits of control. The devices have been particularly useful in restoring capabilities for mobility and self-care to patients.

Typically, movements of various muscles and body parts are used to activate the drives and linkages which permit the person to control positioning of the device, or to control the degree of pressure applied. However, there are some patients, particularly those afflicted with diseases involving spasticity and muscular tremors who are unable to utilize this method of control. The problem originator is seeking an alternative control method which is relatively easy to operate and which is basically an on-off, all-or-nothing activating switch. A switch of this sort is expected to facilitate the training in operation of the orthotic device and to improve the capacity of individuals to use the device for various tasks.



View of eye-switch for use with prehension device.

The Southwest Research Institute BA Team personnel considered several alternatives and determined that the sight-operated switch incorporated into the control unit for operation of the MSFC-developed motor-driven wheelchair would provide a satisfactory solution. Further inquiry was directed to the contractors who had developed the NASA technology (Hayes International Corporation, Huntsville, Alabama). The contractor indicated that the switch was highly adaptable to a practically limitless configuration arrangement.

A demonstration of the sight switch was conducted for the problem originator, who indicated that the device would provide an ideal solution for his problem. A sight switch is being obtained for incorporation

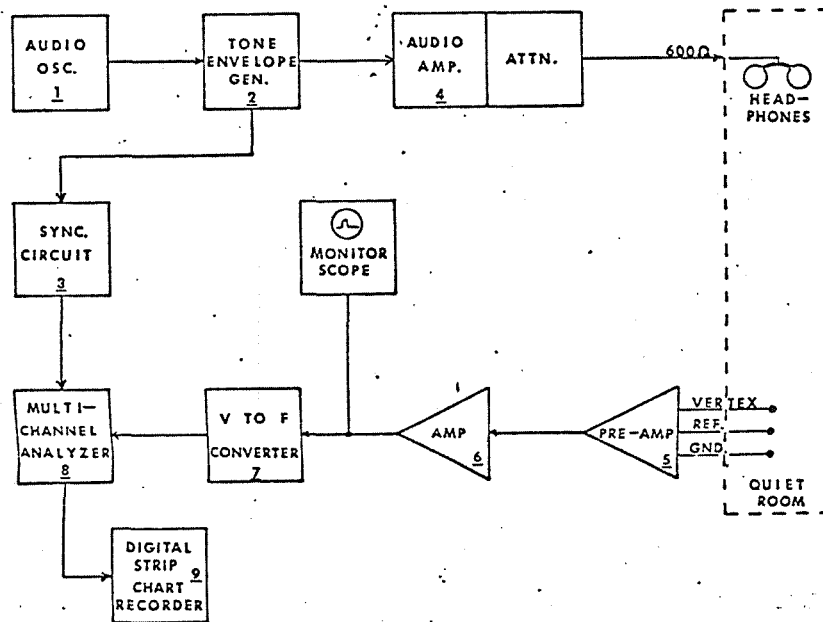
into the control mechanism for the various orthotic devices being fabricated at the Hot Springs Rehabilitation Center.

#### SWC-2: EEG Audiometric System for Use With Infants

Many infants and preschool children exhibit characteristic symptoms of retardation, and many of these are diagnosed as suffering brain damage while their only problem is that they are deaf or hard of hearing. Since infants and small children do not respond well to standard hearing tests either because of an inability to speak or accurately orally respond to testing, more accurate methods are required which will enable the doctor to determine if there is indeed brain damage or a hearing defect. Properly diagnosed, treatment can be administered more concisely and deaf children can be brought to the intellectual level of their peers rather than being classified as retarded during the most important formative years, one to six.

The problem originator and his assistants have developed an instrument which illustrates the feasibility of such an approach to check for hearing defects in infants or children, but have encountered problems that involve so much attention that reliable data are difficult to attain. For example, electrode and earphone attachment with infants and small children is difficult because of their tendency to pull them off. This problem was solved by using a NASA designed helmet with adjustable electrodes incorporated into the helmet. In addition, electrode noise and cabling problems compounded the first stage noise level of the biopotential amplifier being used. This problem was solved using a NASA developed pre-amplifier. However, other problem areas remained sources of difficulty. For example, the unit is made up of cumbersome subassemblies which require much switching, knob twisting, and cabling, requiring the involvement of at least two people to set up. Also, the investigator would like to vary the rise time of the tone burst, which he could not do with his existing circuitry.

While EEG (evoked response) audiometric systems were available, their cost — up to \$20,000 — serves to make them beyond the reach of the many speech and hearing clinics where they are most needed. To provide an effective screening instrument for the use described above, the team proposed that the TU effort undertake applications engineering to significantly reduce the cost, size, weight, and improve operational characteristics of a total system. It was felt that NASA developments in circuitry could produce a system which was both economical and portable, so as to optimize its use as a mass screening device.



INSTRUMENT BLOCK DIAGRAM

Approval of the application's engineering effort was obtained, with the work to be accomplished at MSFC. The project staff has expressed optimism that the aims outlined can be met without difficulty. It is expected that the system resulting will constitute a major contribution to rehabilitation medicine in that the way will have been paved for production of an effective, portable and economical device which can be made standard equipment in the Nation's many speech and hearing clinics and other diagnostic facilities.

### GLM-35: Beta Radiation Catheter Probe

This problem involves the need for a biocompatible catheter probe to detect concentrations of weak beta radiation from an isotope (Krypton-85) administered to head-injured patients as a means of monitoring cerebral blood flow. Present monitoring is accomplished by withdrawing repeated blood samples to determine arteriovenous concentration differences at great discomfort and potential danger (infection) to the patient. Monitoring of cerebral blood flow is necessary to determine effectiveness of therapy which is being administered to head-injured patients. The present blood sample withdrawing technique and subsequent laboratory testing afford few data points for assessing cerebral blood flow, whereas determinations are needed continuously over extended periods of time with the same patient.

NASA Tech Brief 66-10252 describes an innovation which will, with modest applications engineering, solve this important problem. It resulted from NASA's need for a reliable miniaturized radiation dosimeter for biomedical application in vivo. External dosimeters do not accurately

indicate dose level within the irradiated cells because the greater radiation damage is caused by photoelectrons and knock-on protons. Proposed chemical dosimeters for in vivo applications were only partially satisfactory since they will not indicate rate of absorption or number of particles absorbed.

Under contract with NASA, Solid State Radiation, Inc., developed a semiconductor radiation detector in the form of a slender probe that is easily inserted into body tissue. The probe has a signal-to-noise ratio that is acceptable to recording equipment and it provides realistic measurements of the spatial and energy distributions of radiant electrons and protons. It is small enough to mount within a 7 French double lumen catheter.

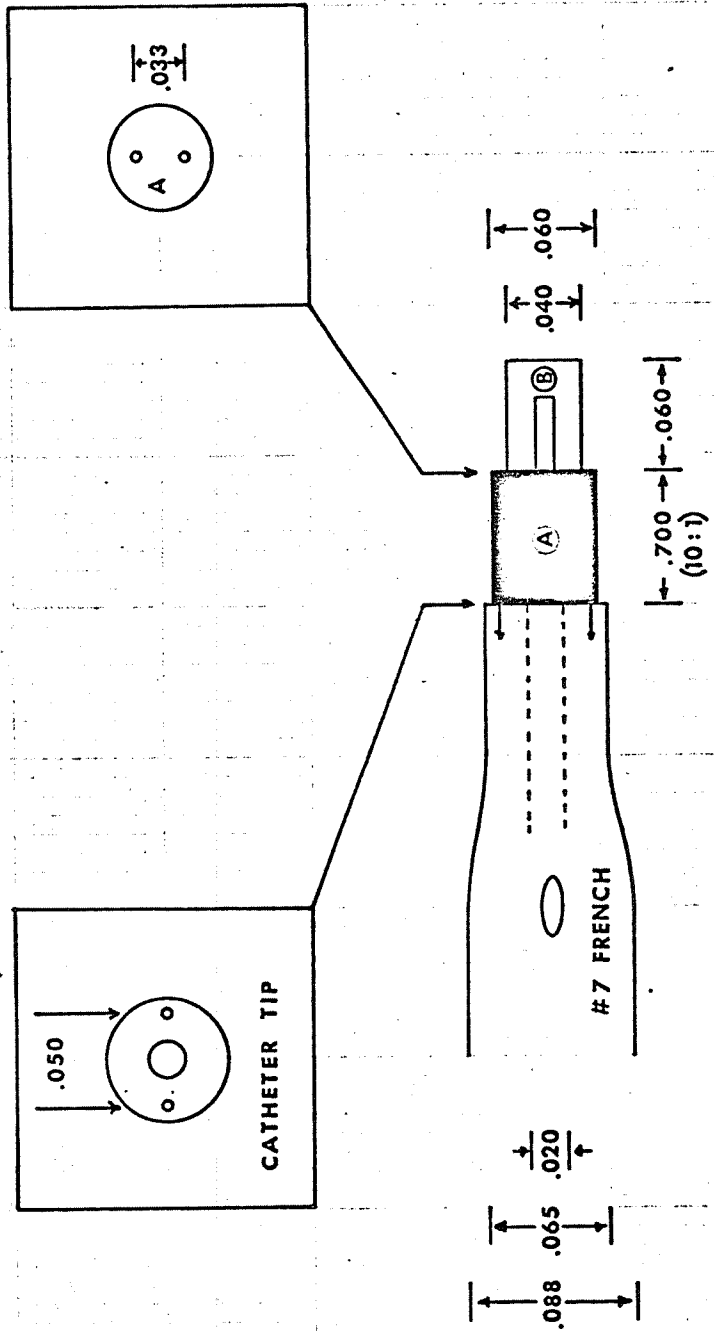
Proposed use of the NASA innovation is described below. The sensing elements are available from Solid State Radiation, Inc., and can be readily mounted in the required biocompatible catheter. Documentation is being submitted for nomination of the problem as an applications engineering candidate. Data concerning the proposed application of the NASA-developed probe follows.

The advantages of using such solid state radiation probes mounted at the tip of a catheter are that the data to be obtained can be observed at the input and output points of interest, and they would allow a larger number of data points to be obtained because of the method of making the measurement.

One catheter mounted probe would be placed in the carotid artery to monitor Krypton-85 concentration in the blood being supplied to the cerebral area. A lumen located near the radiation probe would allow one blood sample to be taken for blood-gas analysis. A second catheter mounted probe with appropriate lumen would be placed in the jugular bulb and would allow the same measurement to be performed on blood flow from the cerebral area.

From the data points gathered at these two locations, the difference of Krypton-85 concentration of cerebral blood flow is easily derived. This difference of Krypton-85 concentration can then be used as a measure of the effectiveness of a certain therapy being applied to the cerebral area under investigation or treatment.

The method of measurement of the Krypton-85 concentration by means of the solid state radiation probe is superior to the present method which requires the taking of many blood samples from the patient under examination and the use of cumbersome equipment as well as an involved process of measurement and adherence to sterile procedures. The present means of obtaining this data is too time consuming to be as effective as could be with the catheter mounted probes described above.



A - PREAMP  
 B - DETECTOR  
 ALL UNITS IN INCHES



## GLM-36: An Objective Measure of Human Motor Activity

Pressures from an ever increasingly complex society in which we live and influences from a variety of other sources affect our mental well-being. A relatively high percentage of the population is being treated or probably should be treated for various kinds of mental illness, according to current estimates. A large proportion of critical bed space in hospitals currently is occupied by patients who are receiving psychiatric or psychological treatments in one form or another because of the psychosomatic nature of human illnesses.

Researchers at a southwestern medical school are assessing the effects of various mental health treatments. Drugs, psychotherapeutic regimens and controlled environmental conditions are employed during therapy. A change in motor activity of the patient is one of the goals of the therapy. The problem originator believes that objective information concerning elicited motor action or reaction from the patient will contribute significantly to both treatment and prognosis for mental illnesses, and illness with mental complications.

A reliable means was needed to objectively and accurately measure and record changes in patients' motor activity elicited from his treatment and observed outwardly. This overt activity reflects the degree of change in generalized hyperactivity and is recorded as fine and gross voluntary movements as distinguished from any involuntary, ultra-fine, tremor-like movements. They seek to measure such activities as scratches or fidgets as well as such activities as pacing or moving about, while a patient is within a therapy enclosure with dimensions of about 15' x 15'. The patient will be alone within the enclosure for possibly extended periods of time, or the patient may have a therapist with him during the early stages of monitoring and treatment.

The patients will be children or young adolescents who can be expected to subject themselves and their environment to relatively rough activities. The required instrumentation must be able to withstand that kind of activity and function accurately throughout the normal and exaggerated motion patterns characteristic of the age groups under consideration. It must meet all the prerequisites of safety and must avoid unduly attracting attention to itself or irritating the individual. Hampering or restricting movement must also be avoided since this alone could introduce an uncontrolled variable into the therapeutic situation which could invalidate all or part of the study.

The BA Team retrieved little of significance from a search of NASA literature on this subject. NASA Tech Brief B68-10315 "Gimble Angle Sensor" appeared to have some applicability but was ruled out when the problem originator evaluated the complete technical support package.

A television approach tied into a computer also was being considered. A Medical Problem Statement was prepared and approved for dissemination to NASA scientists at the research centers.

Dr. Victor Rehn and Dr. David Kyser of the Naval Weapons Center at China Lake, California, directly responded to the problem originator. They proposed an infrared technique incorporating a paper readout. The preliminary testing accomplished to test feasibility of the device and recording of movement encouraged the scientists to believe this could solve the problem. The problem originator evaluated the concept and was pleased with the potential offered. He presently is negotiating for a working model of the arrangement for extensive evaluation within the experimental setting. He expressed the conviction that this technology should be able to satisfy all of the requirements of the problem.

HSR-1: Impression Material for Making Pattern of the Lower Trunk  
HSR-2: Resilient, Breathing Contour Seat Material

Patients who suffer injuries or damage to the spinal cord may develop motor or sensory paralysis. It is not unusual when motor paralysis occurs for sensory paralysis to be a concomitant problem. These patients require a great deal of rehabilitation effort accompanied by extensive patient care requirements. It has been estimated that the ability of a patient to just wash his own face can be converted into a savings of many thousands of dollars related to his rehabilitation. A great deal of effort therefore is directed toward making the patient as self-sufficient as possible by capitalizing on any residual sensory or motor capabilities which remain.

Quadriplegic patients are paralyzed in all four limbs. They are potentially the most expensive of the paralyzed patients from the standpoint of patient care and rehabilitation. Usually they are confined to bed and require someone to be in almost constant attendance for their needs. One of the goals in rehabilitation is to make it possible for the patient to spend part of his time in a specially designed chair in a seated position.

The patients are subject to development of decubitus ulcers (bed sores) whether they are confined to bed or confined to the available chairs. Decubitus ulcers require about \$15,000 to cure and often surgery is needed to close the wound. High pressure points are more easily encountered for these patients since their musculature and other padding tissues atrophy from lack of use. The sensory paralysis prevents the patient from feeling any pain which would cause the average person to reposition themselves before an ulcer could form. The motor paralysis prevents them from moving for any reason.

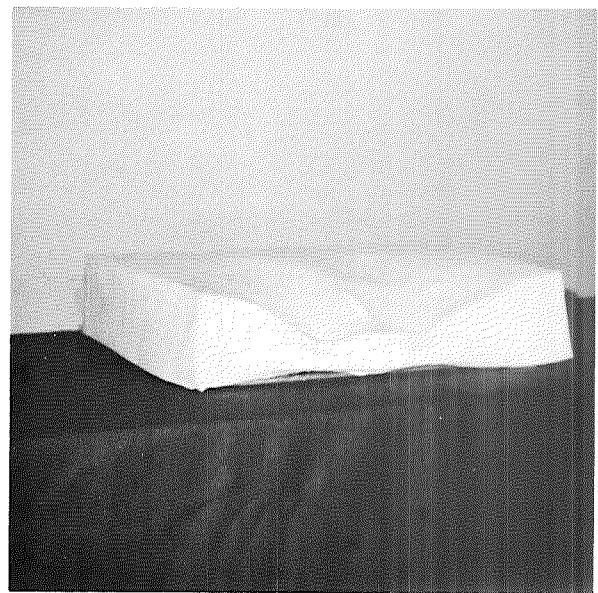
The problem originator sought a means to make an exact impression of the contours of the lower trunk of the patient. He then intended to use that impression to fabricate an individualized contour chair for the patient and thereby avoid the high pressure point problems to minimize development of dangerous decubitus ulcers. He needed materials to fabricate a resilient, breathing seat for the chairs, as the second step of two steps in the procedure.

Several interesting references were obtained by the BA Team from a NASA data bank search. The problem originator evaluated them and was unable to use them for his problem. A Medical Problem Statement was prepared and approved for dissemination to NASA research centers. Several worthy responses were received and forwarded to the problem originator.

Researchers at NASA's Ames Research Center proposed the use of a NASA-developed polymethane foam material. This foam has many unique attributes. For example, it absorbs energy. Further, under the influence of body temperature, it cushions to a comfortable form fitted support which prevents occurrence of high pressure points. It can be easily formed, behaving as a rigid foam at low temperatures and elastic foam at higher temperatures.



Under the influence of local body heat, the NASA-developed polymethane foam produces local cushion flow to provide a fitted uniform support. Use of the foam for fabricating contour chairs for paraplegics is expected to preclude the need for intermediate mold-making.



The foam possesses unique compression rate sensitivity. Its fluid-elastic properties assure a comfortable flow-fitted support. Hard high pressure points yield into soft low pressure uniformity.

This material appeared to satisfy more than the requirements of this problem, and several samples were obtained for evaluation under actual conditions of use by the problem originator. His preliminary reports on the material are most encouraging. He feels that this polymethane foam will not only be the complete solution to this problem, but also may eliminate the need for step one of this two step procedure which was to obtain an impression from which the contour materials could be fabricated. This foam makes its own impressions when warmed before the patient is placed upon it, and then retains the impressions with the breathing resiliency required of the cushion contour seat. Transfer of this technology is expected to solve the HSR-2 problem and make the HSR-1 problem unnecessary simultaneously.

#### BLM-13: Nonthrombogenic Material for Use as a Blood Interface

A southwestern medical school is conducting research in the development of artificial organs. A serious problem has resulted from the non-availability of suitable biochemical material which can serve as a blood interface. Most available materials must be rejected because they are thrombogenic and, therefore, cause blood clotting in the blood stream. Wholly compatible material also must be noncarcinogenic. Its physical characteristics must permit processing into suitable configurations for surgical implants. Nonavailability of suitable biomedical material poses a serious delay in artificial organ research. Work has been advanced in the area of polymer surfaces and heparinization of various materials. This may or may not produce a completely reliable nonthrombogenic material. The treatments applied to a material to render it non-thrombogenic, in some instances, have produced a surface which is highly toxic to tissue cells. All these factors must be considered in selecting a suitable interface material. It was thought that the NASA work being done with biocarbon materials might offer a solution.

After accepting the problem, the team disseminated a description of the problem to the various NASA research centers. As a result, information was provided by Marshall Space Flight Center concerning existing NASA technology in the area, as well as a source (biocarbon<sup>TM</sup>) for samples. A number of samples were obtained (plugs, filaments, woven fabric, etc.) and forwarded to the investigator for long-term evaluation.

### BMC-3: Dark Room Measurement of Eye Pupil Size

Eye pupil size may vary considerably. Variation occurs between individuals and also within the eyes of the same individual. Some pupils are abnormally open (dilated) and some are abnormally closed (constricted). There are several categories of causes for the differences. Some of them result from physical anomalies (structural differences). Others may result from such causes as illness, injury or medications (drugs).

Pupil size is significant since it represents the opening through which light is allowed to enter the eye. In this respect it can easily be compared to the lens opening or setting that is used to control the amount of light which is permitted to enter a camera during photography. It is one of the delicate controls affecting vision.

The researcher is clinically treating patients who have medical problems related to control of eye pupil size. These patients range in age from infants up to mature individuals. The standard method for measuring eye pupil size involves the use of a small point of light in a dark room setting.

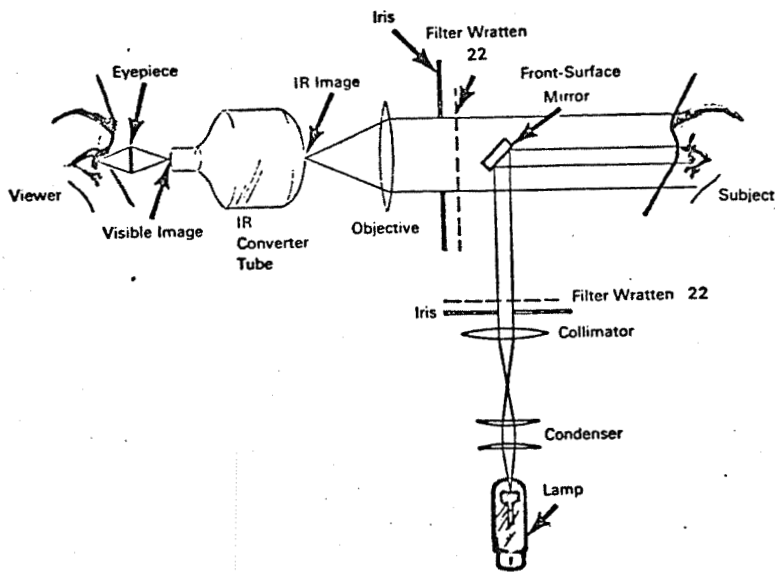
Problems have been encountered under these conditions with many of the patients. Some of the patients with this type of physical disability tend to be sleepy. They either go to sleep or experience difficulty in focusing on the small light source in this setting.

A method was sought which avoided the use of light in the visible spectrum. Television had been suggested since cameras had become available which required very little ambient light conditions. Dark room sensitive film was also suggested as a means for solving the problem.

The Southwest Research Institute BA Team initiated a search and retrieved NASA Technical Brief 68-10206 "Infrared Viewing Would Permit Human Iris Response Studies." Since the infrared light is outside of the visible spectrum and since the system was directly oriented to the specifics of the problem, applicability of this technology appeared likely.

The problem originator was furnished a copy of the technical brief. He was enthusiastic about the concept and indicated that it described an apparently ideal solution for the problem. He requested additional data

## Infrared Viewing Would Permit Human Iris Response Studies



which may have been developed beyond the experimental stage described in the technical brief. The requested supplemental package has been received from NASA. It was forwarded to the problem originator who is attempting to fabricate a working model for direct application to the problem. He expects this working model to contribute to both speed and accuracy of the measurements and to facilitate patient treatment for large numbers of patients with unequal iris size.

### DVM-4: Automatic Atraumatic Blood Pressure Measurement

An investigator at a West Coast medical school needed an atraumatic means to measure blood pressure of humans undergoing a variety of tests. The means must be capable of automatic operation and be relatively immune to acoustical or motion artifacts.

The team accepted the problem and was successful in identifying a relevant NASA-technology device. It is an ultrasonic Doppler blood pressure apparatus. Information concerning the specifications was furnished to the problem originator who has fabricated a working model for use in evaluation against the requirements of his problem area. Documentation is being prepared.

BLM-11: On-Line Analysis of Biochemical Samples Collected  
Automatically from Patients

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A southwestern medical school is performing research in the biochemical study of laboratory specimens. The samples are manually collected, transported to the laboratory for testing, and laboratory procedures are manually performed. Together these processes represent a time-consuming process. Furthermore, significant alterations in concentrations of vital blood substances and urine substances can be missed because collection is too infrequent when the patient's condition rapidly changes; processing delays may produce a late arrival of critical test results needed to help the doctor prescribe a proper treatment; and erroneous and misleading biochemical reports sometimes can result from human errors. The problem originator required a system for automated collection of blood and urine specimens with on-line biochemical analysis of the various constituents. The system must be able to accept quantitative test procedures for sodium, potassium, carbon dioxide, glucose, urea nitrogen, serum glutamic oxalacetic transaminase, and serum glutamic pyruvic transaminase.

The team accepted the problem and made a search of the NASA data bank for appropriate information. Description of NASA-developed technology was obtained from the data search to completely fill the requirements of the problem. This complete information was furnished to the problem originator who obtained additional funds from the National Institutes of Health to develop the necessary on-line biochemical monitoring system.

BLM-11a: On-Line Analysis of Biochemical Samples Collected  
Automatically from Patients

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The problem originator, in continuation of the preceding problem, requested additional information concerning an automated on-line, urine biochemical analysis monitoring system.

The team procured a detailed report of a highly miniaturized urine analysis instrument developed by the NASA Jet Propulsion Laboratories for the Biosatellite III program. A complete description was furnished to the problem originator, and he has included the information in his request for further funding in this area.

### UTM-9: Tidal Volume Measurements in Respiration Studies

Studies relating to definition and diagnosis of emphysema and other respiratory diseases require quantitative information on tidal volume (i. e., volume of air inhaled and exhaled in conjunction with other physiological parameters. In his investigations, the problem originator exercises his subjects and attempts to measure this tidal volume with a high resistance transducer (pneumotachograph). The combined effects of the condition of the patients and a high resistance transducer functioned to increase the respiration work load so drastically in time and amplitude that experiments had to be terminated prior to acquiring necessary data. While the investigator's overall goal was to acquire an instrument that would automatically measure tidal volume, his immediate goal was to develop a low-resistance or resistance-free airflow transducer that would enable him to continue his research while evaluating the data by hand.

The team provided a solution for both problems by recovering document N69-13936 from the NASA data bank. This paper, entitled "Tidal Volume Air Measurement," describes an automatic monitor which incorporates a small, stainless steel, venturi transducer that is obstruction free, thus providing a means for solving the investigator's air resistance problem. The investigator expects to fabricate a prototype from glass, increasing the dimensions proportionately for human use and incorporating a skin diver's snorkle mouthpiece for attachment.

### HSR-3: Padding Material for Orthotic Devices

Hundreds of thousands of persons are afflicted by weak, paralyzed or similarly affected limbs. They are unable to effectively care for themselves or perform productive work without assistance. The assistance frequently can be provided by means of orthotic devices (braces). The orthotic devices are mechanical aids worn to assist the dysfunctioning area.

Orthotic devices must be quite rigid and therefore are composed of metal, leather and other such materials. These materials require padding where they contact the skin surface to avoid chaffing and sores during use. Various sponge rubbers and other pad materials have been used with varying success.



The chronic complaint concerning all of those materials was lack of durability with undesirable qualities during use. The pads quickly wore out, they would shrink and fail to cover the required area to be protected, they caused skin maceration, etc. All of them became objectionably odiferous. Any and all of these unsatisfactory situations required frequent and expensive replacements.

The expense in replacement is demonstrated in many forms. The patient loses the prosthetic assistance which he badly needs during the time it requires for repair. The usable materials have proved to be quite costly. The repair also consumes inordinate amounts of the prosthetist's valuable time.

The problem originator sought to obtain improved padding materials to avoid these "down time" costs. He needed durable, shrink resistant, porous and easily shaped material. The material must be compatible for relatively long term contact with the skin.

Since a solution was not obtained from the NASA data bank literature search, a Medical Problem Statement was prepared and disseminated to NASA research centers. Several valuable responses were obtained from several of the centers and were forwarded for evaluation to the problem originator. Dr. Radnofsky of the NASA Manned Spacecraft Center furnished the names and addresses of several commercial firms who had been contractors for NASA space suit materials. Correspondence with the firms resulted in excellent response and samples of a range of materials were obtained. One NASA-related foam appears extremely promising. The foam can be molded without difficulty to fit the individual characteristics of a given amputee's stump. Further, the foam has characteristics which permit it to adjust automatically to variations in stump configuration attributable to localized edema which can be expected to occur from time to time.

Samples of this foam have been provided to the problem originator who is planning to use them for extensive tests and evaluations. He has expressed satisfaction with the development of the problem up to this point and is confident that the technology will ultimately provide the solution to the complete problem as stated. The enthusiasm of this researcher for applicability of this technology also is shared by researchers at the Texas Institute for Rehabilitation Research, who are concerned with

similar problems. Samples of the polymethane foam have been provided to TIRR for parallel evaluation.

RNV-14: Materials for Prevention of New Decubitus Ulcers

Decubitus ulcers tend to develop over the bony areas of the body of spinal cord injury patients who experience sensory loss. The ulcers require from 2 weeks to 4 months for healing. Some require surgery to effect closure. The average estimated cost of caring for a decubitus ulcer is about \$15,000. Researchers at a West Coast rehabilitation center are seeking help in identifying a type of cushion material for the prevention of the decubitus ulcers. The cushion successfully prevents development of the ulcers by eliminating high pressure points through redistribution of the pressures on the patient's body.

The team accepted the problem and arranged for interaction with the various NASA research centers. Two types of cushion material were identified as holding promise for reducing the incidence of decubitus ulcers. Long-term evaluations are currently in progress at several research institutions. Preliminary information suggests that a special NASA-related foam will meet the problem's requirements.

RNV-28: Accelerometer for Human Motion Studies

Kinesiology investigators at a West Coast rehabilitation center are performing human motion studies on patients who have difficulty in walking. The studies are used for planning corrective surgery or for improving bracing techniques. The investigator believes it may be possible to evaluate and diagnose orthopedic cases in an on-line manner if proper techniques of data acquisition and analysis were available. This could facilitate development of courses of treatment. The investigators requested team assistance in locating small, light, and rugged accelerometers for collecting required motion data. The team accepted the problem and established the availability of the accelerometers via a computer search plus interaction with investigators at the NASA Ames Research Center. The acquired information was provided to the researcher together with a commercial source of supply. Accelerometers have been obtained for use in the research.

RNV-34: Pressure Sensitive Device for Use in Tongue-Operated Control Systems for Assist Devices and Wheelchairs

Many patients surviving from severe neuromuscular disease are faced with the prospect of a bedridden existence. These patients are

extremely limited in what they can do and are essentially totally dependent upon society for their care. The extent of dependence relates in part to the severity of their residual disability. It also relates importantly to technological devices and methodology which can be applied to develop their potential for increased self-sufficiency.

Total care for paralytically disabled patients can be extremely expensive. For example, if a person can merely take a wash cloth and wash or wipe his face, it has been estimated this can result in a saving of about 50% of patient care cost. Those involved in planning for or providing patient care are therefore extremely interested in technological devices and methodology applications to increase the potential for increased self-sufficiency on the part of such patients.

Researchers at a West Coast rehabilitation hospital have developed a very high degree of specialization and competence for innovating in variety of patient assist device areas. Their research is applied not only to the care of severe neuromuscular disability patients, but also to the amputee patients who have parallel patient care requirements. One of their interests is in improving the patient's mobility, with the wheelchair being the most often used means for locomotion.

The basic wheelchair has been modified by the addition of electric motors and various switches and attachments which permit the wheelchair to be operated forward or backward, turn, and even negotiate up and down inclines. The researchers are attempting to refine the control and operation to the extent that the wheelchair can be used by totally paralyzed or amputee patients who have the capability only to use the muscles of the eyes, mouth and head area for operation of control devices.

The above researchers have made considerable progress in development of control systems for externally-powered orthotic devices. These include extra-oral, tongue-operated switch controls which provide sequential off-on control. The problem originator requested assistance from BATEam personnel to identify technological concepts which would lend themselves to incorporation in a reliable, saliva resistant switch that is small enough to fit the lingual area of the mandible and sensitive to tongue pressure operation.

Coordination with NASA and one of the NASA research consultants at the University of California have provided extensive guidance. NASA Tech Brief 70-10157 was retrieved, which identified an insulated-gate field-effect transistor which performs strain-sensing and amplification functions in one integral device.

A copy of NASA Tech Brief 70-10157 was provided to the problem originator, who was extremely pleased with the potentials the device held for solving the problem described. The problem originator feels it can be incorporated into a switching device which will vastly improve the sophisticated but limited devices in use. It will permit graded accelerations to replace the simple off-on capabilities. He is planning to use this concept to develop a switch which will telemeter operating control instructions by wireless means and thereby avoid the inconvenience and hazards of wire attachments and rigid devices. His complete endorsement of this technology as a solution to all aspects of the problem hinges upon development and application of a switch incorporating the technology contained in the NASA Tech Brief 70-10157.

#### SJH-1: Interfacing Biochemical Autoanalyzers with a Computer

The problem originator wishes to interface several biochemical autoanalyzers used in the Pathology Department with computers -- as a means of increasing the efficiency of specimen analysis. This in turn would help introduce savings in cost for laboratory services which ultimately could be passed along to the patient receiving such services. After discussing the problem, the team investigated the computerized diagnostic facilities at the NASA Manned Spacecraft Center, Houston, and concluded that much of the technology and computer programs required were available. Accordingly, arrangements were made for the problem originator to attend a seminar at MSC presented by Dr. E. C. Moseley concerning the center's Medical Information Computer Systems. Arrangements were also made for the problem originator to meet with Dr. Craig Fischer, head of the MSC Medical Directorate's clinical laboratory. As the result of these meetings, the problem originator expressed confidence that if he could obtain copies of the computer programs and related data, he would be able to adapt them for use at his hospital.

Working through the MSC Technology Utilization Officer, the team arranged to obtain (1) a listing and magnetic tape containing all MEDATA-related programs now in operation at MSC, (2) technical documentation of these programs, and (3) a document describing the overall system. These have been transmitted to problem originator for use in perfecting his system. It should be noted that the MSC materials must be adapted for use in the hospital's less sophisticated computer system. Therefore, application of this technology will be delayed for some time. However, the problem originator's enthusiasm and resolve may help shorten the time which would ordinarily be required to adapt the complex MSC program materials.

#### SNM-5: Implantable Telemetry System for ECG

Researchers at a southwestern medical school expressed a need for a small, implantable telemetry system to continuously transmit electrocardiographic data from experimental animals surviving cardiac transplants, to monitor the onset of rejection phenomena. The system had to be small, be biocompatible, and have a useful life of about 60 days. The system also had to have an effective range of about 20 ft.

The team accepted the problem and conducted a search of the NASA data bank for a possible solution. One document retrieved contained circuitry information for the subminiature, remote, biotelemetry, physiological investigations system shown below. Detailed information describing the system was forwarded to the investigator. A replica of the NASA unit has been fabricated which is suitable for long-term implantation in primates and other animals subjected to heart transplants. Additional documentation is being prepared for this particular problem.

#### SWC-4: Information Retrieval System for Clinical Records

A medium-size southwestern medical facility having 80,000 admissions annually desires a means to retrieve information from its bank of one-half million clinical records. The hospital particularly desires access to information contained on the records to augment information related to specific medical treatment, enhance disease prevention, and identify trends in medical treatment. It is also desired that the system permit updating of patient records contained in the data bank as patients return for treatment from time to time. Ultimately, the desire is to perfect techniques for providing guidance in treatment of cryptic diseases by computer analysis. The hospital has sophisticated data processing equipment (IBM Model 360 Computer) but lacks software programs to accomplish the task outlined.

The team accepted the problem and obtained pertinent information from the NASA Manned Spacecraft Center Medical Research and Operations

Directorate. They had developed some general computer programs which appeared to meet the requirements outlined in the problem. They were:

Storage of Medical Records in Retrieval Form

Retrieval of Medical Data According to Specifications

Updating of Medical Data Bank

Arrangements were made for the problem originator's representatives to visit the NASA Manned Spacecraft Center and discuss possible application of these computer programs to resolve the problem. In addition, IBM card images of FORTRAN object deck and a magnetic tape of the MSC programs were made available to the problem originator.

#### SWC-12: Detection of Eye Tumors by Use of Radiation Probes

This problem involves the need for a biocompatible, highly sensitive probe to detect concentrations of weak beta radiation from an isotope (P-32) which is administered to patients who are suspected of having eye tumors and which is selectively absorbed (uptake) by tumor cells. Present monitoring is accomplished by inserting a miniature geiger probe between the eyeball and the eye socket to various quadrants for linear measurements of energy transfer on a linear accelerator. The monitoring of the different energy levels is necessary to detect tumors which are hidden from direct observation or are in such early stages of development that they cannot readily be identified by other means. The present probe is excessively large in dimensions and is insufficiently sensitive to the radiation levels which are encountered.

NASA Tech Brief 66-10252 describes an innovation which will solve this important problem after modest applications engineering. This resulted from NASA's need for a reliable miniaturized radiation dosimeter providing biomedical application in vivo. External dosimetry is applicable in this sense because it can be inserted into a body orifice for direct contact with the organ which is suspected of having cells with higher levels of radiation that differentiate them from other cells in that organ. The capability to identify the cells is only part of the measurement since the positioning of the probe also will permit evaluation of the location and extent of any suspected tumor in the eyeball.

Under contact with NASA, Solid State Radiation, Inc. developed a semiconductor radiation detector in the form of a slender probe that is easily inserted into the area of the eye socket. The probe has a signal-to-noise ratio that is acceptable to recording equipment, and it provides a realistic measurement of the spatial and energy distributions of beta radiation. It is small enough to be effectively used as needed and has high sensitivity.

Proposed use of the NASA innovation is described below. The sensing elements are available from Solid State Radiation, Inc. and can be readily adapted to present instrumentation in the investigator's research area. Documentation is being submitted for nomination of the problem as an application engineering candidate. Data concerning the proposed application of the NASA-developed probe follows.

The advantages of using such solid state radiation probes mounted for insertion between the eyeball and eye socket are that the data to be obtained can be observed at the input and output points of interest and they provide a larger number of data points to be obtained because of the method of making the measurement.

Multiple mounting of the probe into a sensing device that monitors selected areas in various quadrants of the eye socket will provide a range of linear energy transfer which can be readily interpreted on a linear accelerator.

From the data points gathered at the multiple locations, the difference of P-32 concentration in the various positions is easily derived. The difference of P-32 concentration can then be used to identify and outline the area of increased uptake by suspected tumor cells if and when they are present. This information will be used for diagnosis, treatment and evaluation of treatment of the eye involved.

The use of the present concept is superior to the methodology and equipment being used by the investigator. The probe is smaller and its high sensitivity provides advantages in several areas of need. It should be capable of providing the required more than 10% detection of 1.71 MEV (average about 0.7 MEV) of energy from beta radiation of P-32 which is beyond the limits of the investigator's instruments. This basically solves the problem as outlined. A prototype probe is being fabricated under the team applications engineering effort.

## UTM-7: Chronic Electrode Implantation Techniques for Artificial Eye Research

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Investigators at a southwestern medical school are extensively researching development of an artificial eye. Instrumentation and techniques are being perfected to wire an electronic (TV) camera directly into the visual area of the brain. Much basic research must be undertaken before this interface can be accomplished. The various neural and electrical parameters must be clearly defined. The investigators currently desire to define various central nervous system parameters and express them in electrical terms. This is a necessary first step establishing requirements for the electronic camera interfacing with the brain. The investigators must implant miniature electrodes into various, central nervous system locations to define the parameters. The optic nerve is one such location. The precise nature and function of the body's visual mechanisms can be adequately delineated only by such methodology. The investigators desire biocompatible electrode materials from aerospace technology which are suitable for transplant within the central nervous system. They also require related techniques for fabrication and implantation of subminiature electrodes.

The team accepted the problem and surveyed the NASA data bank. NASA Tech Brief 69-10087 was retrieved as a possible source of assistance. It describes technology associated with carbon myoelectric probes. They are implanted in muscle tissue to pick up or receive electrical impulses in the picowatts to nanowatts range. The apparent galvanic inertness of bio-carbons suggests the materials may be compatible with specifications of the problem. The material can be fabricated as filaments or small diameter rods. The investigators presently are continuing their evaluation of the potential that this technology holds for solving their problem. Similar problems have been enunciated by a number of research institutions.



Potential Technology Applications Dropped During The Period

<u>Problem Number</u>	<u>Reason for Dropping</u>
BLM-14	Cost to adapt relevant NASA technology prohibitive.
CAP-1	Lack of investigator desire to pursue use of relevant NASA technology.
DLM-1	Investigator no longer available for interaction.
DLM-2	Investigator no longer available for interaction.
DLM-6	Investigator no longer available for interaction.
DLM-12	Cost to implement proposed solution precludes use of relevant NASA technology.
NWR-5	Lack of investigator desire to pursue use of relevant NASA technology
RNV-13	Investigator decided not to pursue relevant NASA technology.
SNM-4	Lack of investigator desire to pursue use of relevant NASA technology.
UFM-5	Investigator no longer available for interaction.

### III. SUMMARY OF PROBLEM ACTIVITY UNDERTAKEN DURING THE REPORT PERIOD

#### Project Activity Summary

The following is a summary of project activity by the team for the period September 1970 to February 1971. Additional information concerning project activity is attached as Appendix A.

New Problems Accepted	83
Problems Rejected	1
Problems Inactivated	71
Problems Reactivated	2
Total Problems Currently Active	185
Preliminary Problem Statements Prepared	86
Problem Statements Submitted for Review	7
Problem Statements Disseminated	3
Responses to Problem Statements	27
RDC Computer Searches Initiated	70
Other Searches Initiated	24
Search Evaluations	31
Potential Technology Applications Claimed	21
Technology Applications Claimed	7

#### Health Area Impact

The health area impact categories for new problems accepted during the report period are shown in the following table.

#### Description of Currently Active Problems

A description of currently active problems categorized by health areas is attached as Appendix B.

TABLE 1. IMPACT AREAS OF NEW PROBLEMS ACCEPTED  
DURING THE PERIOD COVERED BY THIS REPORT

Health Area Impact Categories	Analytic Inst. Systems	System Components (Equip.)	Computer Programs	Prosthetic Devices	Materials/ Chemicals	Therapeutic Equipment	Other	Total
Communicable Disease	3							
Multiphasic Health Screening								
Rehabilitation Medicine		7		4	1	9	1	22
Artificial Organs		6		1	1			8
Organ Assist Devices								
Mental Health		1					2	3
Heart Disease Treatment	2	4				2		8
Cancer Detection	2					1		3
Ecology		1			1		1	3
Health Care Cost Reduction		2				1	2	5
Remote Health Services								
Medical Personnel							1	1
Kidney Disease								
Infant Mortality	1							1
Respiratory Disease	1	1					2	4
Surgical Procedures	1	3						4
Dental Medicine								
Basic Medical Research	2	5		1		2	3	13
Other	2	1					2	5
<b>TOTAL</b>	<b>14</b>	<b>31</b>	<b>0</b>	<b>6</b>	<b>3</b>	<b>15</b>	<b>14</b>	<b>83</b>

Symposium and Conference Attendance

Earl K. Calvert  
David F. Culclasure

Social and Rehabilitation Services Conference, Steven F. Austin State University, March 25, 1971, Nacogdoches, Texas. Presentation was given on the NASA Biomedical Applications Program.

Earl K. Calvert  
Samuel G. Schiflett  
David F. Culclasure

Texas Rehabilitation Commission, Regional Research Utilization Workshop, December 3-4, 1970, San Antonio, Texas. Presentation was given on the NASA Biomedical Applications Program.

Earl K. Calvert  
David F. Culclasure

Heads of Departments Conference, Texas State Vocational Rehabilitation Commission, November 2, 1970, Austin, Texas. Presentation was given on the NASA Biomedical Applications Program.

Earl K. Calvert  
David F. Culclasure

Regional Directors Conference, Texas State Rehabilitation Commission, December 14, 1970, Austin, Texas. Presentation was given on the NASA Biomedical Applications Program.

David F. Culclasure

Alabama Hospital Association Golden Anniversary Convention, Mobile, Alabama, January 20-22, 1971. Presentation was given on the NASA Biomedical Applications Program.

David F. Culclasure

Texas Rehabilitation Commission Conference attended by Commissioner, Deputy Commissioners and Commission Consultants, Austin, Texas, October 23, 1970. Presentation was given on the NASA Biomedical Applications Program.

David F. Culclasure

Texas Commission for the Blind  
Conference attended by Commissioner,  
Deputy Commissioners and Commission  
Consultants, Austin, Texas, March 8,  
1971. Presentation was given on the  
NASA Biomedical Applications Program.

David F. Culclasure

Texas Rehabilitation Commission,  
Research Utilization Workshop,  
University of Texas Medical School  
at Galveston, October 7, 1970.

Ray W. Ware

Annual Conference on Engineering in  
Medicine and Biology, Washington, D. C.,  
October 26-28, 1970.

Charles J. Laenger, Sr.

Sixth Annual Meeting of the Associa-  
tion for the Advancement of Medical  
Instrumentation, Los Angeles, Calif.,  
March 19, 1971.

IV. INSTITUTIONS CURRENTLY UTILIZING SERVICES OF THE  
SOUTHWEST RESEARCH INSTITUTE BIOMEDICAL APPLICATIONS TEAM



Baylor University Medical School  
Houston, Texas

Brooke General Hospital  
Fort Sam Houston, Texas

Callier Hearing and Speech Center  
Dallas, Texas

Caruth Memorial Rehabilitation Center  
Dallas, Texas

Children's Hospital of Los Angeles  
Los Angeles, California

Community Mental Health Service  
San Diego, California

Doheny Eye Foundation  
Los Angeles, California

Fitzsimmons General Hospital  
Denver, Colorado

Gallup Indian Medical Center  
Gallup, New Mexico

General Rose Hospital  
Denver, Colorado

Hollywood Presbyterian Hospital  
Los Angeles, California

Hot Springs Rehabilitation Center  
Little Rock, Arkansas

Huntington Memorial Hospital  
Pasadena, California

Loma Linda Medical Center  
Loma Linda, California

Los Angeles County Hospital  
Los Angeles, California

Northwest Institute for Rehabilitation  
Seattle, Washington

Palo Alto Medical Research Foundation  
Palo Alto, California

Rancho Los Amigos Hospital  
Downey, California

Rosewood General Hospital  
Houston, Texas

St. Josephs Hospital  
Phoenix, Arizona

Scott and White Hospital & Clinic  
Temple, Texas

Stanford University School of Medicine  
Stanford, California

Texas A & M University  
College Station, Texas

Texas Institute for Rehabilitation and  
Research  
Houston, Texas

University of Alabama Medical School  
Birmingham, Alabama

University of Arizona Medical School  
Tucson, Arizona

University of California Medical School  
Davis, California

UCLA College of Medicine  
Los Angeles, California

University of Florida  
Gainesville, Florida

University of Florida Medical School  
Gainesville, Florida

University of Oklahoma Medical School  
Oklahoma City, Oklahoma

University of Southern California  
Medical School  
Los Angeles, California

University of Texas Medical Branch  
Galveston, Texas

University of Texas Medical School  
San Antonio, Texas

University of Texas Southwestern  
Medical School  
Dallas, Texas

University of Utah Medical School  
Salt Lake City, Utah

University of Washington Medical  
School  
Seattle, Washington

Veterans Administration Hospital  
Albuquerque, New Mexico

Veterans Administration Hospital  
Bay Pines, Florida

Veterans Administration Hospital  
Birmingham, Alabama

Veterans Administration Hospital  
Dallas, Texas

Veterans Administration Hospital  
Gainesville, Florida

Veterans Administration Hospital  
Long Beach, California

Veterans Administration Hospital  
Sepulveda, California

Veterans Administration Hospital  
Shreveport, Louisiana

Veterans Administration Hospital  
Temple, Texas

Veterans Administration Regional  
Office  
San Antonio, Texas

Veterans Administration Southern  
Research Support Center Hospital  
Little Rock, Arkansas

Western Research Support Center  
Sepulveda, California

Wilford Hall Hospital  
Lackland AF Base, Texas



## V. APPLICATIONS ENGINEERING ACTIVITY

The following problems were accepted for consideration as candidates for applications engineering. Under this program, selected items of NASA technology are subjected to modifications designed to render them more appropriate for a particular application. Of special interest are the Southwest Research Institute Biomedical Applications Team's in-house application engineering activities. Here, NASA technology which has been identified as a potential solution to a biomedical problem, is adapted to fit the specific needs of the individual researcher by BA Team engineers, in-house, thus expediting the application of aerospace technology to the medical field.

### CLA-1: Newborn Infant Respiration Monitor and Apnea Alarm

A number of newborn infants and small children are subject to onset of respiratory distress with little or no warning. There are many causes for respiratory distress ranging from factors surrounding child-birth to injuries and illnesses. The child may die unless onset of distress is quickly noted and immediate, positive remedial action is taken. This is particularly true if the baby was born with or developed respiratory or cardiac complications. These children rapidly succumb and require very close observation. A great need exists in hospitals today for technology to effectively and accurately monitor infant breathing. Presently, large amounts of time are required for nurses and hospital personnel to remain at the crib side during the required monitoring of infant respiratory function.

A computerized search of aerospace literature led the team to NASA Technical Brief 64-10171 "Subminiature Biotelemetry Unit Permits Remote Physiological Investigations." This document described a high performance, biotelemetry transmitter designed by Gordon J. Deboo and Thomas B. Fryer in May 1964 that operates in the standard 88 to 108-MHz FM band.

BA Team engineers found the design to be straightforward and determined that it should be relatively inexpensive to fabricate. Southwest Research Institute engineers replaced the original electrocardiograph (ECG) preamplifier of the unit with a thermistor bridge network. Input to the system is provided from a sensor that is attached with a microminiature connector to the patient's airway. This permits competent operation of the monitor and allows for autoclave sterilization of the airway as needed. The redesigned transmitter hangs on the isolette and transmits a pulsating signal to the nurse's station outside of the nursery. Interruption of the signal indicates the infant is having respiratory distress. The problem

originator preferred a continuous signal to indicate respiration rather than the automatic alarm feature mentioned in NASA Technical Brief 64-10365, which sets off an alarm when breathing stops. The problem originator indicated that the quality of the continuous tone transmitted can, to the experienced ear, provide valuable information concerning the infant's respiration.

#### CMR-2: Call Signal for Quadriplegic Patients

Patients who are paralyzed in all four of their limbs (quadriplegics) and patients who are multiple amputees (quadruple amputees) present very special problems for themselves and for the patient care personnel. They require at least as much attention as any of the other patients and possibly more. Yet, they are unable to operate the usual nurse call switch to obtain assistance when they need it.

The only solution available to relieve this situation in the past has been to provide costly full-time nursing staff attendance at the bedside or at least in the immediate vicinity within voice call. Frequent and wasteful bed stops have had to be scheduled and made by patient care personnel if it is not possible to have the staff remain in the immediate area for any reason.

The problem originator sought a means to insure that the patient had nursing staff in attendance when they need it at least on a par with patients who can operate the usual call signal. These patients are limited in movement to face, head and neck muscles because of their handicap and also because of braces. A device was needed which such patients could activate and summon nursing assistance through the usual call switch arrangement, by intentional movement of the extent and type as indicated.

The Southwest Research Institute BA Team searched the aerospace literature stored in the NASA data bank and retrieved NASA Technical Brief 63-10378 "Liquid-Level Meter Has No Moving Parts," which described an electro-optical system which used no moving parts to register liquid levels. Southwest Research Institute engineers determined that modest re-engineering effort could modify the existing specifications to the extent required for solution of the problem.

The concept of the existing technology and the proposed modifications were presented to the problem originator who was very pleased with the potentials offered. The problem originator then requested NASA assistance in the fabrication of a prototype unit, since the hospital (a small rehabilitation center) did not have the necessary facilities. The unit was fabricated and found to perform exceedingly well. Use of the unit will not only help increase the comfort and security of totally paralyzed patients

(who can now summon assistance at will) but will also introduce a degree of economy by releasing nursing service personnel from the requirement for close attendance at all times for such patients.

GLM-32: Signal Conditioner to Record and Playback Electrocardiogram  
Via Inexpensive Hometype Tape Recorders

Simplification and long term applications of electrodes have made it possible to monitor the ECG outside of hospital settings and clinical settings. Doctors seek to be better able to monitor patients to include ECG information that could be obtained while the individual is going about the normal routines. This information can be extremely valuable for both diagnostic and research purposes.

The problem originator is one of a group of researchers in a large southwestern medical school who are seeking to be able to condition the ECG signals and provide an accurate, low-cost interface between the patient and a usual type of home or office, portable tape recorder unit. In this way they can monitor the ECG of outpatients as they engage in normal home or work routines. A permanent tape recorder record can be provided for later playback and tracings as required.

Many of the components of the heart action generated electrical signals are considerably below the 60 Hz, low limit of pickup for tape recorders. The signals therefore must be conditioned and modulated to higher ranges by means of a subcarrier oscillator having a frequency response from d-c to 100 Hz, a low noise figure, and battery operation for patient protection. The Intermed portable analog recorder is one of the portable recorders on the commercial market. They are suitable for the purpose, but they are exceedingly expensive: \$1625 for the Intermed model. They also require a separate reproducer to playback recorded signals into ECG strip charts or ECG apparatus, at a cost of \$3500 for the Intermed reproducer system. Most physicians resist making a capital outlay of this magnitude. They clearly need a unit within a desired price maximum of \$200. The integrated unit should center upon a low-cost home type of tape recorder with a built-in signal conditioner modulator for ECG signal input to the recorder and a demodulator for direct playback of the recorded signals directly into the ECG apparatus or strip chart.

NASA Technical Brief 64-10171 "Subminiature Biotelemetry Unit Permits Remote Physiological Investigations," was retrieved from a data bank search. The document described a high performance, biopotential telemetry transmitter operating in the standard 88 to 108 MHz FM band (Gordon J. Deboo and Thomas B. Fryer, May 1964).

Southwest Research Institute engineers found the circuitry simple, relatively inexpensive to fabricate, and applicable to the immediate problem. They determined that the transmitter circuitry could be removed and a hardwire connection could be made for relay of ECG recordable information through modest re-engineering effort. Signals generated by the heart are conditioned and modulated for presentation as documented in the NASA Technical Brief, and then they are acceptable for recording by the usual type of home or office types of tape recorders. Proven characteristics of the original NASA device seemed to satisfy all of the requirements of the problem.

The prototype has been tested by the cardiovascular research team, who expressed enthusiasm for its low cost and operating characteristics. The consensus is that most physicians will be able to obtain a similar unit to carry as standard equipment in their physicians bag for office calls. This will permit them to take ECG's of homebound patients as needed, evaluating the ECG's upon return to the office. This constitutes a distinct aid to diagnosis and prognosis and will preclude the necessity for a patient having to be referred to a hospital or come into the physician's office just to have an ECG made. Considering advances being made in miniaturization of home tape recorders, it is expected that a reduction in size of about 50 percent can be made over that reflected in the prototype.

#### GLM-33: D-C Powered Proportional Temperature Controller

Researchers at the University of Texas Medical Branch have been considering various aspects of the atmospheric and water pollution problems. One of the largest petroleum refinery complexes in the United States operates in the area around Texas City, Texas. Samples of the various effluents from a number of phases of that operation have been collected, concentrated and used in an extended period of animal research problems. Cresylic acid and other byproducts have been isolated and tested in a five-year program. These agents have proven to be cancer producing (carcinogenic) when concentrated and when the animals were exposed to them in various ways.

The problem originator had been attempting to refine the system of monitoring and isolating the atmospheric pollutants. He needed a drying oven which could be controlled at uniformly constant temperatures so that a series of on-line, 5-25 milliliter charges could be quickly processed as part of a system of qualitative and quantitative analysis. This oven was seen as a means of expediting the collection, processing and analysis to move the research forward at a much faster rate.

He had been attempting to use a constant temperature oven with conventional a-c control methods incorporating silicon controlled rectifiers (SCR). The SCR produced excessive electrical noise which created interferences that were picked up by other required instrumentation. The problem originator needed a d-c powered proportional controller that was capable of maintaining constant temperatures throughout a range of 75 to 225 degrees centigrade, with an accuracy of plus-or-minus two-tenths of one degree centigrade. His oven consumed 25 to 35 watts of power at full load, with an electrical source of 24 to 28 volts and 1 to 1.5 amperes.

The problem was disseminated to the NASA Research Centers and S. W. Billingsley of NASA Goddard Space Flight Center provided a working solution to this problem. He had developed an oven temperature controller which met every specification stipulated, except the hysteresis. That design controls temperatures within one degree centigrade, plus or minus the limits of the need for the original design. He had no need to test within the prescribed plus or minus two-tenths of one degree centigrade, however, inherently it should be able to fit that limit.

Schematics of that controller were obtained and sent for evaluation to the problem originator. He is presently fabricating and testing a working model to determine if he can achieve the prescribed two-tenths of one degree centigrade control with it. He has indicated initial satisfaction with the concept and utility of this technology. He has indicated that he may slightly relax the control limit specifications to incorporate the device in the system because of its outstanding advantages of simplicity and low cost.

#### GLM-35: Beta Radiation Catheter Probe

This problem involves the need for a biocompatible catheter probe to detect concentrations of weak beta radiation from an isotope (Krypton-85) administered to head-injured patients as a means of monitoring cerebral blood flow. Present monitoring is accomplished by withdrawing repeated blood samples to determine arterio-venous concentration differences at great discomfort and potential danger (infection) to the patients. The present blood sample withdrawing technique and subsequent laboratory testing afford few data points for assessing cerebral blood flow, whereas determinations are needed continuously over extended periods of time with the same patient.

NASA Tech Brief 66-10252 describes an innovation which will, with modest applications engineering, solve this important problem. It resulted from NASA's need for a reliable miniaturized radiation dosimeter

for biomedical application in vivo. External dosimeters do not accurately indicate dose level within the irradiated cells because the greater radiation damage is caused by photoelectrons and knock-on protons. Proposed chemical dosimeters for in vivo applications were only partially satisfactory since they will not indicate rate of absorption or number of particles absorbed.

Under contract with NASA, Solid State Radiation, Inc., developed a semiconductor radiation detector in the form of a slender probe that is easily inserted into body tissue. The probe has a signal-to-noise ratio that is acceptable to recording equipment and it provides realistic measurements of the spatial and energy distributions of radiant electrons and protons. It is small enough to mount within a seven french double lumen catheter.

Proposed use of the NASA innovation is described below. The sensing elements are available from Solid State Radiation, Inc., and can be readily mounted in the required biocompatible catheter. Documentation is being submitted for nomination of the problem as an applications engineering candidate. Data concerning the proposed application of the NASA-developed probe follows.

The advantages of using such solid state radiation probes mounted at the tip of a catheter are that the data to be obtained can be observed at the input and output points of interest and they would allow a larger number of data points to be obtained because of the method of making the measurement.

One catheter mounted probe would be placed in the carotid artery to monitor Krypton-85 concentration in the blood being supplied to the cerebral area. A lumen located near the radiation probe would allow one blood sample to be taken for blood-gas analysis. A second catheter-mounted probe with appropriate lumen would be placed in the jugular bulb and would allow the same measurement to be performed on blood flow from the cerebral area.

From the data points gathered at these two locations, the difference of Krypton-85 concentration of cerebral blood flow is easily derived. This difference of Krypton-85 concentration can then be used as a measure of the effectiveness of a certain therapy being applied to the cerebral area under investigation or treatment.

The method of measurement of the Krypton-85 concentration by means of the solid state radiation probe is superior to the present method which requires the taking of many blood samples from the patient

under examination and the use of cumbersome equipment as well as an involved process of measurement and adherence to sterile procedures. The present means of obtaining this data is really too time consuming to be as effective as could be with the catheter-mounted probes described above.

OVA-4: Method for Assessing Sleep Psychophysiology  
in Extreme Environments

Extreme, exotic and stressful environmental conditions are encountered at Amundsen-Scott Station, Antarctica. The investigator is assessing generated, long-term psychophysiological responses to use in constructing an overall picture of the general processes of adaptation to these extreme conditions. He collects and analyzes the psychophysiological concomitants of sleep (as a definitive state of consciousness).

A technique was needed to analyze sleep which would avoid the need for human experts to interpret voluminous conventional EEG data gained over extended periods of time and be reliable under extreme environmental conditions. It was found that a NASA-developed electronic sleep analyzer fit the basic requirements of the problem originator. The instrument, described in Tech Brief 70-10110, automatically monitors the stages of sleep of a human subject. It was designed for possible use in manned spaceflight monitoring and would therefore have to be independent of human experts for the proper interpretation of data over extended periods.

This analyzer differs from previous sleep analyzers in that it includes all of the following features: (1) packageable in small size (for use on a spacecraft); (2) requires very little telemetry bandwidth or time; (3) designed specifically for the determination of state of sleep, (4) operational in real time, (5) requires only channel of EEG activity (central to occipital); and (6) not excessively biased by occasional electrode or movement artifacts.

The end item developed under the applications engineering program will be used at the Amundsen-Scott Station, Antarctica, to expedite the collection and analysis of the psychophysiological concomitants of sleep, providing information needed to construct an overall picture of the general processes of adaptation and disadaptation to extreme environmental conditions.

## RRC-2: Accurate Cardiac Telemetry from Active Subjects

Computer analysis of clinical ECG waveforms has yielded information on "S-T depressions" which have been interpreted to be an indication of cardiovascular malfunction. The problem originator found this information to be significant in relation to patients' reactions during participation in cardiac rehabilitation exercise programs and he required a means to monitor both heart rate and ECG waveforms of exercising patients.

Many varieties of electrocardiograph and heart rate telemetry units are currently commercially available. These were evaluated for applicability to the problem, however, none was found to provide the required precision for detecting "S-T" cardiograph waveform depressions from an active subject.

Computerized and manual searches of aerospace literature were performed and were successful in identifying aerospace technology which met the requirements as stated in the problem. NASA Tech Brief 64-10171 describes a suitable telemetry unit for ECG monitoring and Marshall Space Flight Center New Technology Report MFS-20418 describes an apparently ideal and inexpensive cardiometer. In-house re-engineering efforts are in progress to adapt this technology to the specific needs of the problem originator. Use of this equipment will result in improved monitoring of cardiovascular disease patients during exercise.

## SWC-1: Improved Techniques for Taking EEG in Infants and Small Children

The investigator is perfecting a technique for using the EEG to test hearing of small children. Today thousands of children classified as mentally retarded are believed to be suffering not from mental retardation, but rather from hearing difficulties which have cut them off from auditory interchanges with environment. Such interchanges are needed to develop their intellect. The investigator is convinced that, if hearing defects can be identified early in infancy and appropriate remedial measures initiated (e. g. , hearing aids), many youngsters can be prevented from becoming functional mental retardates. The investigator has developed instrumentation to provide averaged EEG signals during periods of auditory stimulation, which quite effectively reflect whether a child hears when such stimuli is administered. The greatest difficulty is in securely affixing the EEG electrodes to the infant's or young child's head. They tend to tug at the electrodes and frequently yank them off, disrupting the screening procedure. What is needed is an instrumented helmet, with EEG electrodes



in place. A helmet, particularly if equipped with earphones for administering the auditory signal, would substantially assist in identifying hearing defects in young children who cannot verbally communicate information regarding whether -- and to what degree -- they hear an auditory stimulus.

NASA has developed a helmet system for broadcasting electroencephalograms of the wearer. The unique electrodes involved, if incorporated into an audio helmet fitting infants and small children, would provide a means for accurately testing the hearing of infants and small children who are unable to verbalize a response regarding whether or not they heard an acoustically presented stimulus. For this reason, the problem was nominated as a candidate for applications engineering. Several helmets have been fabricated as part of the team's applications engineering effort.

SWC-2: Instrument for Measurement of Evoked  
Cortical Response by Aural Stimulation

Many infants and preschool children exhibit characteristic symptoms of retardation and many of these are diagnosed as suffering brain damage while their only problem is that they are deaf or hard of hearing. Since infants and small children do not respond well to standard hearing tests either because of an inability to speak or accurately orally respond to testing, more accurate methods are required which will enable the doctor to determine if there is indeed brain damage or a hearing defect. Properly diagnosed, treatment can be administered more concisely and deaf children can be brought to the intellectual level of their peers rather than being classified as retarded during the most important formative years, 1 to 6.

The problem originator and his assistants have built up an instrument which illustrates the feasibility of such an approach to check for hearing defects in infants or children, but have encountered problems that involve so much attention that reliable data are difficult to attain.

Electrode and earphone attachment with infants and small children is difficult because of their tendency to knock them off. The proposed solution involves a modified football or baseball helmet which is described in problem SWC-1 and will be incorporated into the final system.

Electrode noise and cabling problems compound the first stage noise level of their biopotential amplifier. This problem has been solved.

Other problem areas in the design of the instrument in operation include that: (1) the unit is made up of cumbersome subassemblies which require much switching, knob twisting, and cabling, requiring the involvement of at least two people to set up, (2) the problem originator would like to vary the rise time of the tone burst as per the specification sheet which he is now not able to do with his existing circuitry.

To provide an effective screening instrument for the use described above, the team proposed applications engineering to reduce the size, weight, and improve operational characteristics of the investigators' system. It was felt that NASA developments in circuitry could produce a system which was portable so as to optimize its use as a mass screening device. The system is being developed at Marshall Space Flight Center.

#### SWC-12: Detection of Eye Tumors by Use of Radiation Probes

This problem involves the need for a biocompatible, highly sensitive probe to detect concentrations of weak beta radiation from an isotope (P-32) which is administered to patients who are suspected of having eye tumors and which is selectively absorbed (uptake) by tumor cells. Present monitoring is accomplished by inserting a miniature geiger probe between the eyeball and the eye socket to various quadrants for linear measurements of energy transfer on a linear accelerator. The monitoring of the different energy levels is necessary to detect tumors which are hidden from direct observation or are in such early stages of development that they cannot readily be identified by other means. The present probe is excessively large in dimensions and is insufficiently sensitive to the radiation levels which are encountered.

NASA Tech Brief 66-10252 describes an innovation which will solve this important problem after modest applications engineering. This resulted from NASA's need for a reliable miniaturized radiation dosimeter providing biomedical application in vivo. External dosimetry is applicable in this sense because it can be inserted into a body orifice for direct contact with the organ which is suspected of having cells with higher levels of radiation that differentiate them from other cells in that organ. The capability to identify the cells is only part of the measurement since the positioning of the probe also will permit evaluation of the location and extent of any suspected tumor in the eyeball.

The advantages of using such solid state radiation probes mounted for insertion between the eyeball and eye socket are that the data to be obtained can be observed at the input and output points of interest and they provide a larger number of data points to be obtained because of the method of making the measurement.

Multiple mounting of the probe into a sensing device that monitors selected areas in various quadrants of the eye socket, will provide a range of linear energy transfer which can be readily interpreted on a linear accelerator.

From the data points gathered at the multiple locations, the difference of P-32 concentration in the various positions is easily derived. The difference of P-32 concentration can then be used to identify and outline the area of increased uptake by suspected tumor cells if and when they are present. This information will be used for diagnosis, treatment and evaluation of treatment of the eye involved.

Since use of the above concept is superior to the methodology and equipment being used by the investigator, the team undertook fabrication of a probe as part of its applications engineering effort. The probe will be smaller than the probe in use. It is anticipated that the NASA probe will be capable of providing better than the desired 10% detection of 1.71 MEV (average about 0.7 MEV) of energy from beta radiation of P-32.

## VI. CONCLUSIONS AND RECOMMENDATIONS

### Increased Personal Interaction by Team Members and Problem Originators with NASA Engineers and Scientists

One of the greatest difficulties encountered by the Southwest Research Institute Biomedical Applications Team during its five years of operation centers upon the inability to elicit a desirable level of participation by NASA engineers and scientists in solving the problems identified via team interaction with the biomedical community. A variety of techniques have been employed to more effectively tap this valuable source of technology, e. g. , preparation of elaborate problem statements utilizing the suggestions of NASA consultant Dr. William A. Clingman and placing summaries of problems on tables in cafeterias located at NASA research centers. However, none of these "motivational" endeavors has served to produce the extent of interaction considered necessary to optimize the technology application process. The team has concluded that the only effective alternative is to encourage increased direct contact between NASA resource personnel, team members, and problem originators -- on a face-to-face basis where possible. This approach is being undertaken on an experimental basis for a number of potentially high impact problems, such as the EEG audiometry system being developed at Marshall Space Flight Center and flexible electrode applications at Ames Research Center.

### Obtaining Increased Participation in the Program by the Clinician/Practitioner

It is becoming increasingly apparent to the team that some of the most meaningful kinds of problems in terms of impact upon improving the delivery of health services may well result not from interaction with the relatively isolated medical researcher, but from the clinician or practitioner who daily faces the increasing demand for health services that the country is now experiencing. Therefore, the team has undertaken limited interaction on an experimental basis with clinician/practitioners with a view of attempting to meet some of the pressing needs they face. To acquaint this category of potential users with the purposes and aims of the Biomedical Applications Program, the Team anticipates development of a suitable static display which will be provided local medical societies in areas of team operation, accompanied by informational brochures and prepaid self-addressed inquiry cards. This will be approached on an experimental basis to evaluate its effectiveness in stimulating the clinician/

practitioner to work with the team in defining significant problems which bear upon developing capabilities to provide improved health services to all segments of the nation's population.

Facilitating Increased Industry Interest in Using NASA-Related Technology to Solve Team-Identified Problems

In addition to the above techniques designed to foster the identification and application of aerospace technology, the team proposes to accelerate its efforts to assure that executives and technical professionals in private industry are maximally exposed to the benefits that their organizations can derive from the utilization of NASA-generated technology -- particularly in terms of meeting those biomedical needs identified by the problem originators. The recent endeavor undertaken by the Research Triangle Institute Biomedical Applications Team in organizing the Aerospace Standards Subcommittee at the Sixth Annual Meeting of the Association for the Advancement of Medical Instrumentation constitutes a valuable first step in assuring greater interplay between industry and the technology utilization program. Increased participation by industry in helping use aerospace technology to solve the team-identified problems would serve to lessen requirements for extensive NASA applications engineering support in rendering aerospace technology applicable for solving submitted biomedical problems. This in turn would permit the limited resources which are made available for applications engineering assistance to be directed towards modifications of those aspects of aerospace technology which hold the promise of meeting significant needs, but which for one reason or another fail to be picked up by private industry.

APPENDIX A  
PROJECT ACTIVITY SUMMARY

## TRANSFERS ACCOMPLISHED

<u>Problem Number</u>	<u>Problem Title</u>
CLA-1	Newborn Infant Respiration Monitor and Apnea Alarm
CMR-2	Call Signal for Quadriplegic Patients
DLM-4	Doppler Probe Holder and Stand for Use in Chronic Fetal Circulation Monitoring
GLM-32	Signal Conditioner to Record and Playback Electrocardiogram Via Inexpensive Hometype Tape Recorders
GLM-33	DC Powered Proportional Temperature Controller
SAV-1	Assist Device for Totally Paralyzed Patients
SWC-1	Improved Techniques for Taking EEG in Infants and Small Children

## POTENTIAL TECHNOLOGY TRANSFERS

<u>Problem Number</u>	<u>Problem Title</u>
BLM-11	On-Line Analysis of Biochemical Samples Collected Automatically from Patients
BLM-11a	On-Line Analysis of Biochemical Samples Collected Automatically from Patients
BLM-13	Nonthrombogenic Material for Use as a Blood Interface
BMC-3	Dark Room Measurement of Eye Pupil Size
DLM-6	Measurement of Respiration Parameters of Cardiovascular Patients
DVM-4	Automatic Atraumatic Blood Pressure Measurements
GLM-35	Beta Radiation Catheter Probe
GLM-36	An Objective Measure of Human Motor Activity
HSR-1	Impression Material for Making Pattern of the Lower Trunk
HSR-2	Resilient, Breathing Contour Seat Material
HSR-3	Padding Material for Orthotic Devices
HSR-6	Sight-Switch Operated Prehension Device
NWR-5	Numerical Methods for Solutions to Wave Equations in Layered Media of Arbitrary Cross Section
RNV-14	Materials for Prevention of New Decubitus Ulcers
RNV-28	Accelerometer for Human Motion Studies
RNV-34	Pressure Sensitive Device for Use in Tongue Operated Control Systems for Assist Devices and Wheelchairs
RRC-5	On-Line Fabrication of Orthotic Support Devices
SJH-1	Interfacing Biochemical Autoanalyzers with a Computer
SNM-4	Improved Techniques for Measurement of Skin Thickness
SNM-5	Implantable Telemetry System for ECG



Problem  
Number

Problem Title

SWC-2	EEG Audiometric System for Use with Infants and Small Children
SWC-4	Information Retrieval System for Clinical Records
SWC-12	Detection of Eye Tumors by Use of Radiation Probes
UTM-7	Chronic Electrode Implantation Techniques for Artificial Eye Research
UTM-9	Tidal Volume Measurements in Respiration Studies

CURRENTLY ACTIVE PROBLEMS AS OF  
28 FEBRUARY 1971

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
AVA-1	B	Chest Wall Movement Transducer for ECG Measurement
AVA-2	B	Carotid Artery Pressure Waveform Measurement
BLM-10	D	Computer Programs and Systems for Analysis of the ECG
BLM-12	F	Flexible Material For Connecting Electrical Stimuli to Nerves Without Damage
BLM-13	E	Nonthrombogenic Material For Use as a Blood Interface
BLM-14	E	A Compound Conduit for Chronically Surviving Animals
BLM-15	D	Location of Na Ions in Living Skeletal Muscle Fibers and Other Cells
BLM-16	C	Measurement of Electrolyte Concentrations in Renal Medulla and Papilla
BLM-17	B	Improved Procedure to Measure Regional Blood Flow in Kidney
BLM-21	C	Artificial Membrane Interface
BLM-22	B	Expired Oxygen Analysis
BLM-23	C	Germ Free Hamster Colony
BLM-24	C	X-Ray Exposure and Gravitational Effects on Body Functions
BLM-25	B	Simple Economical Mass Screening Techniques for Analysis of EKG in Clinical Diagnosis and Multiphasic Health Screening
BMC-1	B	Attraction-Movement of Non-Magnetic Material
BMC-2	B	Measurement of Out-Of-Parallel Tracking of Eye
BMC-3	E	Dark Room Measurement of Eye Pupil Size

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
BVA-1	D	X-Ray Transparent Electrodes and Leads
BVA-3	B	Attachment Techniques for ECG Electrodes
BVA-4	B	Portable ECG Telemetry Receiver and Chart
CAP-3	F	Non-Computerized Reduction of Data Recorded via Conventional Polygraph Techniques
CHS-1	B	Environment Awareness System for Deaf-Blind
CHS-2	B	Automatic Wall/Barrier Seeking Guide Assist Device
CHS-3	B	Multiple Electrode Stimulation of the Cochlea
CHS-4	B	Multiple Microwave Surface
CHS-5	B	Flexible Interface with Auditory Brain Centers
CHS-6	B	Acoustic Analyser for Auditory Configuration
CHS-7	B	Auditory Center Brain Implant Electrode
CHS-8	B	Improved Hearing Aid Amplifier
CHS-9	B	Hearing Aid Tester
CHS-10	B	Hearing Aid Malfunction System
CHS-11	B	Artificial Eye Lens
CHS-12	B	Dipole System Auditory Multichannel Stimulation of the Brain
CLA-1	E	Newborn Infant Respiratory Monitor and Apnea Alarm
CLA-2	B	Measure of Blood Flow Direction and Velocity by Ultrasonic Techniques
CMH-1	B	Biochemical Differentiation of Schizophrenics
CMR-1	B	Improved Method for Managing Body Wastes of Colostomy Patients
CMR-2	E	Call Signal for Quadriplegic Patients

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
DEF-2	D	Ophthalmology Mapping by Pulse Echo Techniques
DLM-5	D	Measurement of Fetal Circulation from Trans-cutaneous Transducers
DLM-9	C	Aerial Image-Fiber Optics Interface
DLM-14	C	Detection of Kidney Stones During Surgery
DVA-1/2	D	Automated Techniques for Administration and Analysis of Diagnostic and Therapeutic Psychological Tests
DVA-3	D	System to Monitor and Record Human Blood Pressure
FTZ-1	B	On-Line Breath Analyzer
FTZ-2	B	Invasive Means for Measuring Blood Gases
GLM-23	D	Determination of Attractive Forces Between Red Blood Cells
GLM-30	C	Electrical Model for Transmission of Information Within a Single Cell
GLM-31	D	Electrodes for Esophageal Speech Improvement
GLM-32	E	Signal Conditioner to Permit ECG to be Recorded and Played Back via Inexpensive Home-type Tape Recorders
GLM-33	E	D. C. Operated Proportional Temperature Controller for Use in Pollutant Studies
GLM-34	B	Protective Coating of Precision Optical Instruments to Prevent Corrosion
GLM-35	E	Beta Radiation Catheter Probe
GLM-36	E	An Objective Measure of Human Motor Activity
GLM-37	B	Activity Telemetry from Single Neurons in Aquatic Animals
GVA-5	B	Computer Analysis of ECG Waveshapes

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
GVA-6	B	Respiration Monitor
HMH-1	B	Ultrasound Mapping of Heart Walls
HPH-1	D	Particle Detector Monitor for Clean Room Surgery
HPH-2	D	Exhaled Air Exhaust System for Clean Room Surgery
HSR-1	E	Impression Material for Making Pattern of Lower Trunk
HSR-2	E	Resilient, Breathing Contour Seat Material
HSR-3	E	Padding Material for Orthotic Devices
HSR-6	E	Sight Switch Operated Prehension Device
HUV-20	B	Perceptual Motor Testing of the Severely Disabled
JVA-1	B	Fluorometry Test Sample Temperature Regulation
LLU-5	D	Method for Taking Repeated Biopsies of Soft Tissue Through a Single Portal in Cancer Detection and Treatment
LLU-6	D	Non-Invasive Minimal Encumbrance Methods for Acquisition of Physiological Data for Improved Surgical Procedures
LLU-7	C	An Adjustable Histamine Aerosol Generator for Air Pollution Studies
LLU-8	D	Methods for In-Flight Tracking of Medically Significant Insects
LLU-9	B	A Simple and Economical Method for Oxygen Isotope Tracing in Lipid Peroxidase In Vitro and In Vivo
LLU-10	B	Non-Invasive Techniques for Measuring Oxygen Content in Blood
LVA-2	D	Methods for Neurological Data Handling
LVA-3	D	Radioactive Microcell Counting Techniques for Diagnosis and Treatment of Leukemic Disorders

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
LVA-4	D	Research Facility Design and Planning
LVA-5	D	Device for Weighing Laboratory Rats
LVA-6	D	Method for Measuring Temperature of Laboratory Rats in Isolation Chambers
LVA-7	D	Method for Acquiring ECG Information from Laboratory Rats in Isolation Chambers
NMA-1	B	Program to Establish Electrical Safety Standards for Equipment and Instruments Used Around Patients
NMA-2	D	Coiled Transducer Cables for Rough Environmental Use
NMA-3	B	ECG Cable Take-Ups for a Portable ECG Monitor in an Intensive Care Unit
NMA-5	B	Cable Crimping on Simmons Bed
NMA-6	B	A Demand Water Level Float for Nebulizer in Inhalation Therapy
NMA-7	B	Ultrasonic Catheter Transducer for Pulse Echo Measurements in Cancer Research
NMA-8	B	Ultrasonic Techniques to Support Radiological Therapy in Cancer Research
NMA-10	D	Video Tape Programming for Speech Therapy
NMA-11	D	Computer Programmed Testing and Teaching in Speech Therapy
NMA-12	B	Sauna Bath Conditions Monitoring
NWR-5	D	Numerical Methods for Solutions to Wave Equations in Layered Media of Arbitrary Cross Section
OVA-2	D	Measurement of Lung Compliance
OVA-4	E	Assessing Sleep Psychophysiology in Extreme Environments
PVA-1	D	Cellular Aging Caused by Ionizing Radiation, Weightlessness and Exotic Cases

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
PVA-2	D	Capabilities for Characterizing New Compounds Deprived from Tumors
PVA-3	D	EEG Analysis Computer Programs
PVA-4	B	EEG Electrode Holders
PVA-5	D	Low Noise EEG Preamplifiers for Clinical Research
PVA-6	B	Band Pass Filtering for EEG Alpha Signals
RNV-14	D	Cushions for Spinal Cord Injury Patients
RNV-21	C	A Wireless Synchronization Link
RNV-23	D	Analysis of Body Motions
RNV-26	D	Angle Measurement in Knee Prosthetics
RNV-28	F	Accelerometer for Human Motion Studies
RNV-29	C	Manual Controls for Self-Propelled Vehicle (Wheelchair; Automobile)
RNV-31	C	Patient Supporting Couches
RNV-32	D	Measurement of Energy Expended in Walking
RNV-34	D	Pressure Sensitive Device for Use in Tongue Operated Control Systems for Artificial Organs and Wheelchairs
ROS-1	B	Constant Velocity Vehicle for Small Laboratory
ROS-2	B	Method for Measuring Blood Gas Without Breaking the Skin
RRC-1	B	High Energy Cost Exerciser with Ergometric Monitor
RRC-2	E	Accurate Cardiac Telemetry from Active Subjects
RRC-3	B	Self-Locking Knee Joint Brace
RRC-5	E	On-Line Fabrication of Orthotic Support Devices
RRC-6	B	Lightweight, Portable Cushion Seat Jack for Weak or Paralyzed Patients

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
RRC-7	B	Oscilloscope Synchronization for Electromyographic Needle Manipulation
RRC-8	B	Ultra Thin Electromyographic Needles
SAV-1	E	Assist Device for Totally Paralyzed Patients
SJH-1	E	Interfacing Biochemical Autoanalyzers with a Computer
SJH-2	D	Interface Schematics for Incorporation of Biochemical Autoanalyzers to a Computer
SNM-4	C	Device for Obtaining Precision Measurements of Skin Thickness
SNM-9	D	Chemical Analysis of Biological Molecules Utilizing X-Ray Fluorescent Techniques
SNM-12	D	Measurement of Uterine Artery Dimensions
SNM-13	D	Miniature pH Electrode for Fetus
SNM-14	D	Fetal ECG Telemetry
SNM-15	D	Uterine Pressure Telemetry
SNM-19	A	Computer Based Health Records Systems Development
SNM-20	B	Immunology Mechanisms for Health and Disease
SNM-21	B	Effective Learner Communications
SNM-22	B	Biological Concomitants of Unusual Environments
SNM-23	B	Ecology and Medicine
SRS-8A	F	Acquisition and Telemetry of Heart Rate, Blood Pressure, and Blood Flow in Free-Ranging Dogs
SRS-8B	F	Methods of Signal Categorization
SRS-9	B	Electromagnetic and Ultrasonic Doppler Blood Flow Velocity Measurement Methods
SWC-1	F	Improved Techniques for Taking EEG in Infants and Small Children



<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
SWC-2	D	Cortical Audiometry Measurements
SWC-3	B	Differentiation Between Normal and Abnormal (Tumor) Tissues by Ophthalmometric Techniques
SWC-4	D	Information Retrieval System for Clinical Records
SWC-6	B	Apparatus for Micropuncture of Pancreatic Gland
SWC-7	D	Improved Scan Resolution of Radio-Isotope Filled Organs
SWC-8	B	Improved Method for Computing X-Ray Dosage
SWC-11	B	Determination of the Dispersion of Energy Distribution of Electron Particles at the Cell Level
SWC-12	E	Detection of Eye Tumors by Use of Radiation Probes
TAM-1	B	Direct Skeletal Attachment of Prosthetic Devices
TAM-2	B	Synthesis of High Protein Food from Raw Materials
TCH-1	B	Quantification of Biochemical Changes in Striated Muscle Due to Inactivity
TCM	B	Peak Detector for Signal Conditioning of Blood in Basic Medical Research
UAM-1	D	Capacitative ECG Electrodes
UAM-2	D	Heart Sounds Telemetry
UAM-3	B	Implantation Techniques for Chronic Measurements of Physiological Data
UAM-5	B	Study of Cell Fluorescence by TV under Low Light Intensity Conditions
UAM-7	B	Xenon Gas Disposal
UAM-8	D	Electrical Safety for Hospital Patients
UAM-9	B	Mossbauer Effects Applied to Measure Blood Flow Rates
UAM-10	B	Design for New College of Medicine Hospital

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
UAM-11	B	Ultra Low Frequency Band Pass Amplifier
UAM-12	B	Cardiovascular Dynamics Models
UFM-1	D	Method for Determination of Maximum Stress in Long Bones
UFM-2	D	Determination of Interfacing Properties of Specific Ceramic Material to Bone
UFM-6	D	Xeroradiography of Mammary Glands for Cancer Detection and Multiphasic Health Screening
UFM-7	D	Methods for Computer Analysis of EEG for Health Care Cost Reduction
ULA-1	D	Orthopedic Surgery Clean Room, Laminar Air Flow Technology
USC-2	D	Skin Elasticity Measurement
USC-3	C	Patient/Specimen Identification Method
USC-4	D	Method for Measuring Rate of Change in Physiologic Data
USC-6	C	Non-Ocular Methods for Monitoring Vestibular Function
USC-7	D	A Method for Measuring Angular Rotation of the Eye
USC-8	D	Methods for Organizing and Analyzing Nystagmographic Data
USC-9	D	Methods for Obtaining Otological Response in Experimental Animals
USC-10	D	Non-Surgical Methods for Treating the Inner Ear
USC-11	B	An Implantable Bone Pressure Transducer
UTM-1	D	Physiologic Data Handling-Systems Approach
UTM-7	D	Chronic Electrode Implantation Technique for Artificial Eye Research

<u>Problem Number</u>	<u>Status Code</u>	<u>Problem Title</u>
UTM-21	B	Animal Passage Direction Sensing
UTM-22	B	Electric Controller Pressure Regulator
UTM-23	B	Servo Valve for Blood Pressure Waveform System
UTM-24	C	Photo-Etched Form to Cast Artificial Kidney Matrix
UTM-25	B	Ionizing Radiation Detection of Thrombogenesis
UTM-26	B	On-Line Blood Gas Measurements in Respiratory Exchange
UTM-27	B	Miniature Mosaic TV Camera
UTM-28	B	Flexible Substrata for Solid State Circuitry
UTP-1	B	Continuous Blood Gas Analysis for Accident Victims
UTP-2	B	Continuous EEG Monitor
UTP-3	B	Measurement of Body Heat Loss
UTP-4	B	High G-Forces Effect on Blood Gas Exchange
WVA-1	D	Suitable Fluid for Foot Pressure Indicating Device
WVA-2	D	Electrodes for Measuring Tooth Potentials

APPENDIX B

ACTIVE PROBLEMS ACCORDING TO  
HEALTH AREAS

## MULTIPHASIC HEALTH SCREENING AND CLINICAL DIAGNOSIS

### BLM-25: Simple Economical Mass Screening Techniques for Analysis of ECG in Clinical Diagnosis and Multiphasic Health Screening

The researcher at a southwest medical institution requires an inexpensive technique for detecting latent heart disease by automatic analysis directly from the patient's heart electric signal (ECG). This will permit implementation of a large-scale, multiphasic health screening program. The method and device must be economical, reasonably portable, adaptable to a minimum number of trained staff personnel, and reliable for mass screening procedures. The NASA real-time analysis of astronaut and spacecraft functions technology may perform ideally in this application.

Available NASA technology is currently being evaluated and application of aerospace technology is likely. NASA-developed EKG mass screening instrumentation is available through the Humetrics Corporation.

### UFM-7: Computer Analysis of the EEG

Researchers at a hospital are attempting to mass screen patients as a community service to determine which patients require further medical attention and identify needed medical help areas for each patient. Computer analysis of EEG recordings is desired to reduce costs and increase speed.

NASA-developed technology for processing medical information was provided to the problem originator. A medical information systems seminar to introduce and demonstrate NASA systems was held at the Manned Spacecraft Center in July of 1970. Technology developments were included in the presentation pertinent to the researcher's problem.

### SWC-1: Improved Techniques for Taking EEG in Infants and Small Children

Investigators at a southwest hospital are perfecting a technique for using EEG to test hearing of infants and small children. Thousands of children have been classified as mentally retarded when their problem has been a hearing difficulty. The hearing abnormality cut them off from the auditory interchanges required to develop the intellect. The investigators believe they can identify hearing defects early in infancy and apply appropriate

remedial measures (hearing aids) to prevent many youngsters from becoming functional mental retardates. An EEG-electrode instrumented helmet has been equipped with earphones to administer the auditory signal, and substantially will assist in identifying hearing defects in individuals who cannot verbally communicate whether they can hear an auditory stimulus.

A NASA-developed device has been modified to answer requirements of this problem. The problem was submitted to NASA as a candidate for applications engineering. Technology described in NASA Tech Brief 66-10536 and USAF Publication ARL-TR-69-17-6571 provided the basis for the reengineering effort, which was accomplished as part of our "in-house" applications engineering effort. For details see Section V of this report.

### SWC-2: Cortical Audiometry Measurements

Infants and preschool children may exhibit characteristic retardation symptoms. Many of them have been diagnosed as suffering from brain damage when their problem is deafness or a hearing defect. Infants and small children are unable to accurately speak or respond to ordinary hearing tests. Accurate methods are needed for the doctor to determine if there is a hearing defect or if indeed there is brain damage. Concise, properly diagnosed treatment can be administered to bring deaf children to the intellectual level of their peers during years 1 to 6, the most formative years.

The researchers have constructed a device illustrating the feasibility of discovering hearing defects in infants and young children. Problems encountered with the current system require so much attention that reliable data are difficult to obtain. Electrode and earphone attachments are difficult to maintain because the youngsters tend to knock them off. The proposed solution is described in Problem SWC-1 and involves incorporating a modified football or baseball type helmet into the final system. Electrode noise and cabling problems compound the first stage noise level of their biopotential amplifier. Problem SWC-9 provided a solution to this problem. There are other problem areas in the design for the instrument in operation. The unit is composed of cumbersome subassemblies. They require much switching, knob twisting, and cabling. At least 2 people are involved in setting up the unit. The problem originator prefers to vary the rise time of the tone burst as indicated in a specification sheet. The existing circuitry does not permit this. Arrangements have been made with researchers at Marshall Space Flight Center to design and build a compact audiometry system to solve the problem.

LLU-9: A Simple and Economical Method for Oxygen Isotope Tracing  
in Lipid Peroxidase In Vitro and In Vivo

A simple and economical method for oxygen isotope tracing in lipid peroxidase in vitro and in vivo is needed.

Oxygen-18 is a non-radioactive tracer. It can be expected to figure in almost as many tracer reactions as do carbon and hydrogen. There is a major disadvantage to the use of oxygen tracing for lipids because biochemical processes are usually accomplished in a water environment. Enzyme action frequently increases the in vitro rate of exchange in a given reaction. For example the exchange of oxygen between the carboxyl and fatty acids and water at neutral pH is catalyzed by the enzyme acetylcholinesterase. Peroxidase is an oxidizing and reducing enzyme and in the absence of oxygen peroxidation does not occur.

A computerized search of aerospace literature has been done. Results were forwarded to the problem originators who are presently evaluating their applicability to the problem.

DLM-9: Aerial Image Fiber Optics

The problem is part of a program to develop a more accurate, rapid, and comfortable method of examining the posterior, inner part of the eye (fundus oculi). This is the portion of the eye as seen through the dilated pupil. The program intends to serve three functions: patient examination, improved patient records, and medical teaching. Research and development is directed toward projecting the desired image upon a screen. This provides simultaneous viewing by consultant specialists as well as medical students. A conventional motion picture screen or TV monitor could be used for the projection. An "interface" unit from the aerial image to fiber optic cable also is needed. The interfacing unit must be relatively small in size to carry an image as seen through the pupil of the eye.

A NASA Data Bank search retrieved relevant literature. This literature and additional articles on optical systems were sent to the problem originator. Response is needed from the problem originator before the team can direct further technology applications efforts.

BLM-10: Computer Programs and Systems for Analysis of the  
Electrocardiogram

Identification of existing computer programs which provide automatic diagnostic interpretation of the electrocardiogram is needed. Portions of these programs are intended for adaptation to a small computer system, to provide multiphasic health screening in multiple testing of large numbers of subjects. It should be economically feasible for clinical use.

Results of a NASA Data Bank search were forwarded to the problem originator. Information obtained about a device developed at Mount Sinai Hospital in Cleveland, Ohio, was forwarded for evaluation by the problem originator. A Medical Problem Statement was approved by NASA for dissemination to the NASA research centers. Several responses were received. NASA Tech Brief B69-10720 on Biomedical Bulk Data was forwarded to the team by Mr. Clint Johnson, Flight Research Center, Edwards Air Force Base, California. Mr. Lee DeGoff, TUO, Kennedy Space Center, also sent information about work being done at Manned Spacecraft Center on the vectorcardiogram-analysis project phase of the Apollo Applications Program which might be closely related to the problem. Mr. Juan Pizarro II, NASA Marshall Space Flight Center, provided useful information. All of this material was furnished for evaluation to the problem originator. A new application of aerospace technology may result from these efforts.

#### GLM-32: ECG Preamplifier for Home Tape Recorder in Clinical Diagnosis

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A southwest researcher needs a preamplifier to interface an ECG from patients to a home or office type of tape recorder. The instrumentation would be used to monitor the electrocardiogram of a patient functioning in a home or office environment. The preamplifier should have a frequency response from 0 to 100 Hz, a low noise figure and capabilities for a-c or battery power. It also should be adaptable for use with a strain gauge transducer. This system should immensely facilitate acquisition, storage, and editing of biological data, and also it will increase outpatient clinical follow-up capabilities.

Relevant technology was identified and the Southwest Research Institute BATeam engineers fabricated a device which met problem requirements and was also economical. See Section II of this report for details.



## REHABILITATION MEDICINE

### CHS-10: Hearing Aid Malfunction Alarm System

The extremely fragile nature of the hearing aids for the very young deaf or deaf-blind children makes them subject to malfunction due to the hard usage factor. These children cannot readily communicate and their habilitation is primarily based upon retention and amplification of available residual sensory physiology that is present. The hearing aids need to work for this habilitation to be most effective. A schedule of screening and rather crude testing is the only apparent solution presently available.

A miniature alarm system to give warning of any malfunctioning within the hearing aid of deaf or deaf-blind children is needed. The device should either sound or flash an alarm to alert the therapist of any malfunction in the amplification, the breakage of lead wire, or if possible also the distortion in quality of sound. The system should be miniature to be accommodating to the size and use of present hearing aid configurations and wearing constraints. It is essential for hearing aid devices to be in working condition to provide a basis for learning in a difficult environment for the child.

A search has been initiated on the problem. Results were forwarded for evaluation by the researcher. A Medical Problem Statement will be prepared to disseminate to various NASA research centers.

### CHS-1: Environment Awareness System for Deaf-Blind

A system is needed which is capable of repeatedly and gently reminding a deaf-blind child of the existence of an outside environment. The problem originator is directly involved with habilitation of blind and deaf-blind children. Such children are isolated from the world of sight and sound which is responsible for creating awareness of self or self/environment. Unless they are held or touched, outside environment ceases. They usually are malnourished because food has no meaning and they lose interest.

The system should be relatively rythmical and varied. It should be gentle and repeated. It should avoid any stimuli which would startle the child, since these children are easily startled and usually have no response other than to scream.

A search has been initiated on the problem. It is being considered as a candidate for dissemination to NASA research centers.

#### CHS-2: Automatic Wall/Barrier Seeking Guide Assist Device

A guidance assist device is needed for deaf-blind children to automatically seek and guide toward a wall or barrier in environment orientation.

The investigator is directly involved with habilitation of deaf-blind children. A great deal of therapist time is required to repeatedly direct and control the child as he walks toward and along a wall or other barrier restraint in developing awareness of environment orientation. If technology could be made available to provide a degree of controlled guidance, learning could be expedited and better use made of available therapists. The guidance should be gentle but firm and consistent in response. It should tend to guide the child toward the wall/barrier and then guide him along it as the child feels with arm and hand movements as he walks and identifies the wall and the wall corner, etc. A relatively large number of these children are the product of the mother contracting Rubella in the first trimester of pregnancy and represent a compelling social responsibility for their care and habilitation.

A search of aerospace and medical literature has been initiated for this problem. Results were forwarded to the researchers for their comments on applicable technology. The problem is a candidate for dissemination to NASA centers.

#### CHS-4: Multiple Microwave Surface

Technological methodology and device to precisely pattern a multiple, microwave surface for telemetry of speech configurations is needed. The problem originator is attempting to devise a means to effectively telemeter speech configurations from a microwave source with an antenna array focused on the cochlea. The array is external to the head. This is to be used to provide hearing to those who are legally deaf or deaf-blind. The microwaves are intended to be delivered to separate areas located within the cochlea of the inner ear for pickup. Instrumentation must be safe for use with humans. Patterns of microwave stimulation will have to be studied experimentally to determine optimal methods of transmitting speech information.

A computerized search of aerospace literature has been done. Results are being evaluated by the problem originator.

#### CHS-5: Flexible Interface with Auditory Brain Centers

Technological methodology and device for a flexible substrate and potting for solid state circuitry to be implanted in the brain is needed. The problem

originator is one of a group who is researching to develop a means for stimulating the auditory centers of the human brain to provide an alternate means for hearing when inner ear anomalies, injuries or nerve damage prevents normal hearing. Electrodes have been implanted within the auditory centers of a cat in parallel studies of hearing stimulation. The substrate and potting needed for the solid state circuitry implantation will be used to present a variety of waveforms telemetered from an artificial ear. Material must be biocompatible with brain tissue and fluids; it must be safe for use within the brain of humans; and it must be flexible to respond to the vibratory motions of the active, living brain to avoid tissue damage or irritation. This material should accept mounting of solid state circuitry.

A search has been initiated to retrieve references to potentially applicable materials. A response from a NASA research center brought attention to newly developed silicone-baked flexible circuitry which may solve the problem.

#### CHS-6: Acoustic Analyzer for Auditory Configuration

An acoustic analyzer for use in conjunction with a black box processor to separate auditory stimuli into electrical patterns is needed.

Large numbers of deaf and deaf-blind persons cannot be assisted by conventional hearing aids to discriminate auditory stimuli. The investigator is attempting to provide stimuli to multiple (20-30) electrodes inserted within the reception area of the cochlea of the human inner ear. A chopping microphone system is already in use to deliver pulses into a single wire. Speech can be differentiated with it as compared to music, and music differentiated from a doorslam as crude measurements. The analyzer should deliver electric pulses to different electrodes according to the analysis of the sound by the black box processor. This may minimize the necessity of relearning hearing patterns in instances used other than with congenitally deaf.

A search has been initiated on the problem. Results have been forwarded to the problem originator for evaluation.

#### CHS-8: Improved Hearing Aid Amplifier

All types of hearing aids available for use in habilitation of deaf or deaf-blind children have a poor frequency response range when used with an earplug. There is only small improvement when the headset is substituted for the earplug. The problem appears to be mainly poor amplification between the FM loop and the receiving instrument -- a poor instrument with a defective mechanism. Commercial attempts seem to solve this problem with more expensive equipment having the same characteristics.

The equipment should be oriented for use with children rather than adults. Flimsy wiring attachments between the amplifier and the earplug have proved to be extremely fragile, to the extent that it is practically impossible to tell whether or not it is operable from one minute to the next. Improved amplification between an FM loop and a hearing aid for use by deaf or deaf-blind persons in learning situations is needed.

A search has been initiated on the problem. In addition, the problem is a candidate for dissemination to NASA research centers.

#### SAV-1: Assist Device for Totally Paralyzed (Quadriplegic) Patients

As a result of the Viet Nam war, the Veterans Administration has an increasing number of veterans who are totally paralyzed -- many without even the ability to move a single finger. Such patients must of necessity depend upon others for everything that is done for them -- from feeding and bathing to turning off the lights when they wish to sleep. Rendering the matter even more difficult is the fact that such patients -- having no control of their appendages -- cannot even activate the call system to summon the nurse or attendant for assistance when needed. The result for those who survive (many quadriplegics do not remain alive for extended periods) is an unending succession of long hours at the complete mercy of others. The Veterans Administration had placed such a survivor in a nursing home in San Antonio. This veteran was quite unusual in that, despite his affliction, he remained exceedingly alert and desperately wanted to be able to do something during the long hours he faced each day, besides watch the television set someone may have turned on for him -- and whose channel selector he could not operate in case he didn't happen to care for the program. He wanted to be able to read books and magazines, to turn the television set or his radio on or off, change stations, turn his room lights on and off, and call the nurse or attendant when he needed help. The local Veterans Administration office, learning of the SwRI BATeam's existence and interest in rehabilitation via a presentation made earlier at a state-wide rehabilitation medicine conference, asked for assistance in meeting the problem outlined.

The assist device must be operable without use of either arms or legs since the patient is completely paralyzed. Either an intra-oral or eye-operated mechanism could be used. The device proposed must be economical since many such patients are in nursing homes where only limited funds are available to procure such ancillary equipment.

The NASA-developed sight switch solved the problem. For further description see Section II of this report.

#### HSR-6: Sight Switch Operated Prehension Device

A simple, easy to operate, all-or-nothing, on-off switch is needed to operate a prehension device by a directed eye movement. The problem originator is one of a group providing care and treatment for paralyzed or amputee patients in habilitation and rehabilitation activities. Prehension devices have been developed to allow the patient capabilities for mobility and self-care. They require movements of the shoulder or torso musculature to control positioning and/or degree of pressure in prehension movements by an assist device. A simple, eye-movement controlled switch is felt to be the ideal answer to this problem.

NASA technology is available to solve this problem. An infrared eye switch developed to allow astronauts under high acceleration forces to manipulate control devices is applicable to the solution of the problem. This technology is presently being evaluated.

#### HUV-20: Perceptual-Motor Testing of the Severely Disabled

The problem originators need methodology or devices to objectively measure the upper extremity capabilities of patients having varying levels of spinal lesion. A group of researchers are developing care and treatment for severely disabled patients in a rehabilitation hospital. The kinds and scope of vocational services for the patient largely depend upon the inherent residual capabilities present. Standard tests of manual dexterity cannot measure the needed parameters to thoroughly test the capabilities of spinal injury patients to care for themselves and perform various kinds of work activities.

The methodology and device must be able to measure reaction times and decision times, to partial out digit and forearm speed, and also to measure accuracy in one- and two-dimensional tracking tasks of various control orders. Effective measurement techniques are expected to enhance the return of severely disabled persons to a productive and independent life.

Two psychomotor performance measuring devices have been identified via aerospace literature searching. Efforts are underway to obtain one of these units for evaluation by the problem originators. The technology is described in two NASA Tech Briefs, B69-10385 "Improved Perceptual Motor Performance Measurement System" and B70-10619 "Human Performance Measuring Device."

### RRC-3: Self Locking Knee Joint Brace

The problem originator is providing rehabilitation regiments for weak muscled patients and patients with partial or mild paralysis affecting one side (hemiparesis). They are unable to arise from a chair when their leg brace is locked, and cannot lock the brace when they are standing. A mechanical lock for the orthotic knee joint is required for mobility where muscle function is impaired.

The feature should be simple, lightweight, durable, inexpensive and convenient to operate. These characteristics are required for almost all orthotic devices. Dependability of the feature is essential since the patient will rely on this support. Providing support for mobility of the patients in this manner will tend to relieve therapists and nurses for other important duties.

The problem has been identified and a search initiated.

### RRC-5: On-Line Fabrication of Orthotic Support Devices

Clinicians at rehabilitation hospitals frequently see patients who could be immediately benefitted by application of such simple orthotic supportive devices as arch supports, etc. Measurements and purchase requests for commercial manufacture can be immediately made. A great deal of therapeutic treatment time is lost in the interval between ordering and receiving the device to be used by the patient, usually about two weeks elapses. The problem originator seeks to avoid delay in treatments.

Lightweight (foam) plastics may be of sufficient resiliency and toughness to function as a mold-poured, temporary to semi-permanent arch support. The plastic should be of a type which will not generate excessive heat to permit it to be in rather close contact with skin surfaces during cure-setting for the procedures sought.

It is felt that plastic materials and methodology for on-line processing of temporary to semi-permanent supportive forms will prove to be an adequate solution to this need.

A search has been initiated. Results will be evaluated for applicability to this problem. A foam-in-place technique for on-line fabrication of pilots' helmets was found to have applicability to this problem. Experiments were conducted and the technique holds promise. See Section II of this report for detailed discussion.

#### RRC-6: Lightweight, Portable, Cushion Seat Jack for Weak or Paralyzed Patients

Between four to five million people in the United States suffer from muscular weakness diseases as arthritis, rheumatism, paralysis (partial), muscular dystrophy, etc., and from debilities of old age. These individuals usually can walk around, but require assistance to rise from sitting positions in low chairs or car seats. They need a lightweight cushion which they can carry around with them and sit on with normal comfort. Assistance to help this person stand up by his own effort is urgently needed.

A simple, lightweight, inexpensive, easy-to-operate, portable, cushion seat jack of novel spring or hydraulic control operation is needed for this purpose. These patients may not be able to perform squeezing hand movements and may require special handle considerations similar to those conceived for Moon cart. A search has been initiated for this problem.

#### RRC-8: Ultra-Thin Electromyographic Needles

Excessive pain is generated in the skin of patients who must be repeatedly exposed to skin punctures by an electromyographic (EMG) needle during evaluations of muscle and nerve damage (muscle electrical energy potential measurements). The pain appears to be closely associated with the gauge or thickness of the needle -- thicker needles cause more pain. About 70 to 80 EMG studies each month are performed at this rehabilitation center. A biocompatible, electrical conductor alloy which can be used as an ultra-thin, insulated electromyographic needle is needed. It should be about 1 1/2 inches in length, should accept a very sharp point, should have flexure characteristics sufficient to resist bending of the shaft (warping) or of the point (fishhooking) to provide lateral stability, should be biocompatible for insertion through the skin into muscle tissue and should accept a form of sterilization.

Relevant NASA technology is presently being sought via computerized aerospace literature search for appropriate material to make ultra-thin needles for electromyographic studies. The problem is a candidate for dissemination to NASA research centers.

#### RNV-34: Pressure Sensitive Device for Use in Tongue-Operated Control Systems for Assist Devices

In the past two decades improved medical care has resulted in the survival of an ever-increasing group of patients with severe neuro-muscular disabilities who otherwise would have succumbed to their disease or remained bedridden. This has created a large population of severely paralyzed persons dependent upon society for care.

Although considerable progress has been made in the development of control systems for externally-powered orthotic devices for use with such persons, they continue to be the major limiting factor in the degree of function which can be attained. Extra-oral tongue-operated switch controls which provide sequential off-on control of the orthosis show great promise as a means of solving the control problem.

A small mechanical pressure switch is needed for placement within the oral cavity as part of a tongue-actuated control system for assist devices and wheelchairs. The switch should be reliable, resistant to deterioration caused by constant exposure to saliva, and small enough to fit the lingual area of the mandible so that pressure can be exerted by the tongue.

A possible solution has been identified (insulated-gate field-effect transistor which performs strain -- sensing and amplification functions in one integral device). The technology is announced in NASA Tech Brief 70-10157.

#### TAM-1: Direct Skeletal Attachment of Prosthetic Devices

Devices and methodology to accommodate bone properties for the direct skeletal attachment of prosthetic devices to replace missing parts are needed. Preliminary in vivo and in vitro studies have been conducted on the mechanical properties of whole equine bones concerning effectiveness of various bone fixation devices. The reaction properties of bones to injury, implants, prostheses, etc., are needed to develop low cost, effective, safe and reliable, direct skeletal attachment devices as replacements for missing limbs. Broad spectrum data tabulations are needed for research and development.

Devices and methodology must be safe for human use. Chemical, mechanical, electrical and physical data are required with reference to the environment, activity workload and nutrition variables. Bone/tendon attachment substitutions are essential to this problem.

A search of aerospace literature was done and forwarded to the problem originator. Pertinent information was retrieved by the search and is undergoing a more extensive evaluation by the problem originator.

#### BMC-1: Attraction-Movement of Non-Magnetic Material

A device is needed to attract and move non-magnetic foreign bodies invasively imbedded in eyeball vitreous humor.



The investigator is clinically treating patients who may have a variety of intraocular foreign bodies. The foreign bodies must be removed to prevent chronic irritation of the eye with attendant visual loss. If the foreign body is magnetic, it is relatively easy to attract and move the body through the vitreous humor (the viscous gel between the eye lens and retina) to an eyeball wall area or to the pupillary aperture, where it can be surgically extracted. Non-magnetic foreign bodies are extremely difficult to move and surgically remove. Attempts to "scoop through" and "fish" them out usually are unsuccessful and sight is lost, with or without surgery.

Vitreous humor is a thick, stringy, sticky gel which must be "clipped" with scissors to remove it from surgically extracted bodies. Foreign bodies may consist of brass, aluminum, glass, plastic, copper, lead, Vietnamese mud, and other particles.

A search has been run and is being evaluated by the problem originator. The problem will be disseminated to individual NASA centers for possible suggestions to a solution.

#### BMC-2: Measurement of Out-Of-Parallel Tracking of Eye

Clinicians use prisms of known refractive power to measure the angular deviations (from vertical and horizontal) of deviated (crossed or divergent) eyes. The patient concentrates his gaze on an object of fixation with one eye, and a prism of appropriate power and orientation is placed before the other eye to produce a single image, and thus correct the deviation being tested. The angle of deviation is computed from the refractive power of the required prism. This method of measurement is impractical in cases where the vision in the deviating eye is very poor. It is very difficult to perform with small children and this category constitutes the major group of candidates for corrective surgery.

The ideal device for this measurement should be of a size, simplicity and cost to permit the clinical ophthalmologist to readily, rapidly and reproducibly employ it. It must be able to laterally, vertically and diagonally measure angular rotations without attachments to the eyes. Rapid measurements are essential because children cannot tolerate attachments and they have short attention spans.

Strabismus is the medical term for out-of-parallel tracking. In exotropic strabismus (wall-eyed) the eyes are divergent; in esotropic strabismus (cross-eyed), they are convergent.

A search of aerospace literature has been done and results were forwarded for evaluation.

### BMC-3: Dark Room Measurement of Eye Pupil Size

The researcher is clinically treating individuals who have problems with control of eye pupil size. Some have different size pupils in each eye and some are abnormally dilated (opened) or constricted (closed) as a result of anomalies, illness, injury or medication (drugs). Pupil opening compares to camera lens opening for control of entering light. Usually a small point of light is used to measure the opening in a dark room setting. Many patients who require pupillary measurements in dark room settings, tend to be sleepy and either go to sleep or experience difficulty in focusing on a small light source. Dark room sensitive film or television capable of imaging under dark room conditions have been suggested as possible applications for this problem. If possible, the method should avoid using light in the visible spectrum.

The problem originator requires new methods to measure the size of the pupil of the eye.

Results of a computerized search of aerospace literature were favorable. The researcher stated that technology was identified through the literature search that would solve the problem.

### NMA-12: Sauna Bath Conditions Monitoring

Sauna baths are given to selected overweight patients as part of the regimen to maintain general health conditions and reduce body weight. Patients individually react to the sauna bath heat and humidity and some develop serious distress. The problem originator is developing a means to recognize those in distress and remove them from the bath before they are detrimentally affected, by monitoring physiological parameters and room conditions.

Devices should telemeter EEG, cardiac output, blood pressure and body temperature of the patient as well as room temperature and dew point. Attachment and accuracy of transducers must be compatible with high sweat and high humidity under sauna bath conditions.

A search has been initiated. A conference with the problem originator is being arranged to discuss specifications and special constraints of instrumentation which would solve the problem.

### PVA-3: EEG Analysis Computer Programs

The problem originator is studying analysis of electroencephalograms by computer. Research is at the stage of evaluation and revision of design plans and a request has been received for comparative NASA technology.

The team currently is processing search results and awaiting evaluation by the researcher.

#### HSR-1: Impression Material for Making Pattern of the Lower Trunk

An interdisciplinary team at a southwest rehabilitation center is constructing bucket-style, contour chairs. They are used in the care and treatment of spinal cord injury patients, particularly quadriplegic patients. These patients traditionally have been confined to bed during most of their waking hours. When a specially fabricated contour chair is used, however, the patients can be permitted to sit up for extended periods. The researchers need material to more accurately, rapidly, and efficiently prepare impressions of the paralyzed patient's body.

Results were obtained from a search of the NASA Data Bank. A response was received from a NASA research center to the problem statement. Relevant technology has been retrieved to solve the problem. Methodology for fabricating a foam-in-place, form-fitting pilot's helmet liner directly on the pilot's head, shows good potential as impression material to make the exact patterns for the lower trunk. Another interesting application of this foam system is consideration as a replacement for plaster of paris cast material for broken bones. See Section II of this report for details.

#### HSR-2: Resilient, Breathing Contour Seat Material

A research team at a southwest rehabilitation center is fabricating and using contour chairs for spinal cord injury patients. The investigators need materials for the contour seat of wheelchair patients. A rigid base material and a resilient, limited degree of cushioning material is needed. Samples of the materials were requested since applicability must be determined empirically.

Appropriate NASA documents were retrieved from a search of literature. NASA-developed polymethane foam material samples were obtained. They were furnished for evaluation to the problem originator. A slit-tube, fiberglass filler material which was developed by NASA is presently being evaluated for prevention of decubitus ulcers (bed sores). This also will be made available for evaluation and use by the problem originator. See Section II of this report for detailed discussion.

#### HSR-3: Padding Material for Orthotic Devices

Orthotic devices are worn by certain patients as mechanical aids to assist functions of weak, paralyzed limbs. Padding is provided at points where the devices contact the skin. The pads must be replaced periodically because the wear and shrinkage cause skin maceration and they become

odiferous with use. The patient loses the prosthetic help during times of repair. This is a direct expense and consumes a valuable part of the prosthetist's time. A suitable padding material is needed that should be durable, shrink resistant, porous, and easy to form or shape with cutting instruments.

Team members scheduled a visit to the Manned Spacecraft Center and received referrals to several commercial sources which had developed materials with the needed characteristics in association with NASA. The Medi-Gard Medical Plastics Corporation can supply samples for evaluation by the problem originator of their antibacterial, polypropylene fiber material. Various materials were evaluated. For further discussion, see Section II of this report.

#### NMA-10: Video Tape Programming

Speech therapy at a V. A. Hospital is an expanding program because of the large number of brain-injured Viet Nam veterans. The problem originator is attempting to computerize some aspects of therapy to assist in reteaching speech. Insufficient therapists and assistants are available to handle this load. The problem originator strengthens oral signals with visual stimuli and needs programming techniques for video tapes including both video and audio signals.

Multiple searches of related aerospace technology have been made to identify relevant NASA-developed data. Results were furnished to the problem originator and he selected four documents of special interest to him. His evaluation of the document contents will direct future research.

#### NMA-11: Computer Programmed Testing and Teaching

Basically, repetitive programs are used to teach speech-handicapped patients. It is frequently desirable to skip one or more sequential batteries in the program after certain patients have mastered a battery. The problem originator needs technology which will permit random selection of the available batteries as needed for effective speech therapy.

Data were retrieved from a NASA-developed technology search and these are being evaluated by the problem originator for follow-up action.

#### RNV-14: Materials for Prevention of New Decubitus Ulcers

Pressure sores (decubitus ulcers or bed sores) develop over the bony areas of the sitting surface of spinal cord injury patients while they are sitting in wheelchairs. Some of the sores require surgical closure. Most of the sores take from 2 weeks to 4 months to heal. The estimated, average cost for treating a decubitus ulcer is about \$15,000. Some type of cushioning material which possibly could distribute pressures to eliminate high pressure points on the patient's body would be useful. This material should be somewhat compressible, lightweight, have properties generally described as viscoelastic, and perhaps a gel.

The results of a search of the NASA Data Bank were furnished to the problem originator, who advised the team they were pertinent, direct, and useful. Materials were purchased and cushion research was initiated. Investigations also have been made concerning a special resin from which pads could be similarly constructed. This problem has been classified as an applications engineering candidate.

#### RNV-21: A Wireless Synchronization Link

The investigator stimulates muscles to correct for dropfoot in the care and treatment of stroke patients. Patients tend to drag the affected foot because the muscles do not function which raise the foot at "stepoff." Researchers electrically stimulate the appropriate nerve in the affected leg. They do this through implanted electrodes and inductively coupled radio frequency energy. The stimulator has several basic parts. These are a waist-belt-mounted radio frequency generator package; an external use, rf transmitting coil; a surgically implanted rf receiver coil; an integral passive circuitry; surgically implanted stimulating electrodes mounted on silastic; and a shoe-heel mounted switch which activates the rf generator when the patient "steps off" with the affected foot. The implanted stimulating electrodes, receiver package, and their connecting wire appear to function satisfactorily; however, the wire extending from the heel switch to the rf generator package interferes with ambulation and is a cosmetic liability. The researchers prefer to use a wireless link to replace the hard wire link between the two points. The wireless link should require little or no battery power and be mounted in the heel of an ordinary shoe. Results of the NASA Data Bank search proved to be used merely as background material. A Problem Statement was prepared and submitted to NASA for approval to disseminate to research centers.

### RNV-23: Analysis of Human Motion Patterns

Human motion pattern studies have been made on patients who have difficulty in walking. Data are gathered to plan corrective surgery and to refine improved bracing techniques. "Normal" motion or gait patterns need adequate and convenient definition. Techniques are required for correlating and analyzing acceleration data generated at selected body sites. The objective of the data is to clearly identify normal motion patterns and determine timing, manner, and degree to which abnormal motion patterns differ from them.

Evaluated multiple-literature search data were furnished to the problem originator. A problem statement was prepared and sent to NASA for approval to disseminate to research centers. The team was contacted by a hardware fabricator who indicated he had a suitable triaxial accelerometer and was interested in developing this medical product line in cooperation with the program. See Section II for details.

### RNV-26: Angle Measurement in Knee Prosthetics

The physician assesses conditions and capabilities of particular muscles and muscle groups by measuring muscle potentials developed under repeatable degrees of static and dynamic stress. A simple method is required for repeatedly measuring the angle between the upper and lower parts of the leg, relative to the knee joint. This is a cam-type joint instead of a pin-type joint.

### RNV-28: Accelerometer for Human Motion Studies

Human motion pattern studies have been made on patients who have difficulty in walking. The results are used to plan corrective surgery and to refine improved bracing techniques. "Normal" motion or gait patterns have not adequately or conveniently been defined. It may be possible to evaluate and diagnose orthopedic problem cases in an "on line" manner with proper data acquisition and analysis. Small, light, and rugged triaxial accelerometers are needed.

A commercial source of applicable equipment was retrieved from a NASA Brief and the TUO at the NASA Ames Research Center. This source suggested that the problem originator fabricate the triaxial accelerometer from single axis units. This recommendation is being evaluated by the researcher.

### RNV-29: Manual Controls for Self-Propelled Vehicle (Wheelchair; Automobile)

A research and development project provides transportation to rehabilitation patients who are able to use a wheelchair. The development of self-propelled wheelchairs has been evolutionary rather than by system design. This investigator currently evaluates transportation needs of the patient and then develops the devices. The controls for powered wheelchairs are being designed from the "systems" approach to obviate the obsolete constraints imposed by early model wheelchairs. The human-machine interface is given paramount consideration in this program in order to produce a wheelchair more suited to patient needs and comfort.

The results of a NASA Data Bank search were provided to the problem originator. A problem statement was prepared and sent to NASA for approval to disseminate to research centers.

### RNV-31: Patient Supporting Couches

The main development has been evolutionary for suitable patient transportation and supportive devices such as wheelchairs, stretchers, hoists, cars, etc. Little consideration has been given previously to compatibility of the anatomy of the patient with the chair, couch, or bench. Little or no effort was devoted to psychological or physiological patient comforts. The development of all of the devices has disregarded the man-machine interface. Wheelchairs were built to minimize weight or to fold up conveniently for storage. Only superficial considerations were given to fitting the chair to the anatomy of a patient. The investigator's engaged in research to evaluate the supportive-cushioning needs of the patient and design them into prototype equipment construction. He is evaluating overall patient transportation needs with a "systems" approach. He includes all factors affecting the patient in the bed, chair, and automobile. He requests NASA-developed technological support to facilitate design of seats and couches. They should support a patient in the supine position (lying on his back), erect position (sitting up), and intermediate positions between these two. The results of a NASA Data Bank search were furnished to the problem originator. A problem statement was prepared and sent to NASA for approval to disseminate to research centers.

### RNV-32: Measurement of Energy Expended in Walking

This investigator is developing an improved means of diagnosing disorders of gait and evaluating "quality of walking." Gait patterns can be analyzed, appropriate diagnoses made, and corrective surgery or improved bracing techniques can be implemented through information gained from the computer, if proper data acquisition and analysis of human motion patterns are available. The researcher has taken the first steps toward realization of "on-line," computerized evaluation and diagnosis of orthopedic cases and problems. Gait motion studies have been made for patients with various disorders of gait. Motion patterns of normal subject also will be studied. A method for measuring the energy expended by a patient as he walks a

certain distance is needed.

The results of multiple searches made to identify relevant NASA-developed technology are being evaluated by the problem originator.

#### WVA-1: Fluid for Foot Pressure Indicating Device

The problem originator designed and built a pressure indicating device for mounting in the sole and heel of a shoe for a prosthetic leg. Water was used as the hydraulic fluid of the transducer -- fluid line-bellows system. Water is unsatisfactory because it permeates the adhesive potting material. A fluid is needed which must be compatible with aluminum, polyurethane potting material, and tygon tubing. It will be used for filling a foot pressure indicating device.

Results of a NASA Data Bank search were forwarded to the problem originator for evaluation.

### ARTIFICIAL ORGANS AND ORGAN ASSIST DEVICES

#### BLM-14: A Compound Conduit for Use with Chronically Surviving Animals

A compound umbilical conduit providing 2 electric leads, 2 pneumatic lines, and 6 flexible hydraulic lines to power and monitor an artificial heart implanted within an animal is needed by the investigator. The umbilical should be approximately 5 meters and is limited to a thickness of about 1 cm by the space between the animal's ribs. Quick-disconnectors on both ends of the umbilical should provide swivel action to avoid kinking when the chronically surviving animal moves around. The two pneumatic lines will operate with a pulsating flow approximating 0.1 liter per second (CO<sub>2</sub> pressure/vacuum) at -5 and -2 psig, respectively. The six hydrostatic coupling columns will not receive appreciable flow. One of the electric leads will furnish ECG information, and, therefore, must be well shielded to reduce pickup of interference on the 1-mv source impedance ECG signal.

Results of the NASA Data Bank search were provided for the problem originator. All retrieved information proved to be of interest and one of the ten documents proved to be directly related to the problem. A Problem Statement was prepared and sent for approval by NASA to disseminate to research centers. The Research Triangle Institute and Midwest Research Institute cooperated with this team and furnished information on similar problems which was sent for evaluation to the problem originator. NASA Tech Brief 70-10109 described a quick-disconnector which appears to offer a solution to the problem. It will require reengineering before it can be directly applied to the problem and it has been submitted as a potential applications engineering candidate. A response from a NASA center proved to provide an excellent answer to the problem. It is currently being evaluated.



### BLM-13: Nonthrombogenic Biomedical Material Suitable as a Blood Interface

Nonthrombogenic biomedical material suitable as a blood interface is needed by the problem originator. This material must be noncarcinogenic to be suitable for processing into various configurations for surgical implantation. A form of carbon developed by a considerable aerospace research effort was considered to be a possibility for these unique medical requirements.

Results of a search of the NASA Data Bank were furnished to the originator. The NASA Lewis Research Center provided information regarding use of alloys for implantation (hip replacement) and this also was furnished to the researcher. Ten samples of various configurations of special biocarbon materials were obtained in addition to the information and they were sent for evaluation to the problem originator.

### UTM-1: Physiologic Data Handling Systems Approach

The problem originator is establishing a data acquisition and reduction center in an artificial heart test and evaluation facility. The facility will acquire large amounts of data from varied sources. The artificial heart or heart assist device will be tested for its electrical and mechanical properties. It will be subjected to environmental tests, evaluated in mock circulations, physiologically evaluated in animals, and finally implanted in humans. The physiological parameters will be monitored during surgery and a 24-hr. monitoring will continue while the animal's condition is being evaluated for many weeks. The human patients necessarily will have to be monitored later. Some of the in vitro tests must be continuously monitored over long time periods for failure analyses. Automatic control of electrical and mechanical tests are included in planning. Guidance technology is needed concerning interfacing a large number of analog variables to the computer. Continuous monitoring of physiological parameters, methods of real time data reduction, file structure of data storage, methods of retrieval, automatic control of failure tests, and automatic determining when a failure either has occurred or may occur are facets of this same problem.

A copy of NASA Tech Brief 69-10720 was furnished to the problem originator with its information on transmission of medical signals for computer analysis for evaluation. The team is negotiating for approval of a visit by the problem originator to the Manned Spacecraft Center where he can discuss their system of handling physiologic data.

### UTM-7: Chronic Electrode Implantation Techniques for Artificial Eye Research

A TV camera is being developed for use as an artificial eye. It will be wired directly into the brain. Many problems exist in the formulative stages of the development. Basic research is needed to define neural and electrical parameters to successfully interface the TV camera with the brain. The developer requested NASA-developed technology relating to chronic implantation

of electrodes and materials. They must remain relatively inert when subjected to long-term exposure in body fluids and tissue.

Carbon electrode data were retrieved from a NASA Data Bank search and were furnished to the problem originator for evaluation. His comments are needed before proceeding to make a final technology applications report. A problem statement was prepared and sent to NASA for approval to disseminate to research centers. Negotiations are in progress to provide samples of biocompatible carbon materials.

#### CHS-11: Artificial Eye Lens

A large number of children suffer from a condition of cataracts on their lenses. The lenses are surgically removed to prevent blindness. Glasses with eyeframes and contact lenses have not proven to be effective with the very young children, and a modified means of replacing the lens with a semi-permanent functional lens is needed during the rather critical formative years when much about the self and relationship of self to the environment is acquired. Technological methodology and device to operate as a lens for the human eye after surgery for cataracts in eyes of children are needed.

A search has been initiated on this problem and results forwarded for evaluation by the researcher.

#### UTM-22: Electric Controlled Pressure Regulator

The investigator is conducting research with animals in development of artificial organs for transplant within the body. He has produced an artificial heart and is evaluating it within the body of a calf and another within the body of a sheep. He needs a reliable, electrically operated, controlled pressure regulator to improve the pumping device which provides the equivalency of heart action.

A search of aerospace literature has been completed, and results are currently being evaluated by the problem originator.

#### UTM-23: Servo Valve for Blood Pressure Waveform System

The investigator is conducting research with animals in development of artificial organs for transplant within the body. He has produced an artificial heart and is evaluating it within the body of a calf and another within the body of a sheep. He now uses a Skinner Electric, non-NASA programmable assist device requiring synthesizer application. He needs to be able to program the servo valve by amplitude and function rather than time interval only.

Multiple searches of aerospace literature have been performed to identify relevant technology. These search results are being evaluated by the problem originator.

#### UTM-24: Photo-Etched Form to Cast Artificial Kidney Matrix

The investigator is conducting research for the development of artificial organs. He has experimented with several support matrix concepts to separate the flushing solutions from the cellophane tubing which transports blood in an artificial kidney device. He has been able to improve the support concept by using a matrix of points provided from a photo-etched mold. He needs to be able to obtain points at least 3/100-inch to have an effective flushing flow opposite the blood. There should be about 600 points per square inch on the plate to be photo-etched. The depth of photo-etching should provide a mold for a point average of at least 3/100-inch in length. Photo-etching is considered the best uniformity potential process.

Computerized searching of the NASA data bank revealed various techniques which are currently being evaluated for applicability by the problem originator. In addition, the problem has been disseminated to NASA research centers.

#### UTM-25: Ionizing Radiation Detection of Thrombogenesis

An implantable monitor is needed to detect low level beta radiation from build-up of labeled blood components in thrombogenic response to interfacing. The investigator is conducting research with animals in the development of artificial organs (artificial heart, artificial kidney, etc.) for implantation within the body. Various materials are being tested for their biocompatibility as an interface with blood and other body fluids or tissues. Blood tends to clot if the interface is not fully compatible. Thrombogenesis (blood clot formation) must be monitored as a critical evaluation. A means is needed to detect the early stages of thrombogenesis.

Search results are being evaluated by the problem originator.

#### UTM-26: On-Line Blood Gas Measurements in Respiratory Exchange

The investigator is conducting research with animals in development of artificial organs for transplant within the body. He needs to be able to continuously monitor the effectiveness of the transplants in relationship to the natural body system function in life support. The respiratory system function is an essential component of circulatory system effectiveness evaluations when an artificial heart transplant has been made.

A computerized search of aerospace literature has been conducted. Results are being evaluated by the problem originator.

#### UTM-27: Miniature Mosaic TV Camera

The investigator is conducting experiments for development of an artificial eye. He plans to receive and transmit visual images from a television camera implanted within the human eyeball. Output from the TV camera will be fed into a computer system which will translate it into signals that can be relayed to the brain. The design of the system has been formulated and is considered functionally acceptable. He needs a camera capable of transmitting high speed mosaic pictures. It must be extremely miniature to be implantable within a human eyeball. A mosaic type of camera which is an array of photo cells suits this purpose better than the conventional line transfer of data. It must be safe for use within the human body.

A search for NASA technology adaptable to this purpose has been initiated.

#### UTM-28: Flexible Substrata for Solid State Circuitry

The investigator is conducting research for the development of an electronically controlled artificial eye system. He plans to implant a TV camera within the human eyeball to receive and transmit visual images to computer which interprets them. Signals are relayed from the computer to circuitry interfaced with the visual areas of the brain.

Thin, flexible substrate material is needed for interface with brain tissue which is in almost constant, pulsating, vibratory motion. The material must be biocompatible and safe for use within the human body. The material must accept electronic circuitry without introducing signal artifacts.

A search of aerospace literature is underway to identify relevant technology. A Medical Problem Statement was prepared and disseminated to NASA centers.

#### CHS-12: Dipole System Auditory Multichannel Stimulation

Technological methodology and devices are needed for subminiature dipoles to be surgically implanted in an auditory brain area (e. g. cochlear nucleus).

Auditory information needs to be supplied to a deaf child during the critical growing years or certain brain functions central to speech and language function may fail to develop. Dipoles stimulation is the logical choice when researchers are ready to move into practical applications of stimulation since they overcome the crucial problem and remain permanently positioned, unaffected by growth in brain tissue.

Dipoles should be about 0.5-4.0 mm in length, 0.5-1.0 mm cylindrical diameter, function as a receiving antenna while remaining biologically inert, contain internal detector and filter circuit to convert pulses of radio energy into pulses of d-c current (output currents of 100  $\mu$ A may be required but smaller currents (10-20  $\mu$ A) may be acceptable). Extensive animal testing is contemplated if the idea proves technically feasible and before it can be suitably considered for humans.

A search of aerospace literature has been made and results forwarded to the problem originator. Technology developed by NASA dealing with subminiature myoelectric probes made from biocarbon material has been made available to the researcher.

## MENTAL HEALTH

### CAP-3: Noncomputerized Reduction of Data Recorded Via Conventional Polygraph Techniques

The problem originator requires a noncomputerized technique to rapidly and economically reduce data recorded on the conventional Beckman Type RM polygraph strip chart. A digital multimeter arrangement used in conjunction with the oscillograph pen output was considered a likely possibility. The level of the telemetered galvanic skin response (GSR) could be arranged in four or five categories, such as high, medium, low, or none, on a regular time-sampling basis. Recording each time that a response occurred above a certain magnitude is another possibility. Small photocells could be used above the pens to trigger a cumulative counter. The researcher requested any NASA-developed technology for this purpose.

An aerospace literature search was performed. Contacts with NASA contractors also were made concerning availability and prices of suitable equipment. This information was provided to the problem originator.

### DVA-1/2: Automated Techniques and Instrumentation for Administration and Analysis of Diagnostic Psychological Tests

Free word association and projective testing are standard psychological diagnostic and therapeutic techniques which require considerable time for administering, scoring, and analyzing because independent, subjective judgments from several counselors are required. The investigator requested available NASA technology relating to automated administration techniques for mass screening and therapeutic tests. They will be used to objectively diagnose and treat psychological impairments. Methods and instrumentation are required to reduce and analyze large quantities of data obtained from diagnostic and therapeutic psychological tests.

Multiple searches of available aerospace literature were performed, evaluated, and sent to the problem originator. He evaluated the documents and found them relevant to his needs. Further definition of problem solution requirements is in progress. In addition, cognitive function testing instrumentation available from the Manned Spacecraft Center in Houston is being evaluated for applicability to this problem.

### SRS-8A: Acquisition and Telemetry of Heart Rate, Blood Pressure, and Blood Flow in Free-Ranging Dogs

A "normal" and a "nervous" strain of bird dogs are being studied to determine comparisons of the physiological parameters of heart rate, blood pressure,

and blood flow. By understanding the differences between the normal and the nervous dogs, the researcher hopes to apply the knowledge in understanding and treating mental illness in humans. Backpack-mounted, wireless telemetering equipment is needed. Its transmission range should be up to 1 mile. Two channels must be provided to capably handle blood pressure waveform and blood flow velocity. Implantable sensors must be usable with portable telemetry equipment. Service life of the system should exceed one week. A NASA-Ames Research Center telemetry information package was provided to the problem originator. Screened results of an updated NASA telemetry search were furnished to the researcher and he ordered ten of the documents. He indicated he was going to use ultrasonic Doppler equipment to measure and telemeter blood flow information. A copy of RNV-11 "Telemetry of Body Kinesiology" was retrieved and sent to the problem originator. He successfully implanted transducers surgically around the aorta and coronary arteries and obtained good coronary blood velocity records. This telemetry system proved to be noisy and severe errors were produced when the transducers failed to properly perform in vivo.

#### GLM-36: An Objective Measure of Human Motor Activity

A simple device is needed to monitor mobility (walking, running, etc.) and static motor activities (rocking, fidgeting, etc.) of human adolescents and children. Records of these measurements will provide objective information about drugs, psychotherapy and environmental effects on humans in controlled clinical studies. Improved mental health treatments can be derived from applications of the knowledge obtained.

The equipment should provide easily reproducible results, withstand relatively rough usage, avoid hampering normal movements in a playroom or during an interview, and be as simple as possible. It should be non-irritating, non-toxic and worn without producing trauma. It should avoid introducing motion artifacts and avoid unduly attracting the attention of the wearer to itself.

The problem was accepted and a search initiated. Results were forwarded to the problem originator. The problem was disseminated to NASA research centers for individual attention by NASA scientists. A response was obtained from this dissemination suggesting the use of an infrared light source as a detector of activity. The problem originator found this suggestion to be a solution to his problem.

### DVA-3: System to Monitor and Record Human Blood Pressure

A non-invasive, automatic, portable system is needed to unobtrusively monitor and record systolic and diastolic blood pressure changes. The researcher is evaluating pain perceptions and reaction thresholds for humans. Verbal reports have been used as an indicator of reaction to pain producing (thermal and electrical) stimuli. The problem originator needs an objective indicator to avoid concomitant distractor variables. He feels remotely obtained blood pressure has excellent potentials. Findings are planned for use in diagnosing and treating mental patients.

Multiple searches of aerospace literature have resulted in the identification of several potentially useful systems. These are currently being evaluated by the problem originator.

### CMH-1: Biochemical Differentiation of Schizophrenics

A biochemical test to indicate degree and severity of the different categories of the psychosis, schizophrenia, is needed. Millions of people in the United States suffer from treated and untreated mental illnesses. A large proportion of those people suffer from a broad range of split-personality deviations which have been singly grouped under the term "schizophrenic." These individuals may range from such manifestations as excessive daydreaming to the multiple personality of the "Dr. Jekyll/Mr. Hyde" and other aberrations. The problem originator seeks a means to sample blood or other body fluid and determine the different categories of schizophrenia by differences in the biological constituents. Substances have been isolated which appear to induce schizophrenia symptoms.

A computerized search of aerospace literature has been run and results forwarded to the problem originator.

### SRS-8B: Methods of Signal Categorization

Electrocardiograms from two strains of dogs are being obtained. A suitable technique for quantifying visible differences between them is needed.

Results of a search of the NASA Data Bank were furnished to the problem originator. Referenced information was not immediately used because the search project had not progressed to the point that signal categorization methods were required. A Problem Statement then was prepared and sent for NASA approval to disseminate to research centers. Two responses have been received to the Problem Statement. They have been acknowledged, studied, and forwarded for evaluation to the problem originator.



#### PVA-4: EEG Electrode Holders

The researcher needs a convenient method for holding and repositioning EEG electrodes in performing various clinical experiments. Information was furnished concerning related work in progress at the NASA Ames Research Center. The problem originator requested available NASA technology which is clinically applicable to EEG electrodes and techniques for repositioning of electrodes. A search of aerospace literature has been done. Results are being evaluated.

## DETECTION AND TREATMENT OF HEART DISEASE

### GLM-19: Measurement of the Velocity of Myocardial Contractions by Noninvasive Means

The ill-defined characteristic of myocardium contractility refers to several aspects of the act of shortening myocardial muscle. Methodology is needed to detect the velocity of motion of the heart wall without application of intravascular media or surgery. The measurement or observation ideally should parallel the method used by the physician as he listens to heart sounds with the stethoscope. The problem originator requested available NASA technology relating to the pulse-echo and Doppler detection methods which use ultrasonic or similar energy.

Results of a search of the NASA Data Bank were screened and forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers. Four responses to this inquiry have been received, acknowledged, studied, and forwarded to the problem originator. The team arranged for the problem originator to borrow Kubichek Impedance Cardiography equipment from the NASA Manned Spacecraft Center as recommended by Mr. R. R. Smylie in his response. The equipment has been received and the researcher is preparing to test it in his laboratory.

### BLM-21: Artificial Membrane Interface

The investigator is developing a mechanical (artificial) heart in his study of electrophysiology of the heart. An observed electrical phenomenon relative to artificial membranes may be pertinent to this investigation. The investigator needs to know the underlying physical process involved in the phenomenon in order to proceed farther. The phenomenon being studied is that of the Oswald Electric Heart. It is a globule of Hg in a beaker of  $H_2SO_4$  which contains a minute quantity of  $K_2Cr_2O_7$  that colors the acid a light yellow. A fine wire or needle is in point-contact with the mercury but is otherwise electrically insulated from ambient environment. The mercury globule pulsates with rhythmic waves of excitation at regular intervals in this configuration. This gives approximately the same appearance as a beating biologic heart. The problem originator is researching the reactions which occur, the energies produced, and the basic mechanisms involved. He requested available NASA technology to assist him with this problem.

Results of a NASA Data Bank search were furnished to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

### NMA-3: ECG Cable Take-Ups

Small ECG take-up reels are needed for a portable ECG monitor. The monitor is maintained in the intensive care unit and is used in surgery or the emergency room as required. The 4-ft cables frequently become entangled and critical time is lost in attaching the patient to the machine. Time consumed in releasing the cables can be important to the treatment of a patient during emergencies.

The team is considering available commercial technology before disseminating the problem to NASA research centers. The commercial technology was retrieved from research of the NASA Data Bank.

### NMA-5: Cable Crimping on Simmons Bed with Hausted Rails

Hausted bed rails conveniently require only one operation to raise them or lower them. Doctors and nurses prefer this feature, but the hinging arrangements crimp and cut the transducer cables. The problem investigator requested suitable NASA technology to resolve this problem.

The team is surveying Army, Navy, and Air Force hospitals for new approaches to this problem solution.

### NMA-2: Coiled Transducer Cables for Rough Environmental Use

Beds in intensive care wards cannot always be conveniently positioned for the standard length cables necessary to operate essential monitoring units. If rails or the bed itself must be raised or lowered, cable problems arise. They fall across moving bed parts and are cut. They also lie across the patient and increase his discomfort. The problem originator needs lightweight, miniature, coiled, multiconductor cables which have braided shields and can be extended to varying lengths.

The team is searching NASA-developed technology in areas related to hospital monitoring for suitable cables.

### UAM-2: Heart Sounds Telemetry

The heart sounds of convalescing cardiovascular surgery patients are monitored during mild exercise. Hard wire instrumentation is presently being used. The problem originator seeks to remove the interroom cabling and to be able to directly telemeter to the monitoring station. He, therefore, requires a heart sound telemetry unit to transfer signals from the exercise room to a monitor station.

The team provided the problem originator with a complete list of all "state-of-the-art" physiological telemetry. A NASA-developed phonocardiogram system incorporating a chest microphone will also be sent for evaluation to the researcher. The existing telemetry package with its microphone should solve this problem.

#### UAM-1: Capacitive ECG Electrodes

The problem originator monitors ECG and heart sounds with the same transducer during continuing research on heart disease detection and treatment. Reduced numbers of electrodes save time during attachment and reattachment for the data acquired. He requires capacitive electrodes to simultaneously measure ECG and heart sounds and reduce possibilities of shocking the patient, since no current flows in the body with capacitive electrodes.

A search of the NASA Data Bank retrieved materials for various ECG electrodes and applications techniques. A large amount of in-house data also was available. The problem originator has been advised of NASA technology available to solve his problem.

#### GVA-5: Computer Analysis of ECG Wave Shapes

Blood pressure, heart rate, and ECG are monitored once each minute for cardiovascular surgery patients having myocardial infarcts. The problem originator seeks to computer analyze the ECG and continuously measure the waveshapes of the T-T and S-T periods. He requested NASA technology for methodology to monitor and analyze the  $\Delta T$  and the  $\Delta S-T$  periods of the ECG waveshape.

Relevant technology was retrieved from a search of NASA data on computer analysis of ECG waveshapes. Available material was forwarded to the problem originator for his evaluation of applicability to his problem area.

#### BVA-4: Portable ECG Telemetry Receiver and Chart Recorder

The problem originator is looking for a method to monitor the ECG of his patients during his hospital rounds without disturbing them while they are engaged in various convalescent activities at various locations. He needs a portable, hand-carried ECG telemetry receiver and chart recorder. The unit should be lightweight and comfortable to carry for short periods of time.

The team performed a search and identified several sources for portable telemetry receivers. These data were made available to the researcher.

### BVA-3: Attachment Techniques for ECG Electrodes

Researchers on heart disease detection and treatment need better electrocardiogram electrode attachment techniques for use on patients during exercise. Skin resistance, sweating, and layer thickness pose electrode-skin interface problems in retaining signal integrity for the ECG of cardiovascular patients undergoing controlled testing. Lightweight and rugged electrodes and leads are needed.

Current NASA ECG electrode technology was retrieved for evaluation by the problem originator after a search. Evaluation of many alternative systems is necessary since the researchers require various suitable hardware and application techniques.

### AVA-1: Chest Wall Movement Transducer for KCG Measurement

The problem originator wants to use the same transducer to measure KCG and heart sounds. A homemade bellows transducer presently is available to the researcher and it measures only the KCG. The researcher believes better diagnosis can be made if the combined KCG and heart sounds are incorporated with the ECG and chest wall displacement. He requires a chest wall transducer that is linear out to 3Hz. It must have a contact point radius of 0.25 in. or less and a sensitivity range of 0.001 to 1.5 inch.

Several approaches to the problem were retrieved from a search and they are being evaluated as a possible technology application.

### BVA-1: X-Ray Transparent Electrodes and Leads

The problem originator wants to monitor extensive ECG information while obtaining x-ray, dye-study information on the cardiac circulatory system. ECG leads and electrodes presently negate dye-study effectiveness because they mask the arteries and veins. Interference of the smallest of wires can be very misleading since the prime interest lies in the circulation of small veins and arterioles. The researcher requires essentially x-ray transparent ECG leads and electrodes.

Several interesting approaches to this problem were retrieved from a NASA Data Bank search. Tech Brief 68-10363 contained additional information about an electrically conductive film which is transparent to radiation. This material hopefully may be fabricated into suitable x-ray transparent electrodes.

### RRC-1: High Energy Cost Exerciser with Ergometric Monitor

A portable, low-cost, high energy cost exerciser technological methodology and device and means to measure expended energy is needed.

Patients convalescing from cardiac illness or certain other disabilities, frequently require high energy cost exercise in their rehabilitation programs. The physiatrist therefore prescribes measurable degrees of exercise. The patient may be overstimulated and overmotivated if he participates in team or group activities, or understimulated and undermotivated if he is unattended during exercise at home. Both fail in attainment. The device should be sufficiently small to be portable. It should be interesting and safe for use by a cardiac patient and should provide high energy cost conditioning and accurately ( $\pm 5\%$ ) measure expended energy.

A search for relevant NASA technology has been initiated. Results have been forwarded to the researcher for evaluation.

### RRC-2: Accurate Cardiac Telemetry from Active Subjects

Computer analysis of clinical ECG waveforms has yielded information on "S-T depressions" which have been interpreted to be an indication of cardiovascular malfunction. The problem originator considers this information to be significant in relation to patients' reactions during participation in cardiac rehabilitation exercise programs. He seeks a means to monitor both heart rate and ECG waveforms from exercising patients. Both hard wire and wireless telemetry are eligible for consideration. The patient should be minimally encumbered and the equipment must be safe for use with cardiac patients. There should be a direct and accurate readout of the ECG wave form to indicate any possible S-T depression.

A variety of commercially available ECG telemetry devices have been considered, but fail to provide the required waveform precision. A search of aerospace literature to determine if NASA has developed technology meeting these requirements has been initiated.

### UAM-12: A Model for Cardiovascular Dynamics

The investigator employs a cardiovascular model which consists of a 30 meter length of penrose surgical tubing at rest on a porous aluminum extrusion, connected to a 30 meter slotted box. A blower attached to the slotted box should distribute pressure to uniformly lift the tubing from the extension. It proves to be insufficient to raise the tubing except for the end distal to the blower, causing unstable vertical and horizontal plane oscillations. The poor pressure profile must be corrected to continue research.

A means to provide a constant pressure profile in the end box of an elastic artery model which rides on an air bearing is needed.

Any proposed methodology should recognize that static pressure rises monotonically with distance away from the blower, due to conversion of velocity head to pressure head along the length of the box in the present configuration.

A search of aerospace literature has been initiated.

#### AVA-2: Carotid Artery Pressure Waveform Measurement

The investigator has been using a glycerine-filled transducer to monitor the pressure waveform of the carotid artery in his patients. He uses the acquired data to check circulation and correlate these findings with normal sphygmomanometer blood pressure readings taken from the arm. The glycerine-filled transducer no longer is being manufactured and a suitable substitute is needed to replace it.

A flexible pressure transducer to noninvasively measure carotid artery pressure in humans is needed. A computerized search of aerospace literature was done. Evaluation of results is in progress. Flexible electrode technology developed at Ames Research Center may have application to this problem.

#### UAM-9: Mössbauer Effects Applied to Measure Blood Flow Rates

Devices and methodology are needed for applying the Mössbauer Effects to measure blood flow rates in human arteries and veins. The problem originator is researching the development of superior methods for measuring blood flow rates in human veins and arteries. He is seeking a means to practically apply the Mössbauer Effect to measuring blood flow rate and then compare the technique to the Doppler ultrasonic technique.

Manual and computerized searches of aerospace literature have been performed. Evaluation of potentially applicable technology is in progress.

#### UAM-11: Ultra-low Frequency Bandpass Amplifier for Electric Potentials

An ultra-low frequency bandpass amplifier to transmit gastrointestinal electric potentials is needed. Various gastrointestinal disorders selectively alter the characteristics of the gastrointestinal tract. The problem originator is interested in determining whether these changes in the tract are accompanied by characteristic changes in the electrical potential of the gastrointestinal system. He is researching any correlation of disorder symptoms and electrical potential phenomena.

A search of aerospace literature was done. Applicable technology was retrieved. It is envisioned that this problem will develop into an applications engineering project.

#### CLA-2: Measure of Blood Flow Direction and Velocity by Ultrasonic Techniques

A physician is benefitted by accurate data concerning blood flow direction and velocity in the large arteries and veins near the heart of patients for whom he is providing cardiac treatment. The investigator has been using electromagnetic flowmeters to acquire this data from his patients. He is seeking reliable measuring techniques to replace the electromagnetic flowmeters, using catheters and ultrasonics to improve quantity and quality of acquired data. The problem originator prefers to use catheter tip transducers in his procedure and avoid the cuff-type transducers. Methodology should be safe for use with humans.

A search of aerospace literature has been done and results are being evaluated by the problem originator.

#### PVA-6: Bandpass Filtering for EEG Alpha Rhythm Signals

A bandpass filter to attenuate signals outside of the electroencephalogram alpha rhythm signal band (8-13 Hz) is needed. Methods to teach cardiac patients to completely relax without employing pharmacological agents, are being investigated to provide an improved clinical regime for a large number of patients who can benefit from the self-help. As a psychiatrist coaches each subject, he monitors progress in relaxation with electroencephalograms (EEG). A generation of high intensity alpha rhythm relative to other rhythms is a criterion indicator of successful relaxation by this method. The bandpass filter is intended to reflect variations in the intensity of the EEG alpha rhythm signals directly into a system which will correspondingly vary the intensity of a display lamp. The equipment will be used in the physiology laboratory, in the clinic, and in hospital rooms as required.

A search has been done and is being evaluated by the problem originator. In addition, the problem holds promise for developing into an applications engineering project.

#### HMH-1: Ultrasound Mapping of Heart Walls

Technological methodology and device to map the intact human heart of patients in a hospital are needed. The investigator is clinically treating patients with various kinds of heart disease. He seeks to find improved diagnostic tools for detecting myocardial infarctions and for mapping the walls of the heart. Ultrasonics have been used to establish the midline



of the brain, breast tumors, foreign bodies and mitral valve disease with limited success. The problem originator needs assistance from improved technology. The methodology and device are intended for clinical use. The electronic equipment and ultrasonic transducers must be non-invasive, atraumatic and safe for use on human subjects. Power levels also must meet these criteria.

A search of aerospace literature has been done and is presently being evaluated by the problem originator.

## DETECTION AND TREATMENT OF CANCER

### LLU-5: Method for Taking Repeated Biopsies of Soft Tissue Through a Single Portal

Apparatus is needed to take repeated samples of spleen, kidney, liver, and lung tissues which are soft and relatively free to migrate. Repeated samples should be taken very near the same sites and this requires an in-dwelling cannula or similar apparatus. Several needles have been tried and found to be unacceptable.

Exceptionally few references were retrieved from a search of relevant NASA technology. The Southwest Research Institute work in the field of tissue interface studies may be directly applicable to the problem. Problem originator evaluations of currently available information were requested.

### UFM-6: Xeroradiography of the Mammary Glands

Xeroradiographic mass screening tests for detecting breast cancer are being considered to reduce medical treatment costs and increase effectiveness of the screening process. A method is needed to rapidly xeroradiograph mammary glands. Mass screening of other soft tissues will follow if suitable and successful procedures are developed here. The problem originator was asked to evaluate the screened results of a search of NASA ultrasonic holography, telemetry, and other devices.

### LVA-3: Radioactive Cell Counting Method

It is extremely time consuming to use microradiography to detect the amount of tritiated thymidine uptake by rapidly growing malignant leukemic bone marrow cells. It requires 7 to 14 days to expose the emulsion to  $H^3$  beta particles and another 12 to 14 hr to microscopically count the exposed grains in developed radiographic emulsions. The procedure is a gross representation of radioactive uptake since the stem cell, monocyte, or megakaryocyte types cannot be identified. Identification of these cell types is a prerequisite to specific treatment of leukemic patients. The researcher needs a microdetector for beta particles ( $H^3$  or  $C^{14}$ ) adapted to a microscope and microlocator slide.

A Problem Statement is being prepared for sending to NASA for approval to disseminate to research centers.

### NMA-8: Ultrasonic Techniques to Support Radiological Therapy

The researcher needs techniques to nondestructively measure blood flow and arterial dimensions to assist in radiological therapy. Radiological therapy administered at hospitals must frequently be undertaken without direct knowledge of the inner surface of arteries to be treated. Knowledge of flow and arterial diameter is required for accurate calculation and administration of dose.

A search of relevant NASA technology is in progress. Results are being forwarded to the researchers for evaluation.

### SWC-3: Differentiation Between Normal and Abnormal (Tumor) Tissues by Using Ophthalmometric Techniques

The researcher determines differences in temperature, pressure, and flow rate of blood in the internal carotid artery and eye lesions (tumors), by applying sensitive thermistors, infrared detecting devices, and/or pressure and flow transducers. His research goal is developing improved clinical diagnostic tools for use on the 30 percent of eye tumor patients who constitute problems in diagnosis. Inadequate diagnostic techniques frequently hamper accurate diagnosis and early treatment of these cases. Improved diagnostic techniques will permit initiation of early treatment and lead to development of suitable preventive measures.

Results of available aerospace literature were sent to the problem originator. He was also provided with identification of a scientist who is researching a similar area.

### SWC-8: Improved Method for Computing X-Ray Depth Dosage

The radiologist normally computes an x-ray dose distribution when administering x-radiation for such therapeutic purposes as tumor treatment. Contours are delineated which circumscribe a body area in computing dosage. The technique fails to adequately evaluate absorbed tissue doses between the contours, and generally interpolates the data. Precision and accuracy in this area frequently may be lacking. The investigator needs a computer technique to x-y plot a dose between contours at any depth.

Results of a search of relevant aerospace literature were furnished to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers. A response was received from the NASA Ames Research Center which provided a possible problem solution. Evaluation is pending receipt of an x-ray dose distribution from an actual case, as requested from the problem originator.

### SWC-7: Improved Scan Resolution of Radioisotope-Filled Organs

The radioisotope imaging system should produce quality images with diagnostically significant detail. Radioisotope scanning and delineation of radioisotope-filled organs for clinical diagnosis is frequently difficult. The investigator is exploring new scanning techniques and considering new isotopes which may provide greater detail or image resolution. Minimal radiation injury protection must be provided for the patient at the same time.

A search was done to identify relevant NASA aerospace technology.

### PVA-2: Capabilities for Characterizing New Compounds Derived from Tumors

The problem originator has isolated minute samples of labile compounds from tumors. Extremely specialized microchemical and structural analyses instrumentation and techniques are required to analyze and characterize the diverse compounds. The techniques should include ultramicro infrared, ultramicro mass spectrometry (measuring compounds of the nature of ATP), fluorescence-phosphorescence, and interpretation of optical spectra. The problem originator has requested assistance with his problem area from available NASA technology.

### UAM-7: Exhaust System for Xenon Gas Disposal

Methodology for venting and disposal of Xenon gas which is exhaled by patients during their treatment at a hospital is needed. The problem originator has the responsibility for design of the exhaled Xenon gas exhaust system for a new hospital to be constructed. He has a 60-ft. horizontal run, plus 5 floors-vertically to plan for in venting the exhaled gas from the roof of the building. A fan will be installed on the roof to create negative pressure along the system.

A manual search of NASA technological literature yielded several possible systems. These are being evaluated by the problem originator.

### SWC-11: Determination of the Dispersion of Energy Distribution of Electron Particles at the Cell Level

Irreversible damage occurs to cells when they are exposed to radiation. This has been used as a principle in the treatment of certain types of tumors, etc. The concept of rads of radiation exposure for treatment and safety factors, was developed empirically from experience or a projection of what was known. Some research has been conducted to determine the impact and distribution of the energy of protons and other large particles. No one seems

to have researched the energy distribution dispersion of electron particles. Electrons tend to scatter because of their extremely small size. The present problem originator requires linear energy transfer relating to microscopic dosimetry data. Studies are to be carried out using the present capabilities for generating electron and gamma ray modes produced by a 6ME Linear Accelerator. Dispersion effects are to be measured using water, tissue cells and ultimately experimental animals. Knowledge is required about the energy deposited on the surface of cells which are some 5 cm below the level of the surface which is exposed to the radiation.

A search of the NASA literature was done and relevant technology provided for the problem originator who will evaluate alternative methods with respect to his specific interests.

#### ROS-1: Constant Velocity Vehicle for Small Laboratory

The investigator wished to study injuries to internal organs by utilizing experimental animals in a simulator in a small laboratory. A means to attain constant speed of 20-30 miles per hour with a minimum run or track is needed. The problem originator wants a constant velocity vehicle simulator for crash impact studies with primates.

A search of aerospace literature was conducted as an initial step in the investigation of the problem. Researcher suggestions as to direction in which to pursue the solution for this problem will guide the next steps.

#### SWC-12: Detection of Eye Tumors by Use of Radiation Probes

Eye tumors are more easily treated and prognosis is favored when early detection is possible. Some tumors can be detected by direct observation. Hidden tumors and tumors in very early stages sometimes must be located and identified by measuring the difference in radiation levels known to exist because tumor cells selectively absorb (uptake) radioactive materials.

Present radiation probe is inadequate. The probe must be able to detect in excess of 10% of beta radiation ranging up to 1.7 MEV (average 0.7 MEV) energy from P-32. The miniature geiger probe will be inserted between the eyeball and eye socket to various quadrants to measure linear energy transfer on a linear accelerator.

An appropriate miniature radiation probe was identified. Efforts are in progress to adapt this instrument for use in treating eye tumors. The engineering effort is expected to be finished soon and the probe will be delivered to the program originator.

CMR-1: Improved Method for Managing Body Wastes of  
Colostomy Patients

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Devices and methodology to effectively better manage body wastes and their byproducts from colostomy patients are needed.

Varying amounts of the lower colon may be removed (colostomy) and a new opening (stoma) from the colon to the body exterior is provided as part of some cancer treatments. Fecal waste materials exiting through the stoma usually have been collected by a plastic bag affixed to the abdominal wall by a belt or other means. Gas (flatus) accumulates in some patients and distends the plastic bag with undue psychological and physiological discomfort.

A search of aerospace literature was done to identify any applicable technology. Evaluation is under way regarding the method of attachment by various glues.

## ECOLOGY

### LLU-7: An Adjustable Histamine Aerosol Generator for Pollution Studies

The investigators are assessing the physiological effects of the characteristic smog-air pollution of large metropolitan areas. They need a method for generating a known and modifiable histamine aerosol to investigate physiological concomitants of histamine exposure. This is used as a proxy to study the effects of smog. The required methodology must provide precise control of output aerosol-histamine concentration. It must overcome heavy histamine molecule tendencies to "fall out" of suspension before they are driven into the surrounding atmosphere. A sensing apparatus possibly could be added to the nebulizer. The sensor automatically adds make-up ingredients as required to assure maintenance of precise concentrations.

A search of available aerospace literature has been initiated. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

### USC-4: Method for Measuring Rate of Change of Physiological Data

Residents living near the ends of airport runways are being studied for possible hearing damage caused by aircraft noise. The researchers intend to measure certain parameters while applying selected acoustical energies via headphones. They are interested in reaction and recovery time response of subjects to noise-bursts. They are looking for a method of taking galvanic skin response (GSR), heart rate, and, plethysmographic data which will simplify data acquisition, storage, and interpretation. Assistance from NASA technology was requested for the problem area.

Results of a search were forwarded for evaluation by the problem originator. He considers several of the documents to be excellent in his problem area. The team plans a visit to the investigator to discuss future planning for solution of his problem.

### GLM-33: DC Powered Proportional Temperature Controller in Biochemical Pollutant Studies

Biochemical pollutants investigators need an instrument to sense, control, and maintain a DC-powered oven. It must control temperatures within a  $0.2^{\circ}\text{C}$  accuracy in a range from  $75^{\circ}$  to  $225^{\circ}\text{C}$ . Conventional AC-powered units (SCR's) previously were used and they created problems of spurious noise signals in the researcher's other instrumentation.

Relevant technology was identified and a unit has been fabricated for the problem originator. See transfer report.

#### UTM-21: Animal Passage Direction Sensing

Crowding studies by psychologists at the University of Utah include the knowledge of the number of rodents passing along certain trails and the direction they are going during different portions of the day and night and under various stress situations.

A sensing system which discriminates direction of travel through a portal for small field rodents is needed.

A computerized search of aerospace literature has been done. Relevant technology was identified. An evaluation of several alternative systems is underway by team engineers. The problem is being considered as an applications engineering candidate.

#### TAM-2: Synthesis of High Protein Food from Raw Materials

A systematic, ecologically efficient means to produce food will be needed as agriculturally available land space is required for housing an expanded human population. Efficient and economically produced high protein food supplements have been developed from agricultural and oceanic products. A long term goal is seen requiring production of these foods from basic raw materials. Studies of food synthesis affect projected interplanetary space flights.

Devices, methodology, materials and chemicals must recognize economic feasibility factors. It would be desirable to recycle human byproducts and waste products as raw materials. The resultant foodstuffs must be safe for human use.

Multiple searches of aerospace literature have been conducted on this problem. Relevant technology has been identified and is currently being evaluated by the problem originator.

#### SNM-23: Ecology and Medicine

Advances in science have shown man to be part of a closed system of ecology. Space flight research has highlighted living conditions for a variety of life forms in a hostile environment. Essential parts of the environment had to be carried in space vehicles for man to survive the shortest flights. The problem originator seeks to organize all available data and apply them to an improved curriculum for optimum patient care.

Adjustments which apply to total ecology must recognize all life forms. Economic feasibility considering the earth as its own space vehicle will be part of anticipated planning and organization. Microsocieties and biological interactions should be included.



Computerized searching of the NASA data bank yielded a wide spectrum of potentially useful material. Evaluation of this material is underway, and important information will be followed up.

## HEALTH CARE COST REDUCTION

### SWC-4: Information Retrieval System for Clinical Records

The investigator needs to retrieve information from a bank on one-half million clinical records in a medium-sized hospital having 80,000 annual admissions. He particularly desires access to information from the records relating to specific medical treatment, disease prevention, and trend identification in medical treatments. He seeks to perfect techniques for providing guidance in cryptic disease treatments by computer analysis. Sophisticated data processing equipment (IBM Computer Model 360) is on hand at the hospital but there are no software programs available for the outlined task. The problem originator sought NASA technology assistance for his problem.

A team visit to the NASA Manned Spacecraft Center provided information concerning Dr. E. C. Moseley, of the Medical Research and Operations Directorate, and his development of some general computer programs for use in the Medical Information Computer Systems (MEDICS) program. They appeared to meet the requirements of the problem. They consist of:

Storage of Medical Records in Retrieval Form

Retrieval of Medical Data According to Specifications

Updating of Medical Data Bank

Action was taken to arrange for the problem originator to visit with Dr. Moseley and to obtain appropriate documentation. A potential transfer has been claimed for this problem.

### SJH-2: Interface Schematics for Incorporation of Biochemical Autoanalyzers to a Computer

The problem originator in his quest to automate the retrieval of biochemical data has acquired CLINC programs which will enable him to utilize a computer with his autoanalyses when suitable interface circuitry is developed. He needs NASA schematics of interface circuits used with his programs.

The problem originator discussed acquiring these with NASA researchers at a symposium in Houston which was sponsored by the SwRI Biomedical Applications Team.

### CMR-2: Call Signal for Quadriplegic Patients

Multiple amputee patients and patients who are paralyzed in all four of their extremities (quadriplegics) are unable to operate the usual call-switch to obtain nursing assistance. These severely limited patients usually need more nursing care than other hospital patients. The only solutions in the past have been to provide costly full time nursing attendance or schedule frequent and wasteful bed stops by the nursing staff. These patients are able to perform limited lifting and rolling head and neck movements. Proposed methodology should be easy to install and operate and should avoid discomfort, distractions and other interferences with normal hospital routines, patient's sleep, etc. The technology should be safe for use with patients and readily adapt for use with body positioning adjustments of hospital beds.

Relevant technology was identified. Detailed discussion is provided in Section II of this report.

### UAM-10: Design for New College of Medicine Hospital

Layout, methodology and design technology relating to construction, equipment, materials and personnel for an ultra-modern, 400-bed general hospital are needed. The problem originator has the responsibility for design of the new College of Medicine Hospital at Birmingham, Alabama. He seeks technology relating to the new NASA hospital under construction in Houston, Texas, as a source of comparative parallels for design and layout to include information on efficiencies, material choices, processing techniques and other planning or operational data.

Information and NASA technology in hospital equipment and facilities design were provided the problem originator for evaluation.

### UAM-8: Electrical Safety Standards for Hospitals

Between 1,200 and 12,000 patients annually are estimated to be shocked during the course of their hospital treatment. Some of the shocks are fatal and many hospital fatalities have not been recognized as caused by electrical shock. Patients and hospital staff members frequently are exposed to many, diverse and complex electrical connections. The problem originator seeks electrical safety standards to provide adequate protection for all types of equipment and procedures. Safeguard grounding of supplies and equipment is needed to prevent discharge of current into personnel. Static electricity and sparks are dangerous since they can cause shocks and also can ignite combustible gases and supplies used in patient care.

Electrical safety standards and NASA technology relating to improved techniques for reducing shock hazards have been provided to the problem originators.

#### CHS-9: Hearing Aid Tester

Hearing aids for deaf or deaf-blind children are very expensive. Only one hearing aid can be furnished for each child. The children usually are unable to communicate and this hearing stimulus is extremely important to their habilitation during the early treatment phases. The only means available for testing now consists of an oscilloscope which indicates presence or absence of waveform. There is nothing to indicate quality of configuration of sound.

The device should be as inexpensive, effective and easy to use as possible. It should be able to test the amplifier as well as the earplug with its hard wire lead. Anything which can be done to improve the quality as well as the consistency of the signal is needed here.

Deaf and deaf-blind children are severely isolated from the "normal" environment and need all available help to maximize their residual sensory physiology. An inoperative hearing aid prevents this.

The problem has been identified and a search initiated. Search results are being evaluated by the problem originator. The problem is a candidate for dissemination to various NASA research centers.

#### USC-3: A Secure Method for Patient/Specimen Identification

More efficient and economical acquisition and utilization of clinical test information is needed. A suitable means for data acquisition, analysis, recording, and billing is required for automation of clinical laboratories. A secure means for patient/specimen identification is a vital need. It must be available if a high degree of automation of clinical laboratories is to be achieved. It must permit accurate and rapid marking and reading of samples. The samples may be in a variety of containers, such as glass tubes, petri dishes, etc. Plastic-tab attachments to specimen containers has proved unsatisfactory. Radioactive coding and mechanical identification, drilling or scoring also have been suggested. Many different means have been unsatisfactory to private and commercial concerns because of misidentifications and other confusions. This constitutes a major roadblock in automation efforts. The problem originator sought NASA-technology assistance for unique approaches to identifications of specimens leading to automated readout and correlation of specimen identity, test data, data analysis, and patient billings. This will provide maximum clinical laboratory benefits at minimum costs in all areas.

Little relevant technology was retrieved from a search of the NASA Data Bank. A Problem Statement was prepared and sent for NASA approval to disseminate to research centers.

#### LVA-4: Research Facility Planning

The problem originator is planning to build a new medical research facility which will require a multi-story building, zonal air conditioning, interchangeable modular cabinetry, and optimum flexibility of modular laboratories and training space. It must accommodate regular and part-time staff members. Research will be broad, though concentrating on biochemistry and neurophysiology.

A large number of relevant references were retrieved by the search of available NASA literature dealing with laboratory facility planning. Other reference documents were provided from an on-site, in-house search. Several documents have been requested by the problem originator. NASA developments in the fields of facility and research-facility planning should prove to be valuable in planning of future medical research facilities.

#### NMA-1: Program to Establish Safe Electrical Standards for Patient Safety

A means is needed to establish a comprehensive set of electrical safety standards for equipment and instruments used around patients. Doctors and hospitals are concerned about the current tolerations in equipment and instruments around the patient in surgery and the intensive care unit. A great deal of electrically powered equipment comes in contact with patients in these situations and some of it has caused problems. A limit can be set to require manufacturers to cut down on leakage current if their devices become disconnected to a ground. Standards must be set for total leakage current about patients.

Reasonable standards also must be set for instruments, beds, stands, monitoring, and therapy equipment, as well as power cords and sockets. The problem originator requested NASA-technology help in this large problem area.

Several possible leads to the solution of the problem were retrieved from a search of the NASA Data Bank. The overall solution will entail proper formulation of a program which is specifically tailored to hospitals. Further definition of the problem is underway.

## SNM-19: Computer-Based Health Records Systems Development

Development of a computer-storage-and-retrieval medical records system which is appropriate for servicing the needs of a large country hospital center is underway. The researchers urgently need existing computer-based records systems to increase speed and accuracy of medical records handling. The present system is proving inadequate for the growing hospital load.

The search of NASA literature retrieved technology concerning medical data processing. The team also sponsored a Medical Information Systems seminar during July 1970 at the NASA Manned Spacecraft Center which the problem investigator attended. A significant application of technology may result from this meeting at Houston.

## KIDNEY DISEASE DETECTION AND TREATMENT

### UFM-1: Rapid Quantitative Analysis of Urine Constituents

A rapid and economical method or instrument is needed to analyze elements and compounds in urine. Diagnosis and treatment of patients are presently delayed in hospitals by the slow and costly urinalysis techniques. The problem originator must analyze urine specimens for sodium, potassium, calcium, magnesium, oxalates, urates, and urea.

Previously searched, related bioproblems provided the team with relevant and current information for this problem. This was furnished to the problem originator while the team continues to search for an economically acceptable method to solve this problem.

### BLM-16: Measurement of Electrolyte Concentrations in Renal (Kidney) Medulla and Papilla

A renal physiologist is investigating the microcirculation of blood in the medulla and papilla of a dog's kidney in ongoing research into kidney function and operation. He is particularly interested in the in situ and in vivo acquisition of sodium, potassium, and chloride ion concentrations obtained by inserting a minute probe into the kidney. Salt and water intake will eventually be introduced to physiologically vary the ion concentrations in the study.

A computer search of the NASA Data Bank was completed and the results were forwarded to the problem originator. This search provided interesting and useful information but failed to solve this problem. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers. The team visited the NASA Manned Spacecraft Center and learned that NASA-sponsored researchers were working on a similar problem. The problem originator was urged to individually contact these scientists to discuss possible approaches to the problem.

### BLM-17: Improved Procedure to Measure Regional Blood Flow in the Kidneys

A renal physiologist is investigating the microcirculation of blood in various layers of the kidney in ongoing research into kidney function and operation. Rigid electrodes are inserted into the kidney with micromanipulators while the kidney is lying in a cup outside the body during hydrogen-washout techniques. The investigator needs suitable electrodes to implant and measure

regional blood flow in situ. Observations must be repeated on the animal over long periods of time.

Results of a manual search of relevant NASA technology were forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers. The team made a visit to the NASA Manned Spacecraft Center and obtained names of researchers. They are being contacted for suggestions in this problem area.

#### DLM-14: Detection of kidney Stones During Surgery

A physician urgently needs a method or instrumentation to detect small stones in the kidney during surgical procedures. Larger renal calculi (stones) can be removed with surgical techniques. The smaller calculi are difficult to locate and remove, however, and commonly cause recurrence of the calculi problem with a requirement for repeated surgery. This increases both hazard and expense for the patient as well as inconvenience. The required technology must be accurate, reasonable in cost, relatively easy to operate, and adaptable for operating room use. Roentgenography, which has been useful in establishing the presence of large renal calculi, has been inadequate to identify the smaller calculi. Improved radiographic techniques or ultrasonics may provide applications to solve the problem.

Efforts were initiated to acquire an ultrasonic scanner to be evaluated by the problem originator. A Problem Statement was prepared in June and sent to NASA for approval to disseminate to research centers. Following approval, dissemination was made to NASA Manned Spacecraft Center, Goddard Space Flight Center, Marshall Space Flight Center, Langley Research Center, Lewis Research Center, Ames Research Center, and John F. Kennedy Space Center.



## REDUCTION OF INFANT MORTALITY

### SNM-12: Measurement of Uterine Artery Dimensions

The problem originator hopes to reduce the numbers of stillborn infants and incidence of birth defects by measuring the diameter of the uterine artery to provide better obstetrical care. Measurement of the uterine artery during gestation will provide additional physiologic information for insuring the birth of healthy babies. It has been practically impossible to directly measure the uterine artery diameter because physical contact can induce spasms which greatly reduce or halt the flow of blood to the fetus. He needs a nondestructive, nonconfining, uterine-artery-diameter measuring method.

A search of aerospace technology was performed and applicable documentation was retrieved. These were sent to the problem originator. The pulse-echo ultrasonic techniques hold the most promise for a solution to the problem. A custom-designed transducer assembly may be required to modify the technique and fit specifications of the immediate problem.

### SNM-13: Miniature pH Electrode for Fetus

Researchers are seeking supplemental physiologic information concerning the well being of the infant as the birth process begins. Measuring the in vivo pH of the fetus during labor may provide such information. A pH probe for this purpose necessarily has unusual requirements and this complicates solution for the problem.

A computerized search of NASA technology is presently in progress to identify any relevant methodology and devices.

### SNM-14: Fetal ECG Telemetry

The problem originator seeks to telemeter fetal ECG with clip-on electrodes to provide better obstetrical care, specifically during labor and birth. A transmitter will be inserted at the onset of labor to monitor continuously until birth. Bulky, hard-wire instrumentation is used for this purpose and it decreases mobility of the patient. The needed transmitter must be small enough to insert into the uterus and must be nonirritating during the course of labor. It should transmit at least 10 ft. and have a useful life of 10 hr.

Search retrieved information about a NASA-designed ECG transmitter which is in the final testing stages. The instrument is sufficiently small to be used for this purpose. Data will be forwarded to the problem originator as soon as it becomes available for evaluation.

#### SNM-15: Uterine Pressure Telemetry

The problem originator seeks to monitor a pregnant patient's uterine pressure during labor to provide better obstetrical care. The data must be telemetered over a short distance. He currently measures the pressure by hard-wire instrumentation. This is encumbering to the patient and he feels telemetry could provide optimized care. He needs an implantable pressure telemetry unit which should be able to transmit for 10 ft., have a useful life of 10 hr., and throughout the period, be noninjurious to the uterus or the fetus.

A search of aerospace literature retrieved relevant technology. The problem can be solved by an in-house fabrication of a pressure telemetry unit after the problem originator decides on an acceptable design.

#### DLM-5: Measurement of Fetal Circulation from Transcutaneous Transducers and Artery Location by Depth Measurement

The problem originator uses ultrasonic techniques to monitor fetal blood circulation during labor and delivery. The procedure detects abnormal conditions which may arise during this critical period. He uses the same transcutaneous, ultrasonic probe without changing probe location to acquire flow information and determine the distance to the artery as well as determine arterial diameter. The investigator requested available NASA technology to solve this multiple requirement.

A manual search of NASA technology was performed. The screened results were forwarded, with some additional materials, to the problem originator. A Problem Statement was prepared and sent for approval to NASA.

#### DLM-4: Doppler Probe Holder and Stand

The problem originator uses ultrasonic techniques to monitor fetal blood circulation during labor and delivery to determine if abnormal conditions arise during this critical period. He uses a hand-held probe to monitor the blood flow. A means to stabilization for the probe is needed for chronic measurements to reduce artifact generation from movement of the probe. The holder and stand should firmly hold the probe, but should not hold it rigidly to avoid pain during the procedure. The arrangement must be adjustable because the probe and holder must be positioned over women of various dimensions.

Interaction with NASA Langley Research Center retrieved a solution inherent in a holder which is used extensively in their work. It is operated by a lever-activated cam which quickly and firmly tightens the flexible shaft. The problem originator was furnished the information and he has obtained the holder for his use. See Section II of this report.

## RESPIRATORY DISEASE DETECTION AND TREATMENT

### OVA-2: Measurement of Lung Compliance

The lung volume-pressure relationship is measured by having a patient breathe into a closed system to assess function of the lungs. The data acquisition is time consuming, involves bulky equipment, and is difficult when the patient is seriously ill. The indications are suitable for bases of gross diagnosis. Subtle abnormalities or changes are not readily detectable. A reliable, convenient, and atraumatic method is needed to measure pulmonary compliance of the lung by the signaling rate and volume of airflow. It must be possible to sterilize the temperature and moisture insensitive transducer or head. It can be attached to a standard endotracheal tube through which the patient breathes, or through which he is ventilated by a respirator. Acoustic or mechanical vibration may be applicable.

The team performed an aerospace-technology search. The problem also is being circulated to NASA research centers for possible solutions.

### GVA-6: Respiration Monitor

Cardiovascular patients require certain respiration studies. Analysis of the expiration cycle of tidal volume measurements are compared with the respiration rate,  $pO_2$  and  $O_2$  concentration to accurately describe the pulmonary well-being. The problem originator needs techniques to monitor respiration rate,  $pO_2$ ,  $O_2$  and analyze expiration waveshapes.

Data on measurement of exhaled gases were forwarded to the problem originator. A computerized search of aerospace technology was performed. Evaluation of possible approaches to the problem led to a suggestion that a respiration monitor be modified. It would control a gas analyzer to exclusively analyze exhaled air during a respiration cycle. This appears to be the best solution available.

### NMA-6: Demand Water-Level Float

The problem originator needs a demand water-level float for a nebulizer. It cannot contaminate the water supply source. Nebulizers which are currently being used for inhalation therapy are being contaminated with Pseudomonas organisms. Pseudomonas organisms appear in the supply bottle within 12 hr. The designed operation of the nebulizers is for 72 hr. The water-level float operates specifically on the return air from the jet bowl. The new design of the demand float should not allow air to return to the jet and then to the supply bowl.

A search of relevant NASA technology has been run. Evaluation by researchers is in progress.

BLM-21: Expired Oxygen Analysis in Respiratory  
Physiology Studies

The investigator requires a method to rapidly measure the quantity or partial pressure of oxygen concentration in gaseous mixtures. This must be a reliable and accurate technique for breath-by-breath analysis of oxygen. The technology should have sufficient response time to follow oxygen concentrations throughout each breath pattern. Paramagnetic-type oxygen analyzers, currently in use, are inadequate because they are slow-responding devices. The needed instrument must continuously measure with a response time less than 40 msec, a response interval time of 1 to 10 msec, and a known and negligible latency interval.

The team performed a manual search of available NASA technology. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

CLA: Newborn Infant Respiratory Monitor and Apnea Alarm

A short range thermistor-telemetry device to monitor newborn infant respiration with alarm for respiratory arrest or apnea is needed. Doctors and nurses have been required to minimize infant mortality. This is particularly important if the baby is born with or develops respiratory or cardiac conditions. These children are in marked danger of respiratory arrest or apnea. The problem originator seeks to relieve doctors and nurses of this time consuming observation by means of a small thermistor. It can monitor respiration by short range telemetry and activate an alarm if respiratory arrest or apnea occurs. Immediate alert is provided for respiratory distress and prompt treatment is enhanced as required. The device should be lightweight, small, and have a non-invasive sensor.

Relevant NASA technology has been identified. Applications engineering activity has resulted in providing the investigators with a device to solve the problem. See Section V of this report for detailed discussion of the problem.

TCH-1: Quantification of Biochemical Changes in Striated  
Muscle Due to Inactivity

The problem originator uses standard micromethods to determine muscle cell levels of water, fat, sodium, potassium, calcium, magnesium, protein, adenosine triphosphate and water soluble nitrogen. He plans to establish treatment schedules for chronic, bedridden, iron lung patients. He needs assistance to develop reliable and rapid techniques and is particularly interested in the potassium microtechniques available. Methodology must be safe to use with patients. It should be on the order of a microprobe

which can evaluate small sections of biopsy materials. The researcher is willing to travel to any applicable NASA technology and evaluate it on-location if necessary.

The researcher was advised of the availability of an electron microscope and microprobe at Houston Manned Spacecraft Center. A search of aerospace literature has identified relevant technology in several areas.

#### FTZ-2: Invasive Means for Measuring Blood Gases

The researcher needs to measure blood  $pO_2$ ,  $pCO_2$  and pH, on-line with needle electrodes. He is searching for an accurate, relatively economical and convenient method which does not require blood sampling. A system to measure blood gases in critically ill patients is needed. Small needle electrodes will be acceptable.

Advanced NASA technology for measuring blood gases is being identified and will be made available to the problem originator for evaluation.

#### ROS-2: Method for Measuring Blood Gas Without Breaking Skin

Accident victims and critically ill patients must be quickly diagnosed with minimum trauma. Knowledge of blood-oxygen would be very useful in many instances. An atraumatic, skin-contacting method for measuring  $pO_2$  in the blood is needed.

The problem originator is presently evaluating the latest NASA developed technology for non-invasive blood gas measurements.

#### FTZ-1: On-Line Breath Analyzer

An accurate, reliable, on-line analyzer to identify contents of expired gases is needed. The researcher is specifically interested in the analyzer described in the NASA document N70-25476 "Astronaut Breath Analyzer." He also is interested in other on-line devices that measure these parameters.

Information has been provided for evaluation by the problem originator.

#### UTP-4: High G-Forces Effect on Blood Gas Exchange

G-forces encountered during falls and vehicular accidents are essentially similar to those encountered during launch and recovery of space vehicles. Only a relatively small G-force is needed, for example, to fracture the spine.

The problem originator is directly involved with patient care for victims of impact injuries. He is interested in the abrupt and remarkable changes in the physiology of the respiratory exchange that occur in addition to any other trauma suffered in a variety of impact injuries. Respiratory changes may contribute to or be the cause of death in fatal accidents, and he feels the key may be found in NASA-acquired data on the physiological changes in blood gas exchange under high G-forces.

A computerized search of aerospace literature has been initiated. It is expected that much relevant and applicable technology will be recovered.

#### UTM-1: Continuous Blood Gas Analysis for Accident Victims

The problem originator is directly involved with patient care for victims of impact injuries. He is interested in the abrupt and remarkable changes in the physiology of the respiratory exchange that occur in addition to any other trauma suffered in a variety of impact injuries. These changes may either contribute to or be the cause of death in fatal accidents. He needs a means to continuously monitor and analyze blood gases to assess diagnosis, prognosis and response to treatment. The monitor must be accurate, reliable and sufficiently miniature to avoid unnecessary trauma from implantation. It must be biocompatible and safe for use on humans. Results obtained from the monitor must be reproducible.

The problem has been identified and a search has begun for relevant NASA technology.

## SURGICAL PROCEDURES

### ULA-1: Orthopedic Surgery Clean-Room, Laminar Air-Flow Technology

Prevention of infections directly bears on improved patient care and also on increased legal interest in malpractice suits arising from hospital-acquired infections. Modern medicine continuously emphasizes control of infections in hospital surgery. This is critically important for orthopedic surgery because prosthetic hardware devices frequently are placed and maintained within surgical openings to repair or replace patients' damaged or missing bone structures. In the past some ( 8%) orthopedic patients experienced delayed (3-5years) postsurgery, low-grade infections. The rate has been lowered (1-3%) whenever clean room and ultra-clean room orthopedic surgery was employed. Controlled (vertical, horizontal, etc.) laminar flow of filtered air has been proposed as a means to insure that only sterile air will contact or pass over exposed surgical surfaces and/or the prosthetic devices. The problem originator needs technology design for contamination-free, surgically clean rooms. The design should be flexible enough to permit use within present hospital facilities and incorporation within plans for new hospital construction.

NASA advancements dealing with clean-room technology have been made available to the problem originator via computerized searching of aerospace literature. Various designs are under consideration by the problem originators.

### HPH-2: Exhaled Air Exhaust System for Clean-Room Surgery

Hood and mask technology to exhaust the air exhaled by surgical team personnel during clean-room procedures is needed. Clean-room procedures have assumed increasing importance in orthopedic surgery because they have effectively lowered the rate of postsurgery infections. Laminar air-flow surgery techniques have been developed as a part of the clean-room procedure to provide a flow of sterile air across the surgical opening. Air exhaled by the surgical team could contravene other clean-room efforts if a means for venting it is not provided. The problem originator seeks technology to exhaust the exhaled air.

The latest available clean-room technology developed by NASA was provided for the researchers. Assistance in evaluation of alternative systems is being given by Biomedical Applications Team members.

#### HPH-1: Particle Detector Monitor for Clean-Room Surgery

A particle detector system to monitor the output of the air balance filters for clean-room orthopedic surgery is needed. Prevention of infections is essential to improved patient care in a hospital. Control of infections is critically important for orthopedic surgery because of the added hazard when prosthetic hardware is used in the surgical openings. Low grade infections (some delayed 3-5 years postsurgery) have been significantly lowered in rate whenever clean-room surgery was employed. The problem originator proposes to use a monitor system to detect particles at air filter outputs to assist in assuring clean-room conditions.

Searches of aerospace literature to retrieve clean room technology are being done. Assistance in evaluation of equipment which offers a potential solution to the problem is being given by engineers and scientists on the Biomedical Application Team.

#### LLU-6: Noninvasive Minimal Encumbrance Methods for Physiological Data Acquisition

A surgical research team at a western university is seeking noninvasive, noncontacting methods to measure blood pressure, heart rate, respiration, and other parameters. The parameters are useful in surgery and in the intensive care ward.

Information on advanced bioinstrumentation concepts and equipment was retrieved through a literature search. Material has been sent to the problem originator and it is currently being evaluated for a possible solution to this problem.



## DETECTION AND TREATMENT OF DENTAL AND ORAL DISORDERS

### WVA-2: Electrodes for Measuring Tooth Potentials

New methods are being developed for predicting and diagnosing peridontal disease. Suitable electrodes are needed to measure resting potentials on the surface of the teeth. Calomel and Ag-AgCl electrodes have been tried and their stability proved to be inadequate. The electrodes must be applied to small contact areas on dry, intact teeth.

The team performed a search of NASA technology. A NASA electrode-design scientist was contacted and, after he considered the problem, he agreed to respond to it.

## BASIC MEDICAL RESEARCH PROBLEMS

### PVA-1: Cellular Aging Caused by Ionizing Radiation, Weightlessness, and Exotic Gases

The problem originator's research is to explain the process of aging. Certain gerontological phenomena may be explained by changes in organelles. The researcher is relating effects of ionizing radiation, weightlessness, and exotic breathing gases to aging in the cells. He has requested assistance from relevant NASA technology in this problem area.

A manual review of the aerospace indices has been prepared.

### BLM-24: X-Ray Exposure and Gravitational Effects on Body Functions

Whole body responses to x-radiation are being studied to include the circulatory (blood) system, respiratory system, and kidney functions. The researcher determines the effects of gravity upon physiological changes in an x-irradiated experimental animal. The animal is whole-body exposed to x-radiation and then placed upon a tilt table. Changes of posture are employed which are accompanied by hemorrhage or other injury. The problem originator requested available NASA technology relating to body functions in zero-gravity or partial-gravity environments.

A manual search was made of NASA literature and the screened results were forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

### SNM-9: Chemical Analysis of Biological Molecules Utilizing X-Ray Fluorescent Techniques

The investigator is studying relaxed application of x-ray energy to the life sciences and the field of x-ray diagnosis. X-ray fluorescence has been successfully employed for elemental analysis in physical and mechanical sciences. The problem originator is seeking a method for using x-ray fluorescence as a practical biochemistry, analytical tool. He has requested NASA technology for x-ray microprobe analysis of biological molecules. He feels that expanded insight into advanced technology may develop x-ray intensities for quantitative analysis with selective excitation of molecular structures.

A manual search was made of NASA literature and the screened results were forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

#### USC-11: An Implantable Bone Pressure Transducer

The problem originator seeks to apply external pressure during the healing process in his study of bone fracture healing. He will measure axial pressure by implanting a pressure transducer in the bone. He will place the transducer in drilled and counterbored flat holes. Wire leads are acceptable in his planned technology.

The team plans to make a computerized search of NASA technology relating to implantable pressure transducers. This will be made available to the problem originator. In-house information concerning miniature pressure transducers will also be evaluated for application to this problem.

#### SNM-4: Improved Techniques for Measurement of Skin Thickness

The physician indirectly measures fat and skin thickness on the body by a caliper measurement of skin fold thickness over body fat tissue. These measures of skin thickness lack the precision required for reproduction of reliable research data. The problem originator requires an accurate and precise new method to measure skin thickness. It must be compatible with procedures of obtaining skin thickness measurements as a function of time. The technology must be designed to be portable and useful under changing conditions of field research as well as under hospital conditions. It must be simple to operate, sufficiently precise to minimize experimental error, and provide a permanent record of collected data.

Only five references were retrieved from a computerized search of the NASA Data Bank. None of them were pertinent to the problem. Material on hand and that retrieved from a manual search of literature possibly may meet requirements of this problem. The data evaluation is being made by the problem originator. This problem is being classified as a potential technology application. A Problem Statement has been prepared and sent to NASA for approval to disseminate to research centers.

#### USC-2: Skin Elasticity Measurement

The researcher needs a satisfactory means for quantitatively measuring skin elasticity. The clinician pinches and pulls the skin to evaluate it. He uses this test and other clinical diagnostic information to detect and evaluate the severity of Hansen's disease and certain congenital conditions or diseases. A quantitative test procedure will provide more valid information and may be performed by paramedical personnel. A suitable, temporary, mechanical connection to the skin must be able to displace the

point of contact 1 cm from the normal, and provide a measure of the required tension. There must be a maximum of 2 lb tension and calibrations must be provided for displacements of 0.5 to 1 cm. Tension and displacement measurement accuracy must be  $\pm 10$  percent. Tensions will be maintained for no longer than 5 sec. A visual readout is acceptable.

Few retrieved references came from a search of aerospace technology. Two possible approaches to the problem were identified. There is a skin glue developed at an Army hospital and a torque method for measuring skin condition. More information is being sought in these areas.

#### LVA-7: Rat ECG Measurement with Minimal Encumbrance

Rats are confined in an inflatable plastic chamber and are being studied for trace element deprivations. Rats must be handled minimally and avoid exposures to metallic apparatus. The researcher seeks an integrated instrumentation enclosure which simultaneously acquires ECG, foot pad temperature, and weight. Each test colony will contain 32 rats.

NASA-developed technology is being searched for a system to measure the three parameters. The problem has been disseminated to NASA centers. Several promising responses have been received.

#### LVA-6: Rat Temperature Measurement Device

Rats are confined in an inflatable plastic chamber and are being studied for trace element deprivations. The temperature of the rats must be taken periodically without removing them from isolation and without exposing them to metallic apparatus. Researchers have detected noticeably "cold feet" on animals that have been deprived of certain trace elements. Deep body temperature previously has been observed. The researcher seeks an integrated instrumentation enclosure which simultaneously acquires ECG, foot pad temperature, and weight. Each test colony will contain 32 rats. The method should be rapid, convenient, and minimally restraining within the isolation chamber.

A computer search of aerospace literature has been initiated for the problem. The problem has been disseminated to NASA centers. Several promising responses have been received.

#### LVA-5: Rat Weighing Device

Rats are confined in an inflatable plastic chamber and are being studied for trace element deprivations. The individual rats must be weighed

periodically without removing them from isolation and without exposing them to metallic apparatus. The researcher seeks an integrated instrumentation enclosure which simultaneously acquires ECG, foot pad temperature, and weight. Each test colony will contain 32 rats. The device must operate in trace element sterile environments and be small enough to be portable and easily moved from chamber to chamber. One possible application could be an enclosure mounted on force or pressure transducers to provide a direct readout. A metallic scale with a plastic cover presently is being used. Surgery and wireless telemetry should be avoided. The problem has been disseminated to NASA centers. Several promising responses have been received.

#### BLM-23: Germ-Free Hamster Colony

The experimental biology investigator requires germ-free experimental animal colonies which are developed by means of sterile caesarean surgery. The animals are nourished on a sterile diet and maintained in sterile environments. All efforts to provide these conditions with the hamsters have failed in spite of successes to produce germ-free strains of rabbits, rats, etc. Nutritional inadequacy of the synthetic milk formula diet has been suspected as the cause of this failure, but this has not been established. The investigator needs a means for hamster care in the germ-free environment in order to proceed with his work.

A manual search was made of NASA literature and the evaluated results were forwarded to the problem originator. A Problem Statement has been prepared and sent to NASA for approval to disseminate to research centers.

#### LLU-8: Methods for In-Flight Tracking of Medically Significant Insect Vectors

Control of the Triatoma bug is of significance to medical entomologists because it is a carrier (vector) of Chaga's disease. This sleeping sickness disease afflicts thousands of people in Central and South America. It poses a threat to millions in this country because of the widespread presence of the Triatoma bug. The problem originator plans to track this bug in its nocturnal flights to ascertain its ranging habits and provide a means of effective controls. This bug is about the size of a large cockroach and can carry a very modest package. The investigator has applied radioactive paint and thus located them when they were inactive. He needs a method of in-flight tracking to continue his research with these insects.

Locally available NASA technology is being evaluated for possible application to this problem. A computer search has been made to retrieve relevant technology.

#### PVA-5: Low Noise EEG Preamplifiers for Clinical Research

A California researcher in experimental physiology needs a small, low-noise preamplifier which can be attached very near the EEG electrodes. The system currently in use is excessively noisy. The solution should provide a schematic since the circuitry is to be custom-packaged and this will facilitate self-fabrication.

The team currently has completed a NASA Data Bank search. Results are being evaluated.

#### LVA-2: Methods for Handling Data Related to Neurological Research on Nerve Firings

The problem originator stimulates sensory cells of cats and manipulates feedback paths. He requires technology for handling nerve-firing-potential neurological data to provide immediate playback, storage, and analysis. A request was made for available NASA assistance with the problem area.

Information and available NASA technology were provided to the problem originator as a result of a computer search of aerospace literature.

#### USC-10: Nonsurgical Methods for Treating the Inner Ear

Meniere's Disease has been treated by a semidestructive application of ultrasonics. There have been some indications that electromagnetic energy also has been used, according to the reference "Treatment of Meniere's Disease," M. Basesy Laringo, Laryngoscope, 80:768, May 1970.

A computer search has been initiated for the problem. The team is awaiting results of this search for indications which will determine the further direction of investigations.

#### USC-9: Methods for Obtaining Otological Response in Experimental Animals

Human otological responses are measured by recording the skin potentials that are generated by eye movement. The problem originator needs an improved methods for measuring this indirect response, or some means for measuring a direct response.

A search of available aerospace technology is in progress.

#### USC-8: Methods for Handling Electronystagmology Data

Otological functions are determined and otological diseases are diagnosed through recordings of electric potentials caused by lateral and azimuthal motions of the eye. A semiautomated means is needed to handle and analyze data derived from the investigator's experiments with laboratory animals (guinea pigs).

A search of available aerospace technology is in progress.

#### USC-7: A Method for Measuring Angular Rotation of the Eye

Electric potentials at the surface of the skin measure indications of lateral and azimuthal motions of the eye. Rotation of the eye in its orbit causes no detectable potentials. Rotation of the eye in its orbit currently must be measured by photographic techniques. The problem originator requested available NASA technology concerning clinically applicable measurements of angular rotation of the eye.

A search of available aerospace technology is in progress.

#### USC-6: Nonocular Methods for Monitoring Vestibular System Function

Hot or cold water applied to the ear, and observation of induced lateral and azimuthal eye reactions, is currently an acceptable otologic-function evaluation method. Temple-region skin electrodes are used in electronystagmology to measure electric potentials caused by eye movement. The problem originator requested available NASA technology related to other clinically applicable, atraumatic methods.

A search of available aerospace technology is in progress.

#### TCM-3: Peak Detector for Signal Conditioning of Blood Velocity Measurements in Basic Medical Research

Erythrocyte velocity is measured in microcirculation studies of capillaries which supply blood to critical organs. The problem originator intends to apply better understanding of these organs in his research of diabetes and other organ breakdown studies. Erythrocyte capillary velocity is photometrically acquired. The erythrocytes pass over two slits where two phototubes measure and present transit-time information to a correlator. The problem originator seeks to generate sharp pulses at the instant of passage to improve the methodology. Better definition of erythrocyte passage time requires technology which will read the peak analog signal and then generate a pulse at the peak.

The team is studying locally available NASA literature for application to this technological problem.

NMA-7: Ultrasonic Catheter Transducer

Determinations of artery inner-layer dye uptake by nuclear dosimetry require measurement of the inner surface layer of the artery. The diameter of the artery must be known to properly make the determination. The problem originator requires an ultrasonic transducer for pulse-echo measurements. Methodology should be nondestructive in application to animals and later to humans.

A search of available aerospace technology has been made. Results are being evaluated.

SRS-9: Comparison of the Electromagnetic and Ultrasonic Doppler Blood Flow Measurement Methods

The problem originators measure blood flow, with the electromagnetic and ultrasonic Doppler methods, to comparatively determine the most reliable, accurate, and convenient technique. The problem originator requested available NASA technology concerning comparative electromagnetic and ultrasonic Doppler applications to measure blood flow velocity.

The team has assembled available information and forwarded it for evaluation and comments by the problem originator.

SWC-6: Apparatus for Micropuncture of Pancreatic Gland

The basic research of the problem originator relates to cystic fibrosis as it affects children. The investigator requires a subminiature electronic device to micropuncture ducts and cells of the pancreas for in vivo chemical analysis of various inorganic ions and enzymes.

Screen results of a completed search of aerospace technology have been forwarded to the problem originator.

BLM-15: Determination of the Physical Chemical State of Ions and Water in Living Cells

The problem originator is determining the physical location, in three dimensions, of the sodium ions within skeletal muscle fibers and other cells. The researcher requested available NASA technology for measuring this parameter.

The screened results retrieved from a computer search of NASA data were forwarded to the problem originator. He indicated that some of them could



be applied for later studies, but none solved his immediate problem. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers. During a team discussion with NASA Manned Spacecraft Center researchers, an electron microprobe which can provide the required information developed as a potential solution. The electron microprobe used at the NASA Manned Spacecraft Center is not presently adaptable to in vivo determinations. The microprobe is available for use by the problem originator if it is possible to make specimen preparations.

#### JVA-1: Fluorometry Test Sample Temperature Regulation

The problem originator presently uses a ratio fluorometer to analyze enzymes in the hospital. The light source of this instrument has created temperature problems which have severely hampered efficient operations during research and clinical applications. Inside instrument temperature has been elevated to the point where cuvettes become overheated; this affects the validity of the results.

The team is investigating NASA technology in the areas of equipment cooling and life support in an attempt to solve the problem without extensive redesign of existing equipment.

#### SJH-1: Interfacing Biochemical Autoanalyzers with a Computer

The problem originator seeks to increase the efficiency of the pathology department and medical costs-to-patient by interfacing biochemical autoanalyses to a SMN-12-60 computer. He has requested available NASA technology concerning the required logic and necessary programming to acquire autoanalyzer outputs and convert them for analysis and summary by computer. He requires a fixed window or variable window gating system to peak-read autoanalyzer signals and a program to acquire a summulative summary report.

The team learned that the NASA Manned Spacecraft Center has a computerized autoanalyzer. A team-sponsored medical information system seminar was presented in Houston, Texas, during July 1970. The problem originator attended the seminar and has requested schematics of the autoanalyzer-computer interface. This will be made available from the NASA Manned Spacecraft Center together with several computer programs which they developed for it.

### GLM-23: Determination of Attractive Forces Between Red Blood Cells

It has been experimentally determined that the effective viscosity of blood increases as a result of decompression sickness and other types of trauma. The problem originator seeks to identify changes in the attractive forces between red blood cells. He proposes to take the strongest available theories of dispersion viscosity and examine their suitability to the study of blood. He will modify the theories as required for the specific application and then analyze available blood viscosity data.

A manual search was made of NASA literature and the screened results were forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

### GLM-30: Electrical Model for Transmission of Information Within a Single Cell

A model is needed to determine how contact information that is obtained at one end of a protozoan cell reaches the other end. The Paramecium is a single cell animal which propels itself by means of hundreds of cilia that are distributed over its surface. It presumably reverses direction of cilia beat and instantaneously reverses its movement upon contact with a mechanical or chemical interference. This presumption is valid because its forward motion is in a spiral and the reverse motion is in a reverse spiral. New electron microscopy evidence indicates a continuous fibrous network located beneath the cell surface which could serve to pass information from one end to the other, in spite of the discreditation of an impulse hypothesis by other researchers in the past. Analogy of this concept with the function of a nerve cell is poor for many reasons. The concept of translocation of simple information to rapidly cause ciliary reversal may be advanced through developments in solid state electronics. This could permit construction of a model.

The screened results of a search of NASA literature were forwarded to the problem originator. A Problem Statement was prepared and sent to NASA for approval to disseminate to research centers.

### GLM-34: Protective Coating for Precision Optical Instruments

A protective coating material is needed to prevent corrosion of brass. The problem originator seeks material to prevent corrosion of valuable microscopes over a long time period. The material should not affect optical surfaces or qualities of the microscope. It should not affect the ease of mechanical movements of the gears and other moving parts. The material should be clear and reasonably wear-resistant. It must be available

in the small quantities needed and must be applicable to assembled microscopes having optical surfaces and lubricated mechanical elements.

Literature search results are being evaluated.

### CHS-3: Multiple Electrode Stimulation of the Cochlea (Ear)

A system of multiple (20-30) electrodes mounted on flexible plastic for insertion into the cochlea of the human inner ear is needed. The researcher has been attempting to transmit electrical pulses via electrodes inserted within the cochlea of the inner ear, with a range of 3 to 200 pulses/sec. Three pulses/sec applied to appropriate cochlea region may sound like a 1000 Hz tone - another region may yield a 3000 Hz tone, etc. Pulses transmitted through cochlear fluid will stimulate auditory fibers within a 5-10 mm area (although possibly 1-2 mm). Insertion material with 3 to 4 electrodes have been used. The increased numbers will expand research. Gold or platinum is suggested as a suitable biocompatible material. Electrodes should avoid overlap for transmission of the pulse. They should be able to handle 300 to 500 microamp pulses from an electrical source. Lead wires must fit a diameter of 0.5 mm. Insulation should be provided to avoid leakage and electrodes should minimize polarization. Pulses will be distributed among electrodes to approximate auditory configurations.

A literature search is presently being done on this problem. Results will be forwarded to the problem originator for evaluation.

### CHS-7: Auditory Center Brain Implant Electrode

The researcher has been studying cat responses to stimulation of auditory centers by means of hard wire electrodes implanted within the brain. The electrode assembly is held in the end of a hollow needle during implantation. Glial cells appear to attach themselves to the implanted system and hold it relatively firm in place. Present materials have not been sufficiently precise in configuration and this has delayed research. A biocompatible electrode for long term (balance of lifetime) implantation into auditory brain centers to stimulate responses is needed.

NASA developed electrode technology has been made available to the problem originator for evaluation.

### RRC-7: Oscilloscope Synchronization for Electromyographic

Technological methodology or device to initiate an immediate triggering of an oscilloscope sweep upon movement of EMG needle is needed.

It is possible to control the operation of a recording oscilloscope in a free-running mode, internal synchronizing and external synchronizing. The problem originator is clinically investigating the electromyographic (muscle electrical energy) impulses of different muscle layers. He needs a means to trigger a synchronizing sweep of the oscilloscope based on the insertion movement of the needle as it is moved from a layer of muscle to a deeper muscle layer. The investigator feels that important signaling is lost from the electromyographic reading if the synchronization were to wait for a definite pattern to develop after muscle reactions to the needle movement subside. He feels important signals are present and should be monitored immediately.

A search of aerospace literature is presently being performed to identify relevant technology.

#### GLM-35: Beta Radiation Catheter Probe

Cerebral blood flow must be monitored to determine effectiveness of therapy applied to head injury patients. Few data points per patient can be obtained if blood samples have to be drawn and laboratory tested. Technology is required to repeatedly determine arterio-venous concentration differences of Krypton-85 showing cerebral blood flow without need to draw blood from patients. Determinations are needed continuously over a period of time on the same patient. A biocompatible catheter probe for detecting concentrations of weak beta radiation from Krypton-85 circulating in human arteries and veins is needed.

The probe must be biocompatible, sensitive to beta radiation, tolerant to x-ray encountered during fluoroscopic implantation, able to withstand exposure to biological fluids (blood) for several days, non-toxic, sterilizable, and safe for use in the human body. The probe must use low voltage because of risk to human life.

A miniature solid state radiation probe developed by NASA was identified. Applications engineering efforts are in progress to build a probe for use by the problem originator. See Section II of this report.

#### GLM-37: Activity Telemetry from Single Neurons in Aquatic Animals

Biocompatible, high impedance microelectrodes are needed for implantation in nerve tissue of freely swimming fish.

Basic research into motor control mechanism study is fundamental to treatment of defective motor control. Implanted sensors will detect

central nervous system activities of single neurons in the vestibulospinal pathway of 2-ft long experimental fish. Neuron activity observation in the unrestrained animal relates unit activity to whole animal behavior and assesses the mechanism by which this system controls movement. Anesthetized animal acute experiments also will be performed in this study.

The amplifier should detect signals in the order of 100 microvolts with 100 to 5000 Hz bandpass. Signals from the fish in a tank must pass through sea water. Microminiature apparatus to be fastened to the skeleton of the fish should not interfere with normal movement patterns. If ultrasound is to be considered, the sound must not cause the fish to change movement patterns. The waveform of the nerve impulse must be distinguished from artifact and other nerve impulses, and therefore should not be appreciably distorted.

NASA technology in the form of underwater telemetry equipment and aquatic animal equipment was retrieved via aerospace literature searching.

#### UAM-3: Chronic Micro-Miniature L-C Transducer/Transmitter Implants Within the Human Eye

Biocompatible techniques for sealing of chronically implanted transducers and transmitters within the human eye are needed.

Pressure and temperature must be measured within the eye of a patient during convalescence following eye surgery or eye injury. These parameters indicate conditions of healing to the attending physician. The problem originator intends to chronically implant micro-miniature L-C transducers to obtain the desired eye measurements. Convalescence extends for months in some instances. Therefore, it is necessary that the transducer be effectively sealed.

A search of aerospace literature was done and results are presently being evaluated by the problem originator.

#### UAM-5: TV Study of Cell Fluorescence Under Low Light Intensity Conditions

Certain chemical actions occur during the study of amino acids, proteins and their synthesis, which yield spectrums that are specific to their makeup. Living cells which are checked with a microspectral polarimeter, will yield the same spectrum if the same proteins are present. Synthetics can be compared in this manner to the in vivo conditions. An orthicon tube or isocon tube television system for low light intensity fluorescence studies is needed.

A search of aerospace literature has been done and results forwarded to the problem originator for evaluation.

#### SNM-22: Biological Concomitants of Unusual Environments

Technology (devices and methods) to study the wide range of biochemistry problems encountered during unusual environment conditions is needed. Physical and psychological modifications in the human milieu are producing unusual conditions and evoking critical biological responses. Stress conditions and environmental changes appear to be occurring more frequently and for longer periods of time. Unless the biological adjustments of humans to such conditions are plotted in conjunction with these exotic environments, serious consequences can be expected.

Any devices intended to be applied directly for test and evaluation of human subjects, must be safe for human use. Microdevices and microtechniques will be specially helpful for establishing biochemistry determinations at the cellular level.

The problem has been identified, a search initiated and results forwarded the the problem originators for their evaluation of the information provided as well as their suggestions for areas which should be followed up.

#### SNM-20: Immunology Mechanisms for Health and Disease

Devices, approaches, techniques, methods and procedures are needed to demonstrate the etiology of immunology mechanisms. Individual immunological responses determine to a large extent a person's success or failure to cope with factors in the environment. They determine whether disease will be contracted or the course of a disease even in the midst of severe epidemics. They operate to accept or reject certain aspects of foods or atmosphere and artificial organs or devices. The investigator is seeking the etiology of the immunology mechanism. The research seeks to identify the specific system of biological alarm which is set off by a wide variety of activators, and which responds by an apparently wide range of specific biological counteractants.

#### SWC-5: Recovery and Separation of Amylase Subgroups

Saliva and pancreatic juices contain amylase which combines with food and aids in digestion of starch. Distinctly different structures and functions have been discovered in amylase from the two sources. Also, different subgroups have been noted within each source of amylase. The problem originator is seeking to determine why salivary amylase should be quite different from pancreatic amylase in demonstrable ways. There are also nondescriptive amylase substances secreted from the mucosa of the small intestine. The various subgroups have been electrophoretically separated

by the investigator by the use of polyacrylamide gels. He intends to use the information gained from this study to assist the physician with specific diagnoses and treatments for a variety of diseases and disorders.

The problem originator is seeking a rapid and accurate method for recovery and separation of the various amylase subgroups. The usual source of amylase is from human or animal blood fluids (serum or plasma). The polyacrylamide gel electrophoretic separations are time consuming and therefore costly.

A search was performed on the problem and results were sent to the investigator for evaluation.

#### ROS-1: Constant Velocity Vehicle for Small Laboratory

A constant velocity vehicle simulator for crash impact studies with primates is needed. The investigator wishes to study injuries to internal organs by utilizing experimental animals in a simulator in a small laboratory. A means to attain constant speed of 20-30 miles per hour with a minimum run or track is needed. Economical construction is required. Terminal speed must be selectable and the vehicle should be able to accommodate large baboons or chimpanzees.

Information from previous searches has been selected and forwarded to the problem originator who is in the process of evaluating this information.

#### LLU-10: Non-Invasive Techniques for Measuring Oxygen Content of Blood

Physicians conducting research on head injuries are in need of new methods to measure and observe certain vital signs. They require non-invasive techniques to measure the oxygen content of blood.

Advanced physiological monitoring technology developed for aerospace applications was provided for the problem originator via manual literature searching. Various methods for non-invasive measurement of oxygen content of blood were described. The information was forwarded for evaluation.

#### USC-12: Effects of Procaine Hydrochloride on Experimental Animals (Monkeys)

The researcher experimentally administers procaine hydrochloride to monkeys to determine the extent of their behavioral adjustments as a result of the drug. These monkeys tend to react by "withdrawing" for short periods of time. He requested NASA-developed assistance if available. He considers that even topical application of the drug to humans possibly could produce temporary adverse effects.

A search of the NASA data bank was run to determine if information on this subject was available. Relevant citations were forwarded to the problem originator.

#### OVA-4: Assessing Sleep Psychophysiology in Extreme Environments

Extreme, exotic and stressful environmental conditions are encountered at Amundsen-Scott Station, Antarctica. The investigator is assessing generated, long-term psychophysiological responses to use in constructing an overall picture of the general processes of adaptation and disadaptation. He collects and analyzes the psychophysiological concomitants of sleep (as a definitive state of consciousness). Phase 4 sleep dropout was noted. Instrumentation must be reliable under extreme environmental conditions and continually assess individual's state of consciousness.

A NASA-developed electronic sleep analyzer was identified through a search of aerospace literature. The problem has been submitted as an applications engineering candidate, and promises to be a significant application of aerospace technology.

#### SNM-21: Effective Learner Communications

Devices and methodology are needed to enhance communication with learners under a variety of learner conditions.

Radical changes have been possible throughout the entire spectrum of instructional curricula. These changes to improve the quality and quantity are essential to keeping pace with a rapidly modifying concept of life and science. This is markedly so in the medical area of instruction. Rapid and precise instruction was required for training of astronauts which the investigator feels could be adapted with ease to this problem. Methodology should be considered for relatively large groups such as didactic lecture types. It should also be considered for individual learning at pacing which fits the student needs. Cost effectiveness is practically as important as optimal learner factors.

A computerized search of aerospace literature is being done to retrieve various teaching techniques and equipment.

#### DEF-2: Ophthalmology Mapping by Pulse Echo Techniques

A pulse echo, ultrasonic device and techniques are needed to identify and locate small particulate masses within the vitreous humor of the human eye.

Standard ophthalmology methods are competent for usual examinations to determine conditions of the interior of the human eye. Some eye conditions



and diseases cause portions of the lens or vitreous humor of the eye to become cloudy or opaque. Diagnosis and prognosis evaluations under such eye conditions could be improved if it were possible to identify and locate any particulate masses and bodies which may exist behind the eye lens.

Searches of NASA literature were done. Relevant technology has been made available to the problem originator for evaluation.

### UTP-3: Measurement of Body Heat Loss

Postsurgery patients and patients with a variety of illnesses are unable to accommodate to offset heat loss demands. Ordinary room equipment such as a fan or air conditioner could aggravate this condition. Some patients in an area may accommodate well to adjustments of temperature or humidity that may be critical to others.

An effective method to measure body heat loss of patients in a hospital is needed that will replace the rectal temperature technique. Skin temperature measurements are felt to be subject to excessive fluctuations. Astronaut instrumentation for temperature measurement may solve this problem.

A search of the NASA data bank has been initiated. Alternative methods for measurement of body heat loss are being evaluated for application to a hospital setting.

### UTP-2: Continuous EEG Monitor

Increasing numbers of drug abuse accidents from excesses and overdoses make the availability of continuous readouts of vital signs a critical necessity for intensive care units.

These patients are frequently in such profound comatose state that it is extremely difficult to monitor their vital signs. The problem originator needs technology to provide basic cues indicating the presence of life and change of condition through electroencephalograph (EEG) readings of a continuous nature.

An economical, easy to use system to monitor EEG is being sought initially through identification of available technology via a computerized search of aerospace literature.